

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of)	
)	
Revisions to Rules Authorizing the Operation of)	WT Docket No. 08-166
Low Power Auxiliary Stations in the 698-806)	
MHz Band)	
)	
Public Interest Spectrum Coalition, Petition for)	
Rulemaking Regarding Low Power Auxiliary)	WT Docket No. 08-167
Stations, Including Wireless Microphones, and)	
the Digital Television Transition)	

REPORT OF V-COMM, L.L.C.

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1 Executive Summary

V-COMM, L.L.C. is a wireless engineering consulting firm. Our principals have over 25 years of in-depth experience in wireless telecommunications engineering. We have provided our expertise to wireless operators and governmental agencies in system design, network engineering, implementation, network expansion, system performance and optimization. V-COMM's technical expertise includes assisting wireless operators in the evaluation and integration of new technology into their networks. We have considerable engineering experience in mitigating interference between adjacent band operators and co-locating wireless systems. We have experience in all commercial wireless technologies, including CDMA, TDMA, GSM and AMPS technologies, in Cellular, PCS, ESMR, Fixed Wireless, and the Broadband Wireless Industries. Further, we have experience in Public Safety wireless technologies including APCO16, APCO25 and many proprietary trunking and conventional radio networks.

The FCC is proposing (NPRM) to modify its rules such that operation of low power auxiliary stations (LPAS) will not be permitted to operate in the 700 MHz Band post the DTV transition period on February 17, 2009. The NPRM also references a petition filed by the Public Interest Spectrum Coalition (PISC) regarding unlicensed use of wireless microphone systems in this band and requested FCC to follow-up and respond to the issues identified in the petition.

V-COMM supports the proposed rules in the NPRM in regards to prohibiting LPAS operations in the 700 MHz band due to the incompatibility of the LPAS operations and the new operations for Commercial Mobile Radio Services (CMRS) and Public Safety (PS) services. The equipment used by new services to occupy the 700 MHz spectrum, both commercial and public safety, are not compatible with LPAS devices and will suffer harmful interference if LPAS services were to continue in the band. V-COMM has provided herein a detailed engineering analysis showing the extent of the harmful interference and impact of LPAS operation on the new services intended for the 700 MHz band. V-COMM further notes that due to the mobile nature of the new services that will occupy the 700 MHz spectrum, both public safety and commercial, and the intermittent use and generally nomadic nature of the LPAS operations; there can be no way for current licensed 700 MHz LPAS operators to ensure their continued operation would not be harmful to public safety and commercial users. In addition, V-COMM has direct experience with impacted operations of its client's commercial wireless systems operating in the 700 MHz band.

V-COMM agrees with the proposed rules that all LPAS operations cease to operate in the 700 MHz bands after the DTV transition date. We further concur with the Commission that it is incumbent upon them to take all steps necessary to make this spectrum effectively available both to public safety and commercial licensees at the end of the DTV transition. As noted above, we demonstrate herein that harmful interference will be caused by the operation of these LPAS

operations in the presence of public safety and commercial wireless networks operating in the 700 MHz spectrum.

2 Introduction

2.1 LPAS (Wireless MIC) Background

Entities that are eligible to operate LPAS under FCC rules (74.832) are limited to:

- licensees of AM, FM, TV, or International broadcast stations or low power TV stations;
- broadcast network entities;
- certain cable television system operators;
- motion picture and television program producers as defined in the rules;
- certain entities with specified interests in Broadband Radio Service (BRS) Educational Broadcast Service (EBS) licenses, i.e., BRS licensees (formerly licensees and conditional licensees of stations in the Multipoint Distribution Service and Multichannel Multipoint Distribution Service), or entities that hold an executed lease agreement with a BRS licensee or conditional licensee or entities that hold an executed lease agreement with an Educational Broadcast Service (formerly Instructional Television Fixed Service)¹⁶ licensee or permittee.

The NPRM listed 156 entities with licenses that include operation on the 700 MHz spectrum bands, and only 30 licenses that are authorized to only operate in the 700 MHz band.

