The birth of WMAS — How Sennheiser brought wideband technology into the wireless game

By Dr Andreas Wilzeck

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Introduction

With Spectera, Sennheiser has unveiled the world's first bidirectional wideband wireless ecosystem, which is based on the company's research into WMAS, Wireless Multichannel Audio Systems. Spectera represents a significant advancement in wireless audio technology, offering superior spectrum efficiency, flexibility, and performance compared to conventional systems. Its ability to accommodate a high number of audio links within a single TV channel, combined with multicast capabilities for IEM and versatile audio modes, make it an attractive solution for complex audio setups in various professional environments.

But where are the roots of Spectera in the world of frequency regulation and standardization?

WMAS — A true Sennheiser innovation

Between an idea for a new kind of wireless transmission and finally having a product in the market lies much engineering work, legal consideration and regulatory work. The latter is especially true for WMAS, which does away with the narrowband transmission scheme that has been used (and has been mandatory) since the late 1950s, when wireless microphone technology became attractive for broadcasting and live audio.

The harmonized ETSI EN 300 422 standard specifies the essential requirements and test procedures for access to radio spectrum, which must be met for any wireless microphone or IEM system to enter the market. While this standard is not a technology specification as such — it needs to be technology-neutral — it is nevertheless driven by technological innovation ambitions. In fact, EN 300 422 is the most cited market access standard for wireless microphones, IEMs and also WMAS worldwide.

Sennheiser was the leading contributor to the corresponding revision of ETSI EN 300 422. The company first introduced the term WMAS via ETSI document ERMTG17WG3(14)011015 on

12th of December 2014. In this document, Sennheiser proposed to include "Wireless Multichannel Audio Systems, WMAS, such as wireless conference systems" in EN 300 422, recognizing WMAS as a professional application. In the same contribution, Sennheiser suggested that "systems operating above 470 MHz will adapt to the given TV channel bandwidth, likely using OFDM technology as a TDMA system scalable to the given channel bandwidth".

In summer 2015, Sennheiser further elaborated on the use of wideband technology like OFDM for WMAS and its application in live sound in contribution ERMTG17WG3(15)000003. This document laid the groundwork for many of the key characteristics now embodied in Sennheiser's Spectera ecosystem, and also inspired market access foundation for other audio manufacturers exploring WMAS.

These two documents are, as it were, the "birth certificate" of WMAS in the regulatory and standardization domain.

Subsequently, Sennheiser also became instrumental in developing the first version of the system reference document ETSI TR 103 450 on WMAS. This pivotal system reference document proposed the removal of bandwidth limitations in key audio PMSE frequency bands to CEPT. As the sole manufacturer capable of showcasing fully functional WMAS prototypes to administrations at that time, Sennheiser played a crucial role in demonstrating the technology's potential. These efforts bore fruit with the successful revision of ERC Rec 70-03 Annex 10, which eliminated bandwidth restrictions for audio PMSE in relevant bands of the CEPT region (Europe) in 2018.

This milestone achievement paved the way for Sennheiser to launch regulatory processes aimed at making WMAS a global success story, ushering in a new era of efficient spectrum utilization for professional audio applications worldwide. In August 2018, Sennheiser filed the "Petition for rulemaking" to start the approval process by FCC in the USA, which concluded with the final rules listed in the federal register on 18th of October 2024.

WMAS — An effective use of spectrum supporting significant efficiency gains through technology and workflow

The Radio Equipment Directive (RED) Article 3.2 calls for radio equipment to be constructed in a way that effectively uses and supports efficient use of the radio spectrum to avoid harmful interference.

Let's elaborate on the key concepts.

As Peter Drucker insightfully noted, "Efficiency is doing things right. Effectiveness is doing the right thing." Applying this to spectrum management:

- *Effective use* refers to using the spectrum in the right way — employing appropriate technologies and approaches that make good use of the available spectrum resources.
- *Efficient use* means optimizing how that spectrum is utilized — maximizing capacity and minimizing waste.

The RED requires manufacturers in Europe to design equipment that both uses spectrum effectively (the right approach) and supports its efficient utilization (optimizing that approach).

Harmful interference endangers the operation and functioning of gear employed by other spectrum users. It can arise both from intentional sources and unintentional sources such as spurious emissions and malfunctioning equipment. The severity depends on factors like transmit power and frequency.

The system reference document on WMAS, ETSI TR 103 450, defines efficiency of spectrum usage as the number of audio channels transmitted per MHz of occupied spectrum, and elaborates implications and advantages in spectrum use delivered by WMAS depending on its implementation.

Key driver of effective use is the larger bandwidth that WMAS operates with by employing advanced modulation techniques such as OFDM, and multiple access schemes, such as TDMA or FDMA. Large bandwidth operation with reduced power spectral density and improved interference mitigation are particularly beneficial in high-density deployments, for example in entertainment districts like the West End and Broadway, allowing for more users in a given area without increasing the risk of harmful interference. Further, larger bandwidth operation provides the necessary system capacity for integration of several audio links with different direction (IEM, mic), and all-device, all-time control and management, while also providing a solution to RF fading and to exploit the properties of the RF channel more effectively.

