Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC

In the Matter of	)	
	)	
Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and	)	ET Docket No. 14-165
	)	
Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap	)	
	)	
Promoting Spectrum Access for Wireless Microphone Operations	)	GN Docket No. 14-166
	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268

COMMENTS OF MOTOROLA SOLUTIONS, INC.

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February 4, 2015

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COMMENTS OF MOTOROLA SOLUTIONS, INC.

Motorola Solutions, Inc. ("MSI") hereby submits these comments in response to the Federal Communications Commission's ("FCC") Notice of Proposed Rulemaking seeking comment on rules for unlicensed operations in the reconstituted TV bands and the repurposed 600 MHz Band after the incentive auction.[1]

I. INTRODUCTION AND SUMMARY

Motorola Solutions, Inc. supports the proposed expansion of unlicensed spectrum for white space devices ("WSDs"), and the expansion of unlicensed device operating rules. The

[1] Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap, ET Docket No. 14-165, *Notice of Proposed Rulemaking*, 29 FCC Rcd 12248 (2014) ("Notice").

FCC should allow WSDs to operate in the guard bands and duplex gap in 600 MHz cellular spectrum, as described below. The FCC also should allow WSDs to operate on channel 37, subject to database protection of wireless medical telemetry services ("WMTS") and radio astronomy services ("RAS") users. MSI further supports the use of higher power WSDs and the allowance of higher WSD antenna heights in rural areas, as the possibility of harmful interference is much lower in those areas. The use of a wider range of potential WSD transmit power levels will increase spectrum opportunities in denser spectral environments, and increase spectrum utilization overall. Several related measures to improve WSD system operation and effectiveness are also discussed below.

II. MOTOROLA SOLUTIONS SUPPORTS DEPLOYMENT OF WSDS THROUGHOUT THE TV BANDS.

MSI supports the Commission's proposed expansion of WSD operations in the TV Bands, 600 MHz Guard Bands, Repurposed 600 MHz bands, and elsewhere, with appropriate safeguards in place. For example, WSDs should be permitted to operate in the lower guard band between DTV and cellular systems, on Channel 37 (subject to database protection of WMTS and the RAS), in the cellular system duplex gap, and on channels 3 and 4, as this will facilitate longer range communications systems for critical infrastructure and utilities. MSI also supports the relaxation of certain WSD operating rules, such as permitting the use of additional WSD power levels (quantized in 4 dB steps) in the database protection computations, to help free up additional unlicensed spectrum opportunities around incumbents in denser spectrum utilization areas. Similarly, MSI supports the increased database query rate of 20 minutes, with slight modifications, as discussed below.

A. WSDs in the TV Bands

1. Permissible Spectrum

The Commission correctly notes the importance of life-safety and other critical communications that take place on Channels 14-20, and these communications should have a mechanism in place to guarantee unplanned protection in an expedient manner, should new WSD operations be authorized. Portable WSD operations might be permissible on Channels 14-20, provided there is a mechanism in place to quickly shut down WSD operations in a geographic area if interference is detected (either by giving the offending WSD(s) a "no-channels available" response from the databases on the affected T-band channel(s) in the channel 14-20 range, or by temporarily prohibiting WSD operations on the affected channel(s) in the channel 14-20 range over a limited geographic area through the databases).[2] Such mechanisms may be necessary due to the portable/mobile nature of WSDs transmitting in the band, and the generally unplanned nature of life-safety communications.[3]

Similar capabilities will need to be developed for other spectrum sharing bands as well (e.g., 3.5 GHz) to protect critical incumbent communications from undue interference in the event of emergencies.[4] The use of a 20 minute TVWS database update rate will help to support these types of uses. Similar to the existing WSD rules, we recommend that WSDs be required to

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[2] This mechanism could be activated by an appropriate authority (e.g., a Part 90 license holder) who observes interference from a WSD. The appropriate authority would notify any of the databases to enact a no-channels available response to the offending WSD(s) over a limited geographic region where the interference event is being observed.

[3] Disaster or incident scenes could occur anywhere within a region. For example, direct mode communications may be utilized by a responding agency near the edge of or even outside of normal T-band operating areas. A mechanism to address these use cases and prevent harmful interference should be present in the WSD database. The proposed increased database update rate will help to ensure timely protection.