However, there are non-licensed operators in the VHF and UHF spectrum; including the 700 MHz spectrum that pose a real threat to licensed 700 MHz commercial and public safety operators. The most common application for this illegal operation is wireless microphone systems. The gravity of this situation is documented in the PISC Petition under this same Rulemaking Matter. It is clear from the PISC Petition that this use has been widely advertised and solicited by the industry. These devices are readily available to the general public through established retail distribution outlets like www.wirelessmicrophones.com, www.bhphotovideo.com, www.musiciansfriend.com and other retail outlets.

These wireless microphone operations take place in public venues, and venues where one would/could expect licensed commercial and public safety 700 MHz operations to take place. One could easily envision a concert event using wireless microphone systems and the presence of Public Safety operation for crowd control, etc. Further, other public venues like theaters, schools, arenas, amusement parks, outdoor amphitheatres, houses of worship, etc. are common venues where the proliferation of these devices can be witnessed. In addition, the venues can have over 100 different microphones operating simultaneously.

2.2 Low Power Auxiliary Station (LPAS) Operations

LPAS operations are to take place on a secondary basis. These operations “*shall be operated so that no harmful interference is caused to any other class of station operating in accordance with the Commission’s rules and regulations and with the Table of Frequency Allocations*”.

For licensed operations, they are intended for use in ranges up to 100 meters to coexist in the TV band spectrum. They are permitted to operate with transmit output power up to 250 mW.

Per the PSIC Petition, the wireless microphone application is very prevalent in the UHF frequency range; and most often by unlicensed operations. These systems are location uncertain, and in fact, the manufacturers and promoters of this equipment acknowledge the “touring” nature of the systems in warning its operators of changes in TV interference environments from location to location. These warnings can be found on the aforementioned websites, and other documents supplied by the industry.

Devices that may be authorized as low power auxiliary stations are intended for such uses as wireless microphones, cue and control communications, and synchronization of TV camera signals.

2.3 Technical Aspects and Deployments of Wireless Microphone Systems

Electro-Voice, Shure, Nady Systems, Inc, Audio Ltd, Sennheiser, Lectrosonics, Samson Technologies, AKG Acoustics MIPRO and Audio-Technica are all major manufacturers of wireless microphone systems. For a description of the frequency band selection, system operation and configuration, transmitter and receiver power levels, antennas, and further reference information on wireless microphones refer to Appendix A, “*Selection and Operation, Wireless Microphone Systems*”, which is a publication by Shure, Inc.¹

When Public Safety and commercial entities were allocated 700 MHz spectrum for two-way radio communications, they anticipated the elimination of wireless microphones operating in the same spectrum. New Commercial and Public Safety 700 MHz systems are being planned and the system designers expect clear spectrum without the interference challenges from wireless microphones. V-COMM is directly involved in several of these upcoming 700 MHz system deployments that envision unencumbered spectrum after the DTV transition.

These wireless microphones are currently being sold to the general public in today’s market via the internet and standard retail outlets. A simple web search

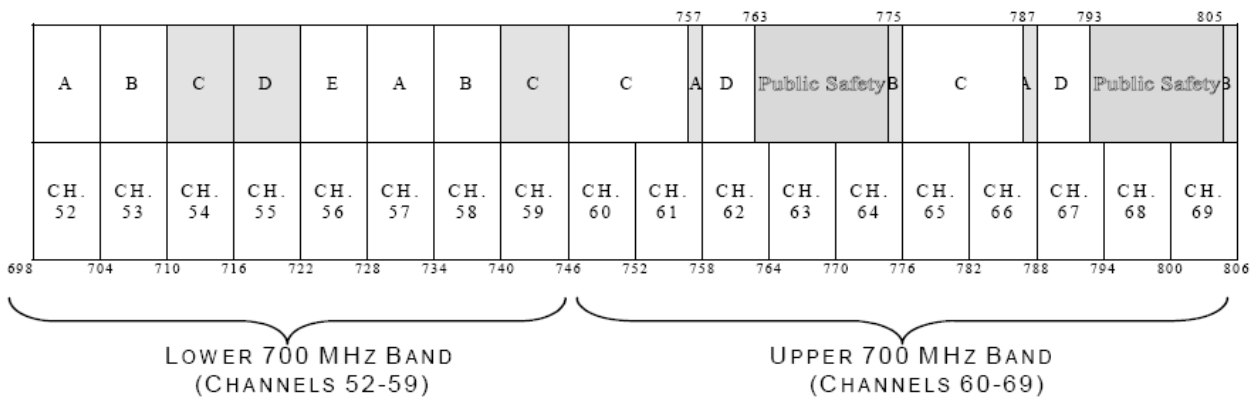
¹ This is an educational publication by Shure, Inc., which is publicly available at the www.shure.com.

