

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
)	
Unlicensed Operation in the TV Broadcast Bands)	ET Docket No. 04-186
)	
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band)	ET Docket No. 02-380
)	

**SECOND REPORT AND ORDER AND
MEMORANDUM OPINION AND ORDER**

Adopted: November 4, 2008

Released: November 14, 2008

By the Commission: Chairman Martin, and Commissioners Copps, Adelstein, and McDowell issuing separate statements; Commissioner Tate approving in part, dissenting in part and issuing a statement.

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I. EXECUTIVE SUMMARY

1. In this Second Report and Order, we adopt rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services (this unused TV spectrum is often termed “white spaces”). This action will make a significant amount of spectrum available for new and innovative products and services, including broadband data and other services for businesses and consumers. The actions we take here are a conservative first step that includes many safeguards to prevent harmful interference to incumbent communications services. Moreover, the Commission will closely oversee the development and introduction of these devices to the market and will take whatever actions may be necessary to avoid, and if necessary correct, any interference that may occur. Further, we will consider in the future any changes to the rules that may be appropriate to provide greater flexibility for development of this technology and better protect against harmful interference to incumbent communications services. Briefly, the rules we are adopting provide for the following capabilities and safeguards:

- We are providing for both fixed and personal/portable devices to operate in the TV white spaces on an unlicensed basis.
- All devices, except personal/portable devices operating in client mode, must include a geolocation capability and provisions to access over the Internet a database of protected radio services and the locations and channels that may be used by the unlicensed devices at each location. The unlicensed devices must first access the database to obtain a list of the permitted channels before operating.
- The database will be established and administered by a third party, or parties, to be selected through a public notice process to solicit interested parties.
- Fixed devices may operate on any channel between 2 and 51, except channels 3, 4 and 37, and subject to a number of other conditions such as a restriction against co-channel operation or operation adjacent TV channels pending consideration of further information that may be submitted into the record in this proceeding. Fixed devices may operate at up to 4 Watts EIRP (effective isotropic radiated power).
- Personal portable devices may operate on any unoccupied channel between 21 and 51, except channel 37. Personal portable devices may operate at up to 100 milliwatts of power, except that operation on adjacent channels will be limited to 40 milliwatts.
- Fixed and personal/portable devices must also have a capability to sense TV broadcasting and wireless microphone signals as a further means to minimize potential interference. However, for TV broadcasting the database will be the controlling mechanism.
- Wireless microphones will be protected in a variety of ways. The locations where wireless microphones are used, such as entertainment venues and for sporting events, can be registered in the database and will be protected as for other services. In addition, channels from 2 – 20 will be restricted to fixed devices, and we anticipate that many of these channels will remain available for wireless microphones that operate on an itinerant basis. In addition, in 13 major markets where certain channels between 14 and 20 are used for land mobile operations, we will leave 2 channels between 21 and 51 free of new unlicensed devices and therefore available for wireless microphones. Finally, as noted above, we have required that devices

also include the ability to listen to the airwaves to sense wireless microphones as an additional measure of protection for these devices.

- Devices must adhere to certain rules to further mitigate the potential interference and to help remedy potential interference should it occur. For example, all fixed devices must register their locations in the database. In addition, fixed devices must transmit identifying information to make it easier to identify them if they are found to interfere. Furthermore, fixed and personal/portable devices operating independently must provide identifying information to the TV bands database. All devices must include adaptable power control so that they use the minimum power necessary to accomplish communications.
- All white space devices are subject to equipment certification by the FCC Laboratory. The Laboratory will request samples of the devices for testing to ensure that they meet all the pertinent requirements.
- We will permit applications for certification of devices that do not include the geolocation and database access capabilities, and instead rely on spectrum sensing to avoid causing harmful interference, subject to a much more rigorous set of tests by our Laboratory in a process that will be open to the public. These tests will include both laboratory and field tests to fully ensure that such devices meet a “Proof of Performance” standard that they will not cause harmful interference. Under this procedure the Commission will issue a Public Notice seeking comment on the application, as well as test procedures and methodologies. The Commission will also issue a Public Notice seeking comment on its recommendations. The decision to grant such an application will then be made at the Commission level.
- The Commission will act promptly to remove any equipment found to be causing harmful interference from the market and will require the responsible parties to take appropriate actions to remedy any interference that may occur.

