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In the Matter of)	
)	
Sennheiser Electronic Corporation,)	RM-II82I
Request for Amendment of Part 74 of)	
The Commission's Rules to Advance the)	
Use of Spectrum Efficient Wireless)	
Microphone Equipment)	
)	

Paula Boyd
*Senior Director, Government and
Regulatory Affairs*

Michael Daum
*Director, Technology Policy,
CELA Privacy and Regulatory Affairs*

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TABLE OF CONTENTS

I. Introduction and Summary	I
II. The Commission Should Not Permit Unlicensed WMAS Operations, or Licensed Operations, in Spectrum Not Currently Designated for Licensed Wireless Microphone Use.	2
III. The Commission Should Not Allow Wireless Microphones to Unnecessarily Waste More than Half of Every Channel They Use.....	6
IV. Conclusion	II

I. INTRODUCTION AND SUMMARY

Microsoft applauds Sennheiser's efforts to pursue wireless microphone technologies that make more efficient use of spectrum. We do not take any issue with its proposal to use advanced wireless microphone equipment on frequencies where licensed wireless microphone use is currently permitted, including the 941.5-952 MHz and 1435-1525 MHz bands,¹ the broadcast television bands, or the 4 megahertz wireless-microphone channel within the 600 MHz duplex gap, so long as these operations are permitted on a strictly licensed basis on frequencies where licensed wireless microphones are permitted today. However, we strongly oppose the idea of the Commission changing its rules to allow wireless microphone operators to use Wireless Multi-Channel Audio Systems (WMAS) technology on an *unlicensed* basis without complying with other Part 15 rules, or to somehow expand the frequencies in the broadcast television and 600 MHz bands available to licensed wireless microphones to accommodate WMAS.

Most critically, licensed Part 74 wireless microphone operations, including WMAS, should continue to be prohibited in the 6 megahertz unlicensed channel within the 600 MHz band duplex gap. Likewise, the Commission should continue to prohibit *unlicensed* WMAS operations throughout the broadcast television bands and the duplex gap, if such operations are inconsistent with other existing Part 15 technical rules. The current rules governing unlicensed wireless microphones allow such devices to operate with a higher power spectral density than other Part 15 devices, but only if they operate using a narrower bandwidth. Permitting 6 MHz WMAS systems under these existing unlicensed wireless microphone rules would break this careful

¹ See Sennheiser Electronic Corporation Petition for Rulemaking at 1 and attached Proposed Rule Language, RM-11821 (filed Aug. 17, 2018) ("Sennheiser Petition").

balance and allow co-channel operation with White Space devices at significantly higher power levels than the FCC intended, especially in the duplex gap. This will also risk new adjacent-channel interference to licensed services such as broadcasters and LTE services adjacent to the duplex gap. Of course, any wireless microphone operator is free to use unlicensed frequencies for any purpose using any technology as long as they comply with the rules. But the Commission should reaffirm that operators seeking to operate in White Space channels with wideband signals must comply with *all* of the White Space rules and cannot selectively take advantage of only the 6 MHz transmission bandwidth.

The 6 megahertz unlicensed portion of the duplex gap is especially critical because it is the only channel available throughout the United States for White Space operations. Its continued availability is therefore key to stimulating investment in White Space technologies and advancing rural broadband deployment. The Commission should not allow wireless microphone operators to claim exclusive access to this spectrum—on either a *de facto* or *de jure* basis—in addition to the other duplex gap spectrum to which they already have access, but generally do not use. In considering Sennheiser’s petition, the Commission should also consider how the FCC’s rules can promote more efficient use of spectrum than the extremely inefficient operations of existing wireless microphones.

II. THE COMMISSION SHOULD NOT PERMIT UNLICENSED WMAS OPERATIONS, OR LICENSED OPERATIONS, IN SPECTRUM NOT CURRENTLY DESIGNATED FOR LICENSED WIRELESS MICROPHONE USE.