for “wireless microphone” yielded hundreds of sites selling UHF-H (high band) 700 MHz wireless microphones manufactured to operate in the 698-806 band. Here are a few examples of microphones being sold today operating in 700 MHz band (698 - 806 MHz):

- Gemini UZ-1128 (740-770 MHz)
- Gemini UZ-9128 (740-770 MHz)
- RE-V Wireless Microphones Systems (614-746 MHz)
- Nady U-81 (740-806 MHz)

These wireless microphones are operating on CMRS and Public Safety spectrum, as shown in the 700 MHz spectrum chart below.

Figure 1 700 MHz Band Plan for Commercial and Public Safety Services



The ordinary user of the wireless microphone does not know that his equipment could cause interference to other entities. The user simply sets up the system to be used in the desired environment (churches, theatres, stadium, public speaking, etc...). In many cases, if your system is not operating correctly you make changes to the system to get optimal performance. These changes can include increasing the output power of the microphone, relocating antennas, switching channels, and the list goes on. Many users do not have the proper qualifications to correctly setup the system to ensure non-interference with newly licensed operators.

In addition, the more qualified and informed users will not be able to avoid interference to the 700 MHz bands as the commercial and Public Safety services are new and very different uses of the spectrum as compared to the original conventional broadcasters’ use of the spectrum. Interference detection, avoidance and understanding new technologies, services, and forward-link/reverse-link uses within the 700 MHz spectrum bands will be beyond the capabilities of wireless microphone users, and it will be impossible for end users to manage the interference.

2.4 FCC NPRM Overview

The FCC is seeking to revise the Part 2 and Part 74 rules for low power auxiliary stations (LPAS) to prohibit their operation in the 700 MHz Band after the end of the DTV transition. Specifically in the NPRM the FCC:

- tentatively conclude to amend our rules to make clear that the operation of low power auxiliary stations within the 700 MHz Band will no longer be permitted after the end of the DTV transition because such operations could cause harmful interference to new public safety and commercial wireless services in the band
- tentatively conclude to prohibit the manufacture, import, sale, offer for sale, or shipment of devices that operate as low power auxiliary stations in the 700 MHz Band
- tentatively conclude that we will modify these licenses so as not to permit such operations in the 700 MHz Band after February 17, 2009
- seek comment on issues raised by the Public Interest Spectrum Coalition (PISC) in its informal complaint and petition for rulemaking (“PISC Petition” or “Petition”).

3 Harmful LPAS Interference into CMRS/PS

3.1 Background

LPAS devices have the potential to cause substantial harmful interference to new services operating in the 700 MHz, which include Public Safety and new CMRS services. These LPAS devices can operate at similar power levels as anticipated CMRS 4G devices that will be deployed and will be strong enough to desensitize mobiles and base stations within a large area. 4G devices are expected to operate at 200 milliwatts nominally which is even lower power than the LPAS device maximum permitted levels.

3.2 Interference Analysis

3.2.1 Link Budget Analysis

Per FCC Regulation 74.861 (e)(1)(ii), Low Power Auxiliary Station’s (LPAS) are currently permitted to operate with a transmit output power up to 250 milliwatts or 24 dBm. Typical assumptions of -2 dB of LPAS antenna gain, -2 dB CMRS antenna gain, -3 dB of body loss, and 10 dB of clutter loss can be used to formulate a range of interference from these LPAS device to Commercial Mobile Radio Services (CMRS) and Public Safety (PS) systems.