II. INTRODUCTION

2. In this Second Report and Order, we adopt rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services (this unused TV spectrum is often termed “white spaces”). This action will open for use a significant amount of spectrum with very desirable propagation characteristics that has heretofore lain fallow. These new rules will allow the development of new and innovative types of unlicensed devices that provide broadband data and other services for businesses and consumers without disrupting the incumbent television and other authorized services that operate in the TV bands. In addition, because transmissions on frequencies in the TV bands are less subject to propagation losses than transmissions in the spectrum bands where existing low power broadband unlicensed operations are permitted, *i.e.*, the 2.4 GHz and 5 GHz bands, we anticipate that allowing unlicensed operation in the TV bands will benefit wireless internet service providers (WISPs) by extending the service range of their operations. This will allow wireless broadband providers that use unlicensed devices to reach new customers and to extend and improve their services in rural areas. We anticipate that allowing use of the TV white spaces by unlicensed devices will have significant benefits for both businesses and consumers and thereby promote more efficient and effective use of the TV spectrum.

3. The plan we are adopting will allow both fixed and personal/portable unlicensed devices to operate on unused television channels in locations where such operations will not result in harmful interference to TV services (including reception by cable headends and low power TV stations, *i.e.*, TV translator, low power TV, TV booster, and Class A TV stations) and other services that use the TV

bands.¹ We recognize the importance of protecting licensed services from harmful interference and the novel challenges involved in reliably identifying unused TV channels. We therefore are taking a cautious and conservative approach in this plan, balancing the need to provide sufficient opportunities for proponents to develop viable unlicensed TV band devices (TVBDs) with measures to ensure that such devices fully protect the important licensed services that operate in the TV bands. In allowing the introduction of unlicensed TVBDs, we also believe it is important to avoid the possibility of disrupting or causing uncertainty in the DTV transition, the current ongoing process whereby TV stations are changing from analog to digital (DTV) operation. As set forth in the *First Report and Order and Further Notice of Proposed Rulemaking (First R&O/Further Notice)* in this proceeding, we have addressed this concern with regard to the DTV transition by restricting the marketing of unlicensed TVBDs until February 18, 2009, the date when the DTV transition will end and all full-power TV stations will be operating on a single channel, and only with digital signals.²

4. We anticipate that the capabilities of products for operating in this spectrum will develop and evolve over time and that much will be learned about the potential for unlicensed TVBDs to cause interference to licensed services and how to avoid that interference. We may therefore need to revisit these rules to make adjustments both to provide more flexibility for unlicensed devices and to refine the protections for licensed services. Consistent with our objective to allow unlicensed TVBDs to operate with the most flexibility and capabilities possible consistent with protection of licensed services, we are directing our staff to conduct a review and report to the Commission in two years from the date of this Second Report and Order on the state of these devices, including the types of devices on the market, the extent of their implementation, technical developments, any interference problems that may have arisen, and aspects of the rules that should be altered to increase features and opportunities for use or to address conflicts.

5. We are also denying all aspects of a petition for reconsideration submitted by the New America Foundation and the Champaign Urbana Wireless Network (NAF/CUWN).³ In particular, we are denying their request that we 1) not re-open the issue of whether to permit new uses of the TV bands on a licensed or unlicensed basis; 2) allow personal/portable devices on channels 14-20; and 3) allow marketing of new unlicensed TV band devices prior to the end of the DTV transition.