Key drivers of efficient use are features enabled by bidirectional communication, which are driving the optimization of spectrum utilization by touching on existing workflows and even enabling new and more effective approaches: The implementation of bidirectionality by WMAS in a single RF channel is the enabler of remote control and management without additional infrastructure, flexible device configuration and dynamic audio resource allocation including multicast operation, and finally also the integration of wireless microphones and IEMs into a single system architecture, a single device and a single wideband RF channel. Further, in a bidirectional WMAS, the transmitters know that there is an intended receiver for their transmissions.

These advantages contribute to both effective use (employing advanced transmission techniques) and efficient use (optimizing spectrum utilization) of radio spectrum, aligning with the RED requirements.

Sennheiser's Spectera is a fully bidirectional implementation of WMAS delivering all of the benefits in spectrum use envisioned by ETSI TR 103 450.

Spectera — a game changer compared to conventional multichannel setups

A conventional multichannel audio setup consists of multiple rack-mount units such as microphone receivers and IEM transmitters, as well as mobile wireless devices such as handheld or bodypack microphone transmitters, and IEM bodypack receivers. The wireless IEM and microphone rack units are usually placed in separate racks, and the performers wear their IEM and mic bodypacks on different sides of e.g. the belt to avoid performance issues due to receiver blocking. Typically, a dedicated and properly coordinated RF carrier frequency is employed per transmitter-receiver pair. Setups with high channel counts get quite impressive in size, and also cumbersome as regards management and control. In conventional wireless microphone systems, the audio performance is fixed or can be just adjusted by selecting one of two modes before operation.

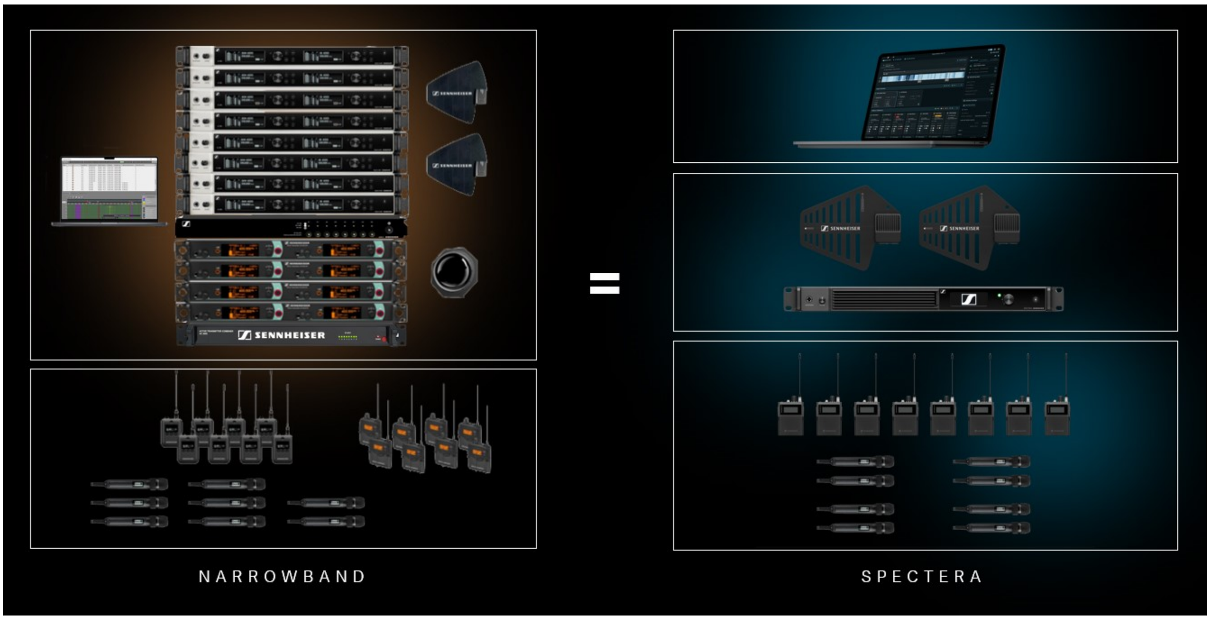

Fig. 1: Typical narrowband setup and its Spectera wideband equivalent

In general, IEMs and mics need to be placed and individually frequency-coordinated in well separated TV channels, so conventional IEM and mic operation always requires at least two TV channels to avoid blocking of the IEM receiver by the mic transmitter.

Today, IEM use is a commodity, so we typically have at least one microphone and/or instrument channel and one stereo/dual mono IEM per artist. So we can assume three, sometimes four audio channels per artist.