The interference analysis threshold point of -100 dBm for mobile CMRS service is used as the interference noise level of the victim receivers, which causes a 3 dB increase in the operating noise floor (desense by 3 dB).² With a threshold of interference of -100 dBm at the CMRS/PS mobile receiver, we can estimate the range of co-channel and adjacent channel interference for these LPAS devices to CMRS /PS mobile devices and CMRS/PS base receiver stations.

The free space propagation model is acceptable in areas where there is clear line of site and flat regular terrain. The Egli model is a greatly simplified model that assumes "gently rolling terrain with average hill heights of approximately 50 feet" (*Land Mobile Radio Systems*, Edward N. Singer, PTR Prentice Hall, 1994, p. 196).³ Because of this assumption, no terrain elevation data between the transmit and receive facilities is needed. Instead, the free-space propagation loss is adjusted for the height of the transmit and receive antennas above ground. The following analysis assumes a base station height of 20 meters and a mobile and LPAS device height of 2 meters.

3.2.2 LPAS Interference to CMRS/PS Co-Channel Analysis

The subsequent Egli model co-channel analysis and results include a 10 dB clutter attenuation factor to account for general obstructions along the path. Using a LPAS 250 milliwatt (mW) output power and a clutter loss of 10 dB, the Egli model predicts a co-channel LPAS device would propagate at levels that could cause loss of service on CMRS or Public Safety (PS) mobiles within 220 meters (700 ft). In cases of stadiums, open space, or outdoor venues a line of site model is more appropriate. Assuming line of site propagation with the Egli model by ignoring the 10 clutter loss, the range of inference is increased to 400 meters (1300 ft). This interference range is enough to completely wipe out CMRS mobile and PS portable communications at an entire concert or professional sporting event and cause loss of service to tens of thousands of customers.

Furthermore, it could jeopardize essential public safety communications at these same events. In narrow bandwidth public safety systems the threshold of

² CMRS receiver thermal noise floor (ktb) -107 dBm, 7 dB noise figure for devices, and 4 dB noise figures for base stations are used for interference analysis purposes. Co-channel interference received at these levels (-100 dBm for mobiles, 103 dBm for BTS) will increase the noise floor of the commercial receivers by 3 dB. BTS antenna gain of 12 dBd and 3 dB cable loss are used in the interference analysis for base stations.

³ Egli Model is a terrain model for radio frequency propagation. This model predicts the total path loss for a point-to-point link. Typically used for line of sight transmission for cellular system links over smooth, plane terrain, the path loss decreases with "40 log (*distance*)". At closer distances, the free-space propagation model is more appropriate, and for further distances we have used the Egli model with a clutter attenuation loss to more accurately model the propagation path loss.

interference could be even lower, which would result in even larger areas of interference. This will create very large dead zones having no mobile/portable coverage in areas around these devices. Furthermore, we are using these interference levels for analysis purposes; interference may also be caused at lower levels as well.

The same co-channel argument can be justified for a LPAS interfering at a CMRS or public safety base station location. Assuming a base station height of 20 meters, 250 milliwatt LPAS output power, and a clutter loss of 10 dB, the Egli model predicts these co-channel LPAS devices will interfere with CMRS or Public Safety (PS) base stations within 1.8 km (1.1 miles). Again, with no clutter, the Egli model predicts the range of interference is increased to 3.3 km (2.1 miles). In cases where the base station is experiencing this LPAS interference, the entire coverage area of the base station becomes reduced or eliminated. In cases where the interference is very high above ground with clear line of site the interference would significantly reduce or eliminate the coverage radius and cause loss of service for CMRS/PS mobiles and portables attempting to communicate with the base station.

Based upon the analysis put forth above, we concur with the FCC's decision to revise the rules to prevent the operation of low power auxiliary stations in the 700 MHz band, and thus avoid potential disruption to new public safety and other commercial services in that band after the DTV transition.