Wireless microphones are one of the few remaining commercial wireless technologies to which the Commission continues to grant special spectrum rights without a requirement to participate in a spectrum auction and without unlicensed sharing obligations. In the absence of either of these efficiency-promoting mechanisms, the Commission should hold wireless

microphone manufacturers to especially high standards to ensure that their use of spectrum advances the FCC's core efficiency and public-interest responsibilities.

Unfortunately, as Sennheiser's filing highlights, the efficiency of existing analog and digital wireless microphones has barely advanced over the past decade and a half.² Even today, high-end digital wireless microphones use only twelve 200 kilohertz channels—for a total of 2.4 megahertz—in every 6 megahertz channel. This means that even with the most advanced high-quality wireless microphones, more than half of the spectrum reserved by a wireless microphone operator can actually lie fallow. Worse still, some manufacturers continue to encourage users to spread their operations widely across the UHF band, rather than investing in engineering advances, to avoid interference between narrowband microphones.

Even so, Sennheiser should be recognized for pursuing any technological advancement that holds the potential to improve the current state of affairs, so long as it does not require the Commission to impose further limitations on other services, including innovative new technologies, for the benefit of a single technology and a single class of spectrum users. Unfortunately, however, it is unclear whether Sennheiser's petition meets this standard. The petition does not request that the Commission allow wireless microphones using WMAS to operate in a 6 MHz portion of the duplex gap. But because licensed wireless microphones' operation in the duplex gap is limited to a 4 MHz channel while the petition asks to use a 6 MHz channel, the true intent of Sennheiser's petition is difficult to discern. The 6 MHz channel

² According to a filing by Shure more than fourteen years ago, "[a] 6 megahertz television channel can support the operation of 6-8 wireless microphones that operate with the current 200 kHz analog technology." *Unlicensed Operation in the TV Broadcast Bands*, Second Memorandum Opinion & Order, 25 FCC Rcd. 18661, 18674 n.58 (2010) (citing Letter from Catherine Wang to Marlene H. Dortch, Secretary, FCC, ET Docket No. 04-186, at 4 (filed July 1, 2004)).

immediately above the WMAS channel in the duplex gap is designated for unlicensed use only. This may include wireless microphones, but not with bandwidths greater than 200 kHz, and wireless microphone operators may not reserve this channel.

Thus, in the 600 MHz duplex gap, Sennheiser's petition should have made it clear that it is only seeking rule changes for the Commission to authorize use of the 4 megahertz channel. The Commission should therefore make clear that even if it grants the petition, FCC rules do not permit WMAS operations in the 6 megahertz channel in the upper portion of the duplex gap where Part 74 microphones are prohibited.³ The petition is limited to relatively narrow proposed changes to the Part 74 rules, and the Commission should not consider other, extremely harmful, changes to the very different set of Part 74 rules and related Part 15 rules that restrict the frequencies available to licensed wireless microphones, and impose bandwidth restrictions on unlicensed wireless microphones.⁴

The 6 megahertz channel in the duplex gap is critical to enabling TV White Space use throughout the United States. Accordingly, wireless microphone operation across the entire duplex gap—either by licensed wireless microphones operating beyond their existing 4 megahertz channel, or unlicensed wireless microphones operating with much greater bandwidths—would undermine the Commission's explicit decision to use this channel to support White Space operations. It would also upend the Commission's general approach to sharing between the two classes of unlicensed devices, which takes advantage of a higher average power density wideband White Space device sharing with a higher peak power density narrowband

³ 47 C.F.R. § 74.802(a).