Analogue technology is capable of delivering roughly one audio channel per MHz, as intermodulation-free placement is a must for the non-linear power amplifiers that are typically used in analogue devices. Digital narrowband technology allows for an equidistant placement of frequencies if linear power amplifiers are utilized, and delivers 1.5 to 3.2 channels per MHz. As mics and IEMs need to be placed in separate TV channels, the average audio channel per MHz value can be assumed to be 2 ch/MHz.

Unfortunately, the common practice in frequency coordination of narrowband systems is to switch on the equipment to show its presence even during times when the equipment is actually not in use. Remember, each device gets its dedicated and coordinated frequency, and this often creates a need to “defend” the claimed resource by occupying it.

	Audio channels (audio channels per MHz)	
TV channel bandwidth	6 MHz	8 MHz
Analogue IEM (mono or stereo), B=200 kHz	7 or 14 (1.2 to 2.3)	8 or 16 (1 to 2)
Digital Mic, B=200 kHz, 600 kHz spacing	9 (1.5)	12 (1.5)
Digital Mic, B=200 kHz, 300 kHz spacing	19 (3.2)	25 (3.1)
Spectera (any mix of mics or IEMs)	Up to 64 (10.7)	Up to 64 (8)

Fig. 2: Comparison of possible audio channels per MHz for analogue narrowband, digital narrowband and Spectera wideband WMAS

Spectera allows for the deployment of any mix of IEMs and mics in a single 6 or 8 MHz TV channel with efficiencies going beyond 8 or 10.7 audio channels per MHz. So if we lived in a world where only a single TV channel was vacant for audio, Spectera would be the ideal solution, allowing parallel IEM and mic use as well as time-driven allocation of resources to devices.

Why more can definitely be less

The Spectera ecosystem is designed for multichannel applications, so it exploits a block of 6 or 8 MHz. This may at first sound like occupying a big chunk of the spectrum, especially if one is used to traditional setup conventions and capabilities. But if we take a closer look, this is exactly what is also required for a three- or four-person band using conventional narrowband technology. Remember, with IEMs, they need 12 to 16 audio links, and with 2 ch/MHz, we arrive at 6 to 8 MHz.

The transmit power of Spectera as a full system is the same as that which narrowband technology employs for a single transmitter, typically 50 mW erp. The larger bandwidth operation of Spectera reduces the power spectral density so that the employed RF channel can be reused earlier over distance. Unlike narrowband audio links, Spectera's RF transmit power is not adding up with the number of devices involved. Going back to RED and its requirement of "support of efficient use of spectrum to avoid harmful interference" — this is just that, making wise use of transmit power and spectrum occupancy throughout a venue or an area of operation.

Furthermore, Spectera's multicast IEM function allows up to 128 devices per RF carrier to listen to the same encrypted audio source. This multicast feature somehow runs outside the audio channel per MHz metric, but it is a good example of how Spectera helps the operator make efficient use of the spectrum:

> *Example scenario: A 16-person dance company can listen to a multicast mix with 0.7 ms latency in dual mono (stereo) with a high-quality SeDAC codec and utilise 25% of the system capacity. This leaves 75% of the capacity of the RF carrier for other purposes, like for example talkback, instruments and vocals.*

In general, a Spectera device supports one or multiple audio channels. The SEK bodypack as device supports 1 mic channel and 2 mono IEM channels (stereo = dual mono). The audio mode of the mic and the IEM can be set independently and simultaneously. The assignment can be done individually per device, and can be changed remotely at any appropriate time.

Fig. 3: The Spectera SEK bodypack supports a mic channel and two mono IEM channels (stereo = dual mono)

The audio modes of Spectera differ in latency, codec (data rate), range and battery runtime. Some modes apply to IEM only, mic only or both.

> *Example scenarios: One Base Station delivers 16 stereo IEMs (= 32 audio channels) with a latency of 1.6 ms using the SeDAC codec and standard range. Alternatively, the Base Station can deliver 32 stereo IEMs (= 64 audio channels) with a latency of 2.7 ms using the SeDAC codec and reduced range. Remember that Spectera's multicast IEM function allows up to 128 devices per RF carrier to listen to the same encrypted audio source.*

Furthermore, if you do not assign an audio mode to a device, no spectrum resources will be used for audio. So an SEK can operate as a paired device without audio assigned, as a mic only, as a mono IEM, as a mono IEM + mic, as a stereo IEM, or as a stereo IEM + mic. All modes and device assignments can be changed remotely — in a nutshell: Innovation sounds like this.

Links:

https://www.etsi.org/deliver/etsi_en/300400_300499/30042201/02.02.01_60/en_30042201v020201p.pdf

https://www.etsi.org/deliver/etsi_tr/103400_103499/103450/01.02.01_60/tr_103450v010201p.pdf

https://single-market-economy.ec.europa.eu/sectors/electrical-and-electronic-engineering-industries-eei/radio-equipment-directive-red_en

https://fcc.report/ELS/Sennheiser-Electronic-Corporation/1697-EX-ST-2018/217080.pdf