3.2.3 LPAS OOB and Intermodulation Interference

In addition to the co-channel interference, LPAS devices have the potential to cause interference on adjacent spectrum bands due to out-of-band emissions (OOBE) and intermodulation products caused from multiple devices. These emissions have the potential to cause interference to commercial and Public Safety 700 MHz base stations and portable devices when the LPAS devices are nearby the portables and base stations that are further away from their source transmitters. For example, OOB from the LPAS devices that are close enough to CMRS base stations may strong enough to interfere with CMRS mobiles that are located further away and received at lower power levels at the base station. This is similar to the near/far problem that occurred mostly in the interleaved channels of the 800 MHz PS/SMR band.

Intermodulation (IM) products can be generated in combiner amplifier devices used for LPAS stations to combine multiple audio recording feeds, and with multiple wireless microphones operating simultaneously at the same venue.⁴ A characteristic of a non-linear amplifier circuit is that its output contains "new" signals in addition to the original signals that were applied to the circuit. These

⁴ For additional information see Appendix A, which is an educational publication from Shure, Inc. that is publicly available on its web site www.shure.com.

additional signals are called IM products and are produced within the circuit components themselves. The frequencies of IM products are mathematically related to the original transmitter frequencies

IM can occur when multiple LPAS transmitters are used in close proximity to each other. The signal from each LPAS transmitter generates IM products in the output stage of the other. These new signals are transmitted along with the original signals and can be picked up by CMRS receivers operating at the corresponding IM frequencies.

IM can also occur when transmitters are operated very close to the CMRS receivers. In this case IM products are generated in the receiver input stage which can interfere with the desired signal or be detected by the receiver if the desired signal (transmitter) is not present.

The use of multiple LPAS devices at concerts, stadiums, and sporting events is well known. Using multiple LPAS devices in a venue can create Intermodulation products transmitting on other channels and thus causing harmful interference to the CMRS or PS receivers.

4 Examples of Actual Interference Occurring in 700 MHz Bands

4.1 Industry Examples

Interference is at least an occasional problem with most types of radio equipment. The effects of interference range from being a minor annoyance to making the wireless system completely unusable. In the typical occurrence, LPAS interference is temporary and/or non-stationary. The interfering device is on/off for short periods of time or moves from place to place as the entertainment moves, therefore the interference can be highly frustrating and difficult to find. There are numerous articles that say that interference can occur, but very few documented cases. This is probably due to the nature of the wireless microphone systems; once the interference is realized, the wireless microphone system relocates to another frequency without the incident being documented by either party.

Interference can occur during large public activities where wireless microphones are used such as professional sports games (NFL, MLB, NHL, NBA, etc...), major city holidays or special parades, park attractions (Disney World, Six Flags Great Adventure), social clubs, Broadway theatre and music concerts. They are not limited to these events mentioned above. These devices are widely available to the general public via the internet; therefore the interference could happen anywhere at anytime. Here are more examples of where interference can occur: weddings, religious gathering, politically gatherings, town activities, museums, auctions, Schools, and Universities.

In one particular instance, the frequency 783.0 MHz was identified by a technician at a major wireless carrier by listening to the audio output. The signal was tracked down to a crew unloading the A/V equipment outside of a Hyatt Hotel. A microphone in the equipment was accidentally left on and was picking up stray sounds like the dogs barking and movement. This is a classic example of the omnipresence of the LPAS interference which is not limited to church services and musical performances, conferences at local hotels and other meeting venues. In this example, the equipment was apparently not based at the hotel and could be used at a different location on the next night. Identifying and stopping this kind of interference will not be easy.

4.2 V-COMM First Hand Experience

V-COMM, L.L.C. has first hand experience with the interference that can occur from LPAS transmissions in the 700 MHz band. While in Las Vegas in 2007, we were testing the operation of a new wideband service in the 700 MHz spectrum for data services.