⁴ 47 C.F.R. §§ 15.713 (permitting only wireless microphones in the Low-Power Auxiliary Service to reserve channels); 15.236(f) (restricting the bandwidth of unlicensed wireless microphones to 200 kHz); 74.802(a)(2) (restricting Low-Power Auxiliary Service operations in the duplex gap to the 4 megahertz portion of it designated for wireless microphones).

wireless microphone. Six megahertz operation in these frequencies would also reopen the issue of potential adjacent-channel interference to the 600 MHz A-block mobile wireless licensees. The fact that Sennheiser’s petition did not propose WMAS conducted power limits, conducted power spectral density limits, or adjacent-channel conducted power spectral density limits only heightens these concerns. Merely retaining the existing power spectral density limits for unlicensed wireless microphones but allowing wider transmission bandwidths would, in effect, permit unlicensed transmissions at power levels far greater than those currently allowed in the unlicensed portion of the duplex gap.⁵

Moreover, a review of Sennheiser and other wireless microphone manufacturers’ marketing materials and datasheets suggests that current professional wireless microphones make little, if any, use of the 4 megahertz in the duplex gap to which they already have access. Sennheiser’s “Frequency Finder” tool, for example, does not even allow users to search for frequencies above UHF channel 36.⁶ Given that wireless microphone manufacturers are no longer able to market devices that operate in the portions of the 600 MHz band on either side of the 4 megahertz wireless microphone channel,⁷ and given the significant amount of contiguous spectrum available elsewhere, it is not surprising that wireless microphone manufacturers have not prioritized the development of microphones that operate in this band. But this lack of investment would be all the more reason not to grant wireless microphone operators special rights to operate in the unlicensed portion of the duplex gap.

⁵ See 47 C.F.R. § 15.236(d).

⁶ Sennheiser, *Sennheiser USA Frequency Finder*, <http://sennheiser.us/freqfinder/index2.html> (last visited Dec. 18, 2018).

⁷ *Promoting Spectrum Access for Wireless Microphone Operations*, Report and Order, 30 FCC Rcd. 8739, 8764 ¶¶ 58-59 (2015).

Finally, the Commission should not allow Sennheiser's proposal to facilitate an end run around the Commission's current rules that restrict wireless microphone operators' ability to reserve channels in the broadcast TV bands. Current rules only allow venues using more than 50 unlicensed wireless microphones to reserve channels. However, WMAS operation on an unlicensed basis using wider bandwidths than existing FCC rules allow for wireless microphones would permit *de facto* reservation of channels by authorizing massively interfering wideband transmissions at higher power levels than those usually authorized by the White Space rules, by any wireless microphone user.⁸ The Commission's existing rules recognize and address this risk. Additionally, the current rules require each unlicensed wireless microphone to register with the White Space database and check the database to determine available channels prior to beginning operation at a given location.⁹ However, the petition provides no explanation of how a WMAS device operating on an unlicensed basis would interact with the White Space database, although it is clear WMAS would have to comply with all the Commission's rules.

III. THE COMMISSION SHOULD NOT ALLOW WIRELESS MICROPHONES TO UNNECESSARILY WASTE MORE THAN HALF OF EVERY CHANNEL THEY USE.

According to their manufacturers, existing wireless microphone products require maddeningly large swaths of spectrum to transmit a single channel of audio service. According to Sennheiser, existing single-channel microphone technology is only able to accommodate, at most, 12 microphones in 6 megahertz, even though each microphone only occupies a single 200 kilohertz channel.¹⁰ This means that fully 60% of this spectrum—3.6 out of every

⁸ 47 C.F.R. § 15.236(d).

⁹ 47 C.F.R. § 15.713(f).

¹⁰ Sennheiser Petition at 4, 6.

6 megahertz—remains vacant and serves, effectively, as guard bands between individual microphones. This practice results in more channel reservations than would be required were manufacturers to use more efficient spectrum practices, unnecessarily blocking access by White Space devices. This level of inefficiency compares unfavorably with international standards. The ITU, for example, compiled operating characteristics of wireless microphones operating in the nearby 800 MHz band and found that, for digital microphones, a microphone occupies 192 kilohertz with a minimum channel spacing of only 375 kilohertz, allowing a total of 10 wireless microphones to operate in every 4 megahertz.¹¹ Accordingly, international standards would suggest that manufacturers should be able to accommodate at least 15, not 12, microphones in a 6 megahertz channel.