6. *Overview of Rules for Unlicensed TV Band Devices.* The new rules provide for operation of two types of unlicensed TVBDs that may provide broadband data and other types of communications services: 1) fixed devices, which will operate from a fixed location with relatively higher power and could be used to provide a variety of services including wireless broadband access in urban and rural areas, and 2) personal/portable devices, which will use lower power and could, for example, take the form

¹ As discussed below, the TV spectrum is also used on a licensed basis by wireless microphone, private land mobile radio, commercial mobile radio, broadcast auxiliary, off-shore radio, and radio astronomy operations. TV translators are low power TV stations that receive a signal from a full service TV station on one channel and retransmit that signal on a different channel in an area where the full service TV station is not normally received. Low power TV stations operate similar to TV translators and may retransmit the signals of a full service TV station and also originate programming. TV booster stations also operate similar to TV translators but transmit on the same channel as their full service station and within the service area of that full service station. Class A stations operate under technical rules similar to low power TV and TV translator stations but are subject to certain minimum operating requirements for service hours and locally originated programming.

² See *First Report and Order and Further Notice of Proposed Rule Making* in ET Docket Nos. 02-380 and 04-186, 21 FCC Rcd 12266 (2006).

³ See Petition for Reconsideration of the *First R&O/Further Notice* submitted by the NAF and the Champaign Urbana Wireless Network, December 18, 2006.

of devices such as Wi-Fi-like cards in laptop computers or wireless in-home local area networks (LANs). In order to operate without causing interference to licensed services, both types of devices will be required to be able to reliably determine which channels are occupied by licensed operations at their location at any given time and to avoid interfering with services on those channels using the following methods. Devices will be required to identify unused channels as follows:

- a) A fixed device must employ both geo-location/database access and spectrum sensing capabilities that enable the device to listen for and identify the presence of signals from other transmitters;
- b) A personal/portable device must either 1) be under the control of a fixed device or a personal/portable device that employs geolocation/database access and spectrum sensing or 2) employ geo-location/database access and spectrum sensing itself.

7. In addition, we are adopting rules that will allow for certification of personal/portable devices that do not include geo-location and database access capabilities and are not controlled by another device but rather determine available channels using spectrum sensing, perhaps in combination with some other techniques. These devices will be required to meet a “proof of performance” standard that they will not cause harmful interference to incumbent radio services. Such devices will be subject to all of the other requirements for personal/portable devices but would be limited to 50 milliwatts (mW) EIRP rather than the 100 mW authorized for personal/portable devices for which available channels are determined based on the geolocation and database method. The certification process will require submittal of a sample for testing in our laboratory and in the field similar to the process that the FCC Laboratory followed for testing of TV band devices. The sample device must be a fully functioning pre-production prototype, identical to the device that will be marketed except for cosmetics. The testing will be open to the public. The application must also show how the device will protect the various incumbent radio services discussed herein. The determination of whether to certify the device will be based on a demonstrated ability to avoid causing harmful interference with an extremely high degree of reliability. If the device is certificated, we will permit routine certification of other devices that have identical characteristics (i.e., have the identical electrical characteristics and antenna system.). We will endeavor to complete the certification process within 180 days of submittal of the device for testing, barring any unforeseen circumstances.

8. *Fixed Devices.* Fixed devices will be allowed to communicate with other fixed devices and with personal portable devices. These devices will be required to determine their geographic location through an incorporated geo-location capability or from a professional installer and to access and register with a database system that contains records of protected services and receive back either a list of the available channels at their location or information on the channels used in their area from which they can determine a list of available channels. In addition, fixed devices will be required to operate with antennas mounted outdoors and to use spectrum sensing to identify any wireless microphone operations and any other protected signals that might be present at their location but do not appear in the database. These devices will be required to sense, at levels as low as -114 dBm, TV signals (digital and analog), wireless microphone signals, and signals of other services that operate in the TV bands on intermittent basis. Fixed devices will be allowed to operate at up to 1 watt (W) transmitter output power and with a gain antenna to achieve 4 W equivalent isotropically radiated power (EIRP), and to communicate with other fixed devices and personal/portable devices, except that they may not communicate with personal/portable devices when operating on channels in the range 2-20. This plan for fixed devices is similar to the provisions of the draft standard for TVBDs under consideration by IEEE 802.22.⁴

⁴ See IEEE 802.22/D0.2 “Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in (continued....)”