The system utilized a 700 MHz high powered 2 kilowatt (kW) signal source transmitter located inside the radio room. The source transmitter antennas radiating at 10 kilowatts ERP were located on the roof above the transmitter and radio room. The signal in the radio room was comparatively low since the room was very well shielded from roof transmissions and beneath the beam of the transmitting high-gain narrow vertical beam width antennas.

There was a restaurant/night club below the radio room. Below the restaurant were two luxury suites used to house entertainers during their stay in Vegas. The source of the interference was in-building transmissions from a wireless microphone system in the luxury suite just below the radio room.

The wideband source signal from the commercial transmitter was measured at approximately -70 dBm and the narrowband interferer at -50 dBm using a spectrum analyzer with resolution bandwidth of 300 kHz. The interferer's bandwidth was approximately 150 kHz. Since the interferer was 20 dB higher than the source, it rendered the commercial mobile service incapable of the receiving the transmissions from the roof antenna. A power level of 250 mW is very strong when indoors and closer to mobiles as compared to base stations transmitting outdoors. This is a clear example of the co-channel interference caused by these low power auxiliary devices. In this case, the LPAS devices overpowered and caused interference to commercial mobile devices that were located in the same building of the commercial base station transmitting at 10 kW ERP.

In discussion with radio engineers in the Las Vegas user community, they have identified low power auxiliary devices such as wireless microphones as responsible for many transmission problems for in-building coverage. The LPAS

devices cause increased noise floors, radio desense, radio overload and IM products which result in interference symptoms in the Land Mobile Radio (LMR) and CMRS radio bands. In areas where entertainment venues exist, the LPAS devices can cause major problems and outages for licensed operators.

In another part the United States, we have second hand knowledge of the problems that can be caused with LPAS devices. In a major stadium for concerts, sports and entertainment within the New York/New Jersey metropolitan area the LPAS devices have caused interference problems with dead zones, no service and potential public safety issues on land mobile radio transmissions used for security and event management. Significant interference was identified by public safety personnel at these events occurring from wireless microphones operating in the upper VHF bands.

Clearly, these two services are not compatible in the same bands. The experiences above justify the elimination of the low power auxiliary devices from the 700 MHz spectrum bands.

5 NPRM Issues

5.1 Prohibiting the operation of LPAS in the 700 MHz spectrum after the DTV transition

LPAS devices have the potential to cause substantial harmful interference to new services operating in the 700 MHz bands, which include Public Safety and new CMRS services. These wireless microphones are currently being sold to the general public in today's market via the internet and other retail outlets. The general public is not properly trained to detect, prevent and eliminate interference into CMRS/PS essential services on the same spectrum.

Therefore, V-COMM agrees with the Commission that all LPAS operations cease at the DTV transition date of February 17, 2009. We further agree with the Commission that it is incumbent upon the Commission to take all steps necessary to make this spectrum effectively available both to public safety and commercial licensees at the end of the DTV transition. We demonstrate herein that harmful interference will be caused by the operation of these LPAS operations in the presence of public safety and commercial wireless networks operating in the 700 MHz spectrum, which is the basis for our agreement with the Commission's position in this NPRM.

5.2 Prohibiting the sale, manufacture and import of these devices

The equipment used by new services to occupy the 700 MHz spectrum, both commercial and public safety, is not compatible with LPAS devices and will suffer harmful interference if LPAS services were to continue in the band.

V-COMM, L.L.C. concurs with the position to prohibit the manufacture, import, sale, offer for sale, or shipment of devices that operate as low power auxiliary stations in the 700 MHz band. We also agree that this prohibition, if adopted in this proceeding, should take effect on the date that the revised rules take effect.

5.3 Approach for updating licenses of current licensees

V-COMM agrees with the Commission, for those licensees that have obtained authorizations to operate low power auxiliary stations in spectrum that includes the 700 MHz Band beyond the end of the DTV transition, these licenses should be modified so as not to permit such operations in the 700 MHz Band after February 17, 2009.

Appendix A

Selection and Operation, Wireless Microphone Systems, Educational Publication by Shure, Inc.