However, even this description overstates the efficiency of existing wireless microphone technology in practice. Although Sennheiser’s filing implies that existing wireless microphones operate in 200 kilohertz sub-channels packed within a single 6 megahertz block, the truth is that wireless microphone manufacturers encourage their users to spread their 200 kilohertz channels across *even wider* swaths of spectrum, apparently in an attempt to use spectral separation, instead of investing in better engineering, to address the possibility of intermodulation between these signals.

For example, Sennheiser’s 300-500 G4 professional audio receivers and microphones are tunable to frequencies in the 470-558 MHz range (among many others). However, users are encouraged to use pre-selected “banks” of frequencies,¹² each of which includes channels that

¹¹ ITU, *Tuning ranges and operational characteristics of terrestrial electronic news gathering (ENG), television outside broadcast (TVOB) and electronic field production (EFP) systems* 55 tbl.21, Report ITU-R BT.2069-7 (Oct. 2017).

¹² See Sennheiser, *Frequenzbereich Aw+ / Frequency range Aw+ : 470 - 558 MHz*, https://assets.sennheiser.com/global-downloads/file/9980/ew_300-

stretch from one end of the 470-558 MHz range. Bank 1, for example, includes 32 channels that range from 470.1 MHz to 555.2 MHz. A user with 12 microphones that simply selected the first 12 of those frequencies would occupy channels between 470.1 and 511.0 MHz—potentially locking up more than 40 megahertz for a mere 12 microphones, actively using a total of only 2.4 megahertz. Microsoft understands that the design of any wireless system requires balancing spectral efficiency with the performance needs of that system. But potentially blocking users from 40 megahertz of highly valuable low-band spectrum in order to protect 12 short range, narrowband transmissions cannot be justified in an age where spectrum users and the FCC must make every megahertz of spectrum count.

Sennheiser’s proposed WMAS system would improve this state of affairs by allowing wireless microphone signals to be aggregated in a single 6 megahertz channel. But it is unclear whether Sennheiser’s proposed rule change would achieve its promised benefit in the real world, by further increasing the number of wireless microphones that can be supported in a single channel. Sennheiser proposes performance standards for devices operating under these rules that would only require the ability to support at least 12 transmitters.¹³ This is despite the fact that Sennheiser claims “WMAS approximately doubles the capacity of a 6 megahertz channel for wireless microphones that deliver the best audio quality, and triples the capacity for intercom quality.”¹⁴ At the same time, Sennheiser also claims that 8 to 12 high-fidelity, performance quality microphones can be used in a single 6 megahertz channel under the *existing* rules.

[500_G4_Aw_Range_Frequency_Sheet_01_2018.pdf?_ga=2.62785129.496424760.1544714702-1645419758.1543942603](#) (explaining that users can also create a limited number of user-defined frequency banks, but “these frequencies are not intermodulation free”).

¹³ Sennheiser Petition attached Proposed Rule Language.

¹⁴ *Id.* at 6.

Plainly, a doubling of channel capacity would result in the ability to support 24 devices in a 6 megahertz channel, not just the 12 that could be supported today. Adding to the confusion, Sennheiser provides a chart that apparently splits the difference between the capacity improvements that it claims and its proposed 12-device performance standard by indicating, without further explanation, that WMAS systems will be able to support 18 wireless microphones in a 6 megahertz channel.¹⁵

These inconsistencies are even more perplexing within the context of wireless microphone manufacturers' previous representations to the Commission about the limitations of digital wireless microphone technology. Although Sennheiser's WMAS proposal and many of its existing professional audio products use digital encoding, other manufacturers have implied that digital encoding might not be appropriate for professional audio applications. In a recent Commission proceeding to evaluate the appropriate technical rules for wireless microphones in the UHF band, Shure opposed rules that might require wireless microphone operators to use efficient digital encoding techniques, claiming that "digital systems have significantly more throughput delay (latency) than analog systems" and "also tend to exhibit an all-or-nothing transmission characteristic -- sometimes referred to as the 'cliff effect' -- that can be disconcerting to performers and presenters."¹⁶