[4] Preliminary meetings of the 3.5 GHz Multi-stake Holder (MSH) group have already discussed the need for such functions, to allow critical incumbents to have positive control over interference in their spectrum in emergency situations. Life safety operations in channels 14-20 would have similar requirements.

shut down within two nominal database query cycles if they are unable to access the database. MSI does not support the use of any sensing-only WSDs in channels 14-20, due in part to the difficulty of reliably sensing intermittent LMR communications, as the Commission recognizes.[5] MSI supports portable WSD operations below channel 14, as this may complement fixed device operation in some deployments.

2. Use of Multiple Power Levels

Permitting the use of multiple transmit power levels for WSDs, with appropriately tailored protections, would expand the flexibility of unlicensed use in the band, and will result in higher spectrum utilization efficiency. When queried, the databases should return a maximum allowed WSD equivalent isotropically radiated power ("EIRP") level for a given location (quantized into 4 dB or less steps). Other methods of WSD and database query interaction could also be allowed (*e.g.*, a WSD sending the database its maximum operating transmit power level in a query), and do not need to be restricted by rule, so long as they provide equivalent or better interference protection. Similarly, WSD location accuracy can be expressed at lower levels (*e.g.*, within 300 meters with 95% confidence), and the database can provide equivalent protection by examining nearby WSD operating locations and returning the most conservative WSD operating parameters.[6] WSD location accuracy reporting could be incorporated into the normal database query process. This will help to allow indoor WSD applications where GPS signals may not be available.

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[5] Notice, ¶ 29. Note that usable signal levels for LMR communication systems can be less than -120 dBm, making reliable sensing extremely difficult if not impossible when considering typical RF sensor environmental effects (*e.g.*, localized shadowing, fading, body losses, polarization mismatch, etc.).

[6] In the simplest form, the database could increase the required separation distances by the amount of excess location error over standard WSD equipment (*e.g.*, by 250m for a WSD with 300m location error). The location errors of Mode I WSDs could be addressed in a similar manner (with the excess location error represented by the maximum expected operating range of a Mode I device).

MSI also supports the newly proposed class of 40 mW fixed WSDs, and their allowed operation inside of adjacent channel TV contours. MSI believes, as previously filed, that adjacent channel operation for WSDs could be allowed at higher power levels, especially in areas where incumbent signals are strong, as long as the proper adjacent channel protection ratios are met.[7] The Commission also should move forward with the proposal to allow fixed WSDs to operate at 4W EIRP in areas where two TV channels are vacant (assuming a 3 MHz offset of the WSD signal to center it on the boundary between the vacant channels). The currently proposed WSD transmit spectral mask is very stringent (even much tighter than full power DTV transmitters), and will more than adequately protect incumbent TV transmissions.

3. Antenna Height

As previously articulated, the Commission should allow higher antenna heights above ground level (AGL) for fixed devices, particularly in rural areas with flatter terrain features.[8] Fixed WSD antenna heights AGL up to 75 meters should be allowed. At this time, there is no need to increase the maximum permitted overall WSD antenna height above average terrain (of 250 meters).[9] Higher transmit power levels (*e.g.*, 10 W EIRP, or 40 dBm)[10] also should be

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[7] *See, e.g.*, Motorola, Inc., *TVWS Power Level and Adjacent Channel Protection* 4, Oct. 22, 2008 *attached to* Letter from Robert D. Kubik, Motorola, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 04-186 (filed Oct. 23, 2008) The 2008 analysis based allowed WSD transmit power on predicted TV signal strength for a simple omni-directional TV transmitter in flat terrain. A 33dB adjacent channel interference U/D protection ratio is typically applied for DTV receivers. A more conservative value of 26dB could be applied within contours to maintain some design margin to account for further variance in predicted incumbent signal strength.

[8] See Joint Reply Comments of the Wireless Internet Service Providers Association et al. at 6, ET Docket No. 04-186 (proposing a 75 meter AGL limit with the additional safeguard that the combination of the ground elevation (measured in HAAT) and the antenna height (measured in AGL) does not exceed a 250 meter HAAT).

[9] The sum of WSD antenna height AGL and tower base HAAT would be limited to no more than 250 meters. The maximum WSD antenna height AGL requirement of 75 meters would then be restricted to base sites with an average height above average terrain of 175 meters or less.

allowed in rural areas, with a corresponding increase in the separation distances (computed using the proposed methodology), and without any additional restrictions on adjacent channel operation. MSI supports the definition of rural areas as areas where no more than 50% of the channels are utilized for broadcast services.

4. Power Limits and Spectral Masks

MSI supports an increase in radiated power levels for portable mode II WSDs (to 28-32 dBm EIRP levels) operating in rural areas, as these levels better support high powered user equipment (HPUE) in some popular communications standards, such as in 3GPP LTE systems.[11] The existing tables of separation distances for higher powered WSDs could be applied for this equipment to provide interference protection. Such equipment should be registered in the database, as are other higher power WSDs (*e.g.*, fixed equipment).

Also, modestly relaxing the PSD limits on WSDs (*e.g.*, by 3-6 dB) over the currently proposed levels would expand the range of applications that could be utilized in white space. For example, the use of time-averaging of interfering signal power (*e.g.*, shorter duration transmissions over narrower occupied bandwidths) would be useful for Internet of Things applications.

MSI supports having at least two classes of transmit spectral masks. In addition to the currently proposed transmit spectral mask, a relaxed transmit mask (*e.g.*, approximating a simple low power DTV transmitter mask,[12] or a spectral mask reflecting popular advanced

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[10] An increase to 75 meters AGL (from 30 meters in flat terrain), and an increase to 10 W EIRP (from 4 W EIRP) in rural areas would approximately double the expected fixed WSD system communication range, greatly improving overall coverage and efficiency.

[11] *See, e.g.*, UE Power Class 1, Table 6.2.2-1 in 3GPP TS 36.101 V12.3.0 (2014-03). MSI would expect HPUE equipment to always have geo-locating capability (as Mode II WSDs require), and would typically be operated with antenna heights of less than 3 meters.

[12] The low power DTV mask is essentially described in Section 74.794(a)(2)(i) of the Commission's rules. 47 C.F.R. § 74.794(a)(2)(i). For a detailed discussion of transmit spectral

communications standards equipment such as 3GPP LTE[13]) should be allowed. The database can be used to enforce the increased separation distances required to maintain equivalent protection to all incumbents. This approach is similar to the method that OfCom has proposed in the UK, which supports several different classes of equipment.[14] The method can be simplified by limiting the number of acceptable transmit masks to two or three possibilities. The current WSD transmit spectral mask has been a significant cost-adder in currently available WSD equipment. The overall goal of providing relaxed transmit masks is to reduce device cost, and make the technology more competitive in the marketplace, while still protecting incumbents. The database can readily store the transmit spectral mask information for WSD equipment in a variety of possible ways, including linking the FCC ID of the equipment to a particular transmit mask,[15] storing the mask information during registration, or gathering the mask information during a database query.[16] MSI also supports the proposed modification of the transmit spectral mask (Section 15.709(c)(2)) when channel aggregation or bonding is utilized.

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mask consideration, *see Motorola Whitepaper: Recommendations on Cognitive Radio (CR) Operations in TV White Spaces* 23-28, *attached to* Letter from Steve Sharkey to Julius Knapp, Federal Communications Commission, ET Docket No. 04-186 (filed Oct. 18, 2007).

[13] *See* General E-UTRA Spectrum Emission Mask, Table 6.6.2.1.1-1, 3GPP TS 36.101 V12.3.0 (2014-03). In addition, a slight reduction in transmit power level may be necessary for WSD operation inside of adjacent channel contours.

[14] *See White Space Devices (WSD): Wireless Access Systems operating in the 470 MHz to the 790 MHz TV broadcast band*, Section 4.2.4.2, ETSI EN 301 598 V1.0.9 (2014-02), which supports approximately a 30 dB range of adjacent channel leakage ratio (ACLR, for n±1) over 5 classes of WSDs.

[15] Note that WSD equipment is already required to provide an FCC ID during normal database interaction. 47 C.F.R. § 15.713.

[16] This type of query would typically only need to occur once, however, the information could also be sent by WSDs during every database query to eliminate the need for the database to store the information. For the earlier described methods, we recommend that portable WSDs register in the database.

5. Propagation Models and Antenna Directivity in the Geo-Location Database

MSI generally supports the use of more detailed propagation models in the geo-location databases, including those incorporating terrain effects, to more accurately model signal propagation. Similarly WSD directional antenna pattern information should be permitted in the database. This information could be provided in 10 degree increments, and linearly interpolated by database providers, should they choose to support those functions. Databases are capable of computing radiated power in several directions towards a protected contour (*e.g.*, along an arc), and can ensure that the required co-channel and adjacent channel protection ratios are met for an incumbent by using an approved propagation model.[17] In a manner somewhat similar to the WSD transmit mask information (detailed above), WSDs could provide antenna pattern information to the database as part of registration (*e.g.*, by a professional installer of fixed WSDs), or as part of the normal database-device interaction process.

B. WSDs in the 600 MHz Guard Bands

MSI supports the use of the 600 MHz guard bands and duplex gap for WSD operations. As the Commission proposes, the database is capable of protecting other services that operate in the band (including WMTS and RAS on channel 37, as well as cellular base stations and handsets on other channels). Mode I portable WSDs should also be allowed to operate on these frequencies, with the appropriate adjustments to their location accuracy, as described above.[18] We support the use of WSD power levels up to 100 mW in the lower guard band (for the 11 MHz and 9 MHz lower guard band options), as long as at least a 3 MHz frequency separation is

[17] As an alternative to the described method, the databases could quantize the radiated power levels in each direction into the same categories as the proposed co- and adjacent channel protection tables (*e.g.*, 36dBm, 32dBm, 28dBm, …), and enforce the pre-computed required minimum separation distances from protected services in each those directions.

[18] *See supra* n. 6.

maintained from downlink (handset) receivers. The occupied signal bandwidth for a standard 802.11af signal in the US is about 4.75 MHz, giving roughly 2 MHz of guard band even for the 7 MHz lower guard band case. Normal use of white space in areas where cellular services are not yet deployed should be permitted, assuming that minimum reasonable separation distances are met. The database is more than capable of protecting cellular users through similar measures as utilized with other incumbents.

C. WSDs and Wireless Microphones in the Duplex Gap

MSI supports having one 6 MHz WSD channel available in the 11 MHz duplex gap, though the wireless microphone allocation in the duplex gap should be limited to 3 MHz, to enable a 1 MHz guard band at the upper end of the duplex gap (between the WSD transmit and base station receive band). Higher spectral efficiency wireless microphones, with improved transmit spectral masks, will be able to operate with more usable channels in the allocated microphone spectrum. The entire ETSI mask is appropriate for unlicensed and Part 74 wireless microphones that operate in the TV bands. Unlicensed wireless microphone transmitter output power level should be limited to 50 mW or less (within the maximum 200 KHz bandwidth) outside of the guard bands, to help limit the impact of interference to other services. Within the guard bands, wireless microphone output power levels should be limited to 10 mW or less, to help reduce the disparity with WSDs.

Wireless microphone operations should not be permitted on channels 14-20. Such transmitters have been difficult to control or police in the past, and do not generally access the database. As such, they could threaten public-safety and life-safety communications that take place in channels 14-20. Moreover, low and high band VHF frequencies (channels 2-13) are not particularly well suited or appropriate for wireless microphone use. Unlicensed wireless

microphones should be required, however, to meet other Part 74 operating specifications (*e.g.*, frequency tolerance over temperature, channelization, etc.), as proposed.

D. Channel 37

Portable WSDs should be allowed to operate on channel 37, up to 100 mW, provided that they obey the required database protections. Fixed device operation should also be allowed,[19] as long as they meet minimum separation distances from WMTS and RAS users. MSI supports registering the perimeter of a hospital facility or campus in order to provide database protection. The FCC should not consider blanket exclusion zones in urban areas for WMTS protection, as they are wasteful of valuable spectrum. Once again, mode I portable WSDs should be allowed to operate with increased separation distances over the proposed distances (increased by a maximum expected communications range to a master WSD).[20]

Regarding the proposed RAS separation distances for channel 37, protection (*i.e.*, maximum separation distances) should be limited to a maximum of roughly the radio horizon (of about 85 km).[21] MSI notes that the typical antenna pointing angles have not been taken into account in the analysis, and are typically 10 degrees or more above the horizon. Other propagation models (*e.g.*, TM91-1) may also be suitable for computing protection distances, and even conservative for these applications, since a large amount of ground clutter is expected. The

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[19] This would preferably include the use of higher powered WSDs in rural areas, as previously discussed. The minimum required separation distances could be increased by the database to accommodate the higher transmit power levels. Fixed WSDs could be allowed to operate centered on the upper edge of channel 37 in cases where an additional 3 MHz upper guard band is present on channel 37, even if a TV transmitter is operating on adjacent channel 36, as proposed in other rule parts.

[20] Note that the maximum expected communications range could be estimated for a typical modern communications system (*e.g.*, 3GPP LTE) based on the master WSD transmit power level and antenna height, thus requiring no special user inputs to the database for mode I WSD operation.

[21] A typical RAS antenna height of 30 meters more accurately reflects actual operation (and hence reduces the required protected areas).

current WSD rules for adjacent channel operation (on channels 36 and 38) are adequate (*i.e.*, the 2.4 km required separation distance). MSI also supports the removal of the channel 36 and 38 out-of-band emissions limits, as proposed.

E. WSDs in the Repurposed 600 MHz Band

All classes of WSDs (*i.e.*, full-power fixed, portable mode I and II devices) should be permitted to operate in un-utilized 600 MHz cellular spectrum. We believe that using polygons to specify cellular base station deployments as proposed is a reasonable approach to providing baseline protection. There should be no restrictions to having a reasonable number of points used for the base site protection polygon. MSI notes however that typical cellular deployments rarely exceed 15 km usable cell range in practice, and the proposed minimum separation distances (*e.g.*, co-channel WSD to handset distances) should be adjusted accordingly.[22] As an alternative, the maximum cell range of the outer edge of the cellular base station deployment could be additionally specified and input into the database, to more efficiently utilize spectrum. By taking into account the actual overlap of a WSD signal with a cellular signal, the resulting interference could be reduced by as much as 7 dB.[23] The database could easily take these effects into account to reduce the required separation distances. Environmental noise will likely reduce sensitivity by at least 3 dB (even at the outer edges of cellular coverage areas), not to mention

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[22] The 1710 MHz rural cellular inter-site distance (ISD) of 7 km in the cited CSMAC report corresponds to roughly a 5 km maximum effective cell range for a typical deployment scenario. The estimated 6 dB decrease in path loss (to account for the propagation differences at 600MHz) would result in approximately a 50% increase in cell range to about 7.5 km for a typical 3.6 path loss exponent. Even with a 9 dB improvement in path loss at 600MHz and square law propagation, the resulting cell range would be less than a 15 km. Thus, the maximum co-channel WSD-to-handset separation distance should be no more than 19.2 km. Antenna gain is likely to go down at the lower frequencies as well.

[23] The 7 dB difference represents the decrease by going from a 5/6 overlap (i.e., 5 MHz overlap of cellular and WSD signals) to a 1/6 overlap (*i.e.*, 1 MHz overlap of the cellular and WSD signals), depending on the relative frequencies of the WSD and 5 MHz cellular signal. A 7 dB decrease in interference would result in approximately a 48% reduction in the required exclusion zone with a 2.5 path loss exponent (*e.g.*, in relatively open areas, as might be expected near the edge of a typical cellular service deployment).

LTE system interference over thermal (IoT) from neighboring cell sites in the inner areas of a cellular deployment. These effects could serve to further reduce the required separation distances. For purposes of computing the required separation distances to cellular handsets, the integrated antennas in cellular handsets typically have antenna gains on the order of -10 dBi, making usable cellular signals that much higher in practice. Finally, an important point to remember is that database protection is essentially dynamic, and can be readily changed once the system is fielded. This could occur either through a software update of the separation distance tables in the database, or an adjustment of the cellular base site deployment polygon (which requires no adjustments to database software). This can be utilized to ensure non-interference in real-world deployments in a timely manner.

III. CONCLUSION

MSI supports the FCC's examination of how to more efficiently utilize WSDs in the 600 MHz band. MSI agrees with the proposals to expand the spectrum available to WSDs and to loosen restrictions on their operations, provided appropriate protections are maintained, including for critical safety of life services operating in the band. The Commission should move forward on the proposal in the Notice, with the modifications and clarifications discussed above.

Respectfully submitted,

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February 4, 2015