9. *Personal/portable Devices.* Personal/portable devices will be allowed to communicate with fixed devices and with other personal/portable devices. These devices will be allowed to operate in two different modes: 1) Mode I - client, whereby a personal/portable device is controlled by a fixed or a personal/portable device operating in Mode II that has determined the available channels in the area and/or 2) Mode II - independent, whereby a personal/portable device determines the available channels using its own internal geo-location/database access capabilities. Personal/portable operations will be permitted at up to 100 mW EIRP, with no antenna gain, except that when operating on a channel adjacent to a TV station or other licensed station/service and within the protected coverage area of that service, operations will be limited to 40 milliwatts. A device operating in Mode II using its own internal geo-location and database access capabilities will be allowed to communicate with other personal/portable devices and function as the master device in a master/client link with another personal/portable device. Devices operating in either mode will be required to sense TV signals, wireless microphone signals, and signals of other services that operate in the TV bands, including those that operate on intermittent basis, at levels as low as -114 dBm. Personal portable devices will not be required to register with the database system.

10. *All Devices.* All unlicensed TV band fixed and personal/portable TV band devices will be permitted to operate on TV channels 21-51, excluding channel 37. In addition, fixed TVBDs that only communicate with other fixed TVBDs will be permitted to operate on channels 2 and 5-20, except that they must avoid operation on channels used by private land mobile radio service (PLMRS), *i.e.*, public safety, and commercial mobile radio service operations on channels in certain markets and areas adjacent to them. Also, in individual markets where there are Private Land Mobile Radio Service or Commercial Mobile Radio Service (PLMRS/CMRS) operations on channels 14-20, two channels in the range 21-51 will be reserved for operation by wireless microphones such that TVBDs will not be permitted on those channels. This plan for channel use is consistent with the requests of the various white space proponents and would reserve channels for a “safe harbor” for operation of wireless microphones and ensure protection of the public safety and other land mobile services that use channels 14-20. At this time, we are only permitting fixed TVBDs to operate on channels not that are not immediately next to (first adjacent on either side of) the channel of a TV station; personal portable devices will be allowed to operate on first adjacent channels to a TV station subject to the power limitation indicated above. All unlicensed TV band devices will be required to limit their out-of-band emissions in the first adjacent channel to a level 55 dB below the power level in the channel they occupy, as measured in a 100 kHz bandwidth. In addition, all TVBDs will be required to comply with a more stringent out-of-band emissions band at the edges of channels 36 and 38 that are adjacent to channel 37 in order to protect medical telemetry devices on that channel 37. Fixed devices will also be required to periodically transmit a signal with their identification when they are operating. This will facilitate identification of sources of interference. The database system for fixed stations and personal/portable devices with geo-location and database access capability will be managed by a database manager or managers selected by our Office of Engineering and Technology. The specific provisions of this plan are presented below.

III. BACKGROUND

11. The Commission provides for the operation of unlicensed radio transmitters in Part 15 of its rules.⁵ Under these rules, unlicensed devices generally operate on frequencies shared with authorized

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the TV Bands,” prepared by the IEEE 802.22 Working Group of the LAN/MAN Standards Committee, November 2006. We note, however, that the IEEE 802.22 plan does not provide for fixed devices to communicate with personal/portable devices on a master/client basis.

⁵ See 47 C.F.R. Part 15.

services and at relatively low power, *i.e.*, at power levels 1 W or less. Operation under Part 15 is subject to the condition that a device does not cause harmful interference to authorized services, and that it must accept any interference received.⁶ The current Part 15 rules provide substantial flexibility in the types of unlicensed devices that can be operated, but prohibit the operation of unlicensed devices on certain frequencies, including the bands used for broadcast television service.⁷

12. The broadcast television service operates under Part 73 of the rules. TV stations operate on six-megahertz channels designated channels 2 to 69 in four bands of frequencies in the VHF and UHF regions of the radio spectrum (54-72 MHz, 76-88 MHz, 174-216 MHz and 470-806 MHz).⁸ As noted above, television stations are now in the process of converting from analog to digital transmissions.⁹ During the transition to digital transmissions, each full service television station that was authorized before 1997 is required to broadcast on two channels, one digital and one analog.¹⁰ At the end of the transition on February 17, 2009, each full service TV station must cease analog operation and operate on a single digital channel.¹¹ Because the new digital TV transmission system is more spectrally efficient than the analog TV transmission system, the Commission has relaxed some of the current analog TV channel separation requirements for digital operation and has eliminated others. Consequently, it has been able to accommodate all existing television stations with channels for post-transition operation in less spectrum. The Commission has specified that digital television stations will operate only on channels 2-51 after the transition and has reallocated television channels 52-69 for other uses.¹²

13. To avoid interference between TV stations, stations on the same and adjacent channels (and in the case of analog TV service certain other channel relationships) must comply with minimum

⁶ See 47 C.F.R. § 15.5.

⁷ See 47 C.F.R. §§ 15.205 and 15.209. Section 15.205 sets forth the restricted bands for operation where unlicensed intentional radiators are not allowed to operate. Section 15.209 provides the general radiated emission limits that apply to intentional radiators, including limits on their out-of-band emissions. Remote control and medical telemetry devices are the only unlicensed transmitters that are currently permitted to operate in the TV bands. See 47 C.F.R. §§ 15.231, 15.241 and 15.242.

⁸ See 47 C.F.R. § 73.603(a). After February 17, 2009, only low power television stations will be permitted to operate on channels 52-69.

⁹ See for example, *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket 87-268, *Sixth Report and Order*, 12 FCC Rcd 14588 (1997).

¹⁰ The analog and digital TV channels currently used by full service TV stations are set forth in Sections 73.606 and 73.622 of the rules, respectively, see 47 C.F.R. §§ 73.606 and 73.622. In developing the initial Table of Allotments for stations' digital TV operations, the channels were selected to minimize or prevent interference between digital stations and between analog and digital stations. Requests for modification of stations on channels in the initial (1998) DTV Table of Allotments are evaluated for technical acceptability using minimum desired-to-undesired (D/U) signal ratios, see 47 C.F.R. § 73.623(c). New digital allotments added after the initial digital TV Table of Allotments must meet minimum separation distances to both digital and analog TV stations, see 47 C.F.R. § 73.623(d). The Commission has issued a *Report and Order* in the third DTV periodic review in which it, *inter alia*, modified the technical standards for new stations and modifications of digital and analog stations to prepare for stations' final conversion to all digital operation, see *Report and Order* in MB Docket No. 07-91,23 FCC Rcd 2994 (2007).

¹¹ See Title III of the Deficit Reduction Act of 2005, Pub. L. 109-171, 120 Stat. 4, 21 (Feb. 8, 2006).

¹² See *Sixth Report and Order* in MM Docket No. 87-268, *supra*; see also, *First Report and Order* in WT Docket No. 99-168, 15 FCC Rcd 476 (2000), *Report and Order* in ET Docket No. 97-157, 12 FCC Rcd 22953 (1998) and *Report and Order* in GN Docket No. 01-74, 17 FCC Rcd 1022 (2002).

separation distance requirements and other technical provisions.¹³ As a result of these provisions, there are geographic areas between the stations on any given channel in local areas where TV service is not available. There are typically a number of TV channels in a given geographic area that are not being used by full service digital TV stations because such stations would not be able to operate without causing interference to co-channel or adjacent channel stations. The minimum separation distances (spacings) between stations are based on the assumption that the stations will operate at the maximum permitted antenna height and power.¹⁴ However, a transmitter operating on a vacant TV channel, *e.g.*, a channel not used by a high power TV station in a given geographic area due to interference concerns, at a lower antenna height and/or power level than a TV station operating at the maximum allowed facilities would not need as great a separation distance from co-channel and adjacent channel TV stations to avoid causing interference to such stations. Also, in some areas channels that could be used by a full service television station simply are not being used. This situation will remain after the transition.

14. In addition to full service TV stations operating under Part 73 of the rules, certain other licensed services are permitted to operate on TV channels. Class A television stations operate under Subpart J of Part 73 of the rules.¹⁵ Low power TV, TV translator and TV booster stations are permitted to operate under Part 74 of the rules on a secondary basis to full service TV stations and on an equal basis with Class A TV stations, provided they meet technical rules to prevent interference to reception of such stations.¹⁶ Part 74 also permits certain broadcast auxiliary operations on TV channels 14-69 on a secondary basis.¹⁷ In addition, Part 74 permits certain entities to operate wireless microphones on vacant TV channels on a non-interference basis.¹⁸

15. Further, in 13 metropolitan areas, one to three channels in the range of channels 14-20 are used by licensees in the Private Land Mobile Radio Service under Part 90 of the rules and the Commercial Mobile Radio Service under Part 20 of the rules.¹⁹ In addition, medical telemetry equipment is permitted to operate on an unlicensed basis on any vacant TV channels in the range of channels 7-46, and unlicensed remote control devices are allowed to operate on any TV channels above 70 MHz (*i.e.*, above channel 4), except for channel 37.²⁰ TV channel 37 (608-614 MHz) is allocated for radio

¹³ See 47 C.F.R. §§ 73.610, 622, 623, and 699.

¹⁴ The separations differ depending on the zone where the stations are located and whether the stations are in the VHF or UHF band. See 47 C.F.R. § 73.623(d).

¹⁵ See 47 C.F.R. Part 73 Subpart J. Class A TV stations operate at the power levels permitted for low power television stations under Part 74 of the rules, but have certain protection rights with respect to full service analog and digital TV stations that are not available to TV translator and low power stations.

¹⁶ See 47 C.F.R. Part 74 Subpart G.

¹⁷ See 47 C.F.R. § 74.602(h). This rule section permits TV studio-transmitter links, TV relay stations, and TV translator relay stations to be authorized to operate fixed point-to-point service on UHF TV channels 14-69 on a secondary basis, subject to the provisions in Part 74, subpart G.

¹⁸ See 47 C.F.R. § 74.861.

¹⁹ See 47 C.F.R. Part 90 Subpart L and 47 C.F.R. Part 22 Subpart E.

²⁰ See 47 C.F.R. §§ 15.231, 15.241 and 15.242. Effective October 16, 2002, the Commission ceased granting certifications for new medical telemetry equipment that operates on TV channels, but there is no cutoff on the sale or use of equipment that was certified before that date, *see* 47 C.F.R. § 15.37(i). To provide spectrum for wireless medical telemetry equipment, the Commission established the Wireless Medical Telemetry Service to operate on a primary basis in 13.5 megahertz of spectrum in three spectrum blocks at 608-614 MHz (TV channel 37, which the WMTS now shares with radio astronomy), 1395-1400 MHz, and 1427-1429.5 MHz. See Amendment of Parts 2 and 95 of the Commission's Rules to Create A Wireless Medical Telemetry Service, *Report and Order*, ET Docket No. (continued....)

astronomy and the wireless medical telemetry service (WMTS) and is not used for TV broadcasting. The Offshore Radiotelephone Service uses channels 15-17 in certain regions along the Gulf of Mexico.²¹ In Hawaii, channel 17 is reserved for inter-island communications.²² However, no active licensees currently use this channel in Hawaii, so we will not provide for protection of inter-island communications operations on channel 17 there unless or until an inter-island communications system is activated in that state.

16. On May 13, 2004, the Commission adopted a *Notice of Proposed Rule Making (Notice)* in this proceeding in which it proposed to allow unlicensed operation in the TV bands at locations where frequencies are not in use by licensed services.²³ To ensure that no harmful interference will occur to TV stations and other authorized users of the spectrum, the Commission proposed to define the conditions under which a TV channel is unused and to require unlicensed devices to incorporate “smart radio” features to identify the unused TV channels in the area where they are located. For the purpose of minimizing interference, the Commission proposed to classify unlicensed TVBDs in two general functional categories. The first category would consist of lower power “personal/portable” unlicensed devices, such as Wi-Fi-like cards in laptop computers or wireless in-home local area networks (LANs). The second category would consist of higher power “fixed” unlicensed devices that would operate from a fixed location and could be used to provide commercial services such as wireless broadband Internet access. The Commission proposed to require that fixed devices incorporate a geo-location method such as a Global Positioning System (GPS) receiver or be professionally installed, and that they access a database system to identify vacant channels at their location. It further proposed to require that personal/portable devices operate only when they receive a control signal from a source such as a TV station or FM radio station that identifies the vacant TV channels in that particular area. The Commission also sought comment on the use of spectrum sensing to identify vacant TV channels, but did not propose any specific technical criteria for spectrum sensing.

17. The comments received in response to the *Notice* were divided between the prospective manufacturers and users of unlicensed devices who believe adequate safeguards can be put in place to prevent harmful interference to authorized services, and the existing users of the TV bands who are concerned about potential interference. A number of broadband equipment manufacturers, trade associations and other parties supported allowing unlicensed operation in the TV bands. These parties generally stated that unlicensed devices could operate in the TV bands without causing interference to authorized services. They further stated that allowing such operation in the TV bands could improve access to broadband communications by taking advantage of the favorable propagation characteristics of the TV spectrum and that this would result in more efficient use of this spectrum.²⁴

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99-255, 15 FCC Rcd 11206 (2000). *See also*, Amendments to Parts 1, 2, 27, and 90 of the Commission's Rules to License Services in the 216-220 MHz, 1390-1395 MHz, 1427-1429 MHz, 1429-1432 MHz, 1432-1435 MHz, 1670-1675 MHz, and 2385-2390 MHz Government Transfer Bands, WT Docket No. 02-8, *Memorandum Opinion and Order*, 18 FCC Rcd 16920 (2003).

²¹ See 47 C.F.R. § 2.106 NG66(b) and 47 C.F.R. § 22.1007.

²² See 47 C.F.R. § 22.591.

²³ See *Notice of Proposed Rule Making* in ET Docket Nos. 02-380 and 04-186, 19 FCC Rcd 10018 (2004).

²⁴ See Intel *Notice* comments at 2, Microsoft *Notice* comments at 3, Consumer Electronics Association (CEA) *Notice* reply comments at 3, Motorola *Notice* comments at 1, Telecommunications Industry Association (TIA) *Notice* comments at 4, IEEE 802 *Notice* comments at 4, NAF *Notice* comments at 1, and Wireless Internet Service Provider's Association (WISPA) *Notice* comments at 4.

18. Full service and low power TV broadcasters generally opposed allowing unlicensed operation in the TV bands, expressing concern that unlicensed devices operating under the proposed rules would cause interference to TV reception, particularly in weak signal areas.²⁵ Several parties also expressed concern that unlicensed devices operating in close proximity to TV receivers would cause direct pick-up interference potentially affecting all channels.²⁶ Manufacturers and users of wireless microphones and other broadcast auxiliary services submitted that unlicensed devices would cause harmful interference to those services. Those parties recommended that the Commission take a number of steps to protect auxiliary services.²⁷ Land mobile interests expressed concern about allowing unlicensed operation on channels 14-20 in any part of the country because devices could be transported into areas where those channels are used for PLMRS/CMRS operations.²⁸

19. On October 12, 2006, the Commission adopted the *First R&O/Further Notice* in this proceeding. In that action, the Commission determined that the record received in response to the *Notice* did not contain sufficient information for it to adopt final rules for unlicensed TVBDs. The Commission did, however, make a number of initial decisions regarding TVBDs. It decided to permit fixed unlicensed power devices to operate in the TV bands at times and locations where the spectrum is not already being used by other authorized services. It also decided not to permit operation of unlicensed TVBDs on channel 37, which is used by radio astronomy and wireless medical telemetry services, and on TV channels 52-69, as that spectrum has been reallocated for other services and will no longer be part of the TV bands after the DTV transition. The Commission further decided to prohibit operation of personal/portable TV band devices on TV channels 14-20 to avoid potential conflicts with public safety services on those channels. In addition, the Commission stated that it will not permit marketing of TV band devices to commence until February 18, 2009, the date on which all primary, full service TV stations will be in operation on their permanent DTV channels.

20. In the *First R&O/Further Notice*, the Commission also asked questions and set forth additional proposals with regard to the provisions necessary to implement complete and final rules for unlicensed TV band devices. While the Commission continued to focus on devices operating on an unlicensed basis, it also sought comment on whether such devices should instead operate on a licensed or hybrid basis. The