Manufacturers' previous statements about the spectral efficiency of wireless microphones were also strikingly different, and more pessimistic, when seeking to secure spectrum for wireless microphone use. Shure highlighted claims, for example, that ESPN uses "245 UHF

¹⁵ *Id.*

¹⁶ Reply Comments of Shure Incorporated at 17, WT Docket Nos. 08-166 & 08-167, ET Docket No. 10-24, GN Docket No. 12-268 (filed Mar. 12, 2013).

frequencies over thirty-one channels in a single day.”¹⁷ This works out to only 7.9 wireless microphone frequencies per 6 megahertz channel—lower than even the least efficient professional-audio grade microphone described in Sennheiser’s petition.

At the very least, the Commission should seek to better understand the technical capabilities of the system Sennheiser proposes and adopt performance requirements that properly reflect those capabilities. Unlike other spectrum users, licensed wireless microphones continue to operate pursuant to an antiquated regime in which they have been granted the privilege of reserved access to spectrum, and the ability to exclude others when they wish to operate, without participating in a spectrum auction that would require them to internalize its value (or the social cost of excluding other users from those frequencies). As a general matter, Microsoft supports the Commission’s policy of technological neutrality in bands that are assigned through competitive bidding, or that are opened for non-exclusive unlicensed operations. White Space devices, of course, may not exclude other technologies from accessing frequencies. However, in cases such as this one, where a past Commission has already profoundly diverged from that policy by permitting free, exclusive access to spectrum by a preferred service and technology, the FCC is obliged to ensure that wireless microphone use remains in the public interest—for which the service’s spectral efficiency is a key component. Accordingly, if Sennheiser’s WMAS technology is, as Sennheiser suggests, capable of supporting many more than 12 users in a 6 megahertz channel, the Commission should encourage Sennheiser to maximize efficiency.

¹⁷ *Id.* at 7 (emphasis in original omitted).

IV. CONCLUSION

Microsoft does not oppose Sennheiser's petition with respect to the 941.5-952 and 1435-1525 MHz bands. Microsoft does oppose more far-reaching changes, beyond those described in Sennheiser's petition, to change the Part 74 and Part 15 rules with respect to the 600 MHz band duplex gap and the repacked TV bands in channels where unlicensed wireless microphones share with White Space devices. Such a change would raise major new coexistence concerns with White Space devices as well as licensed mobile operators adjacent to the 600 MHz duplex gap. In fact, unlicensed wireless microphones do not fall under Part 74 of the Commission's rules, and Sennheiser has not proposed to modify the Part 74 rule that limits the frequencies available to licensed wireless microphones (including the limitation that wireless microphones may only operate in a 4 megahertz portion of the duplex gap). Therefore, although Sennheiser's petition refers to operation in a 6 megahertz channel in the duplex gap, its petition cannot support such operations on either procedural or substantive grounds.

In addition, if the Commission moves forward on Sennheiser's petition—appropriately limiting it to licensed wireless microphones in frequencies where such operations are currently permitted—it should ensure that wireless microphone manufacturers use spectrum efficiently. Finally, the Commission should seek additional technical information from Sennheiser to determine whether licensed wireless microphones using WMAS technology will conform to all other applicable technical rules.

Respectfully submitted,

s/ Paula Boyd

Paula Boyd

*Senior Director, Government and
Regulatory Affairs*

Michael Daum

*Director, Technology Policy,
CELA Privacy and Regulatory Affairs*

MICROSOFT CORPORATION

901 K Street NW, 11th Floor Washington,
DC 20001
(202) 263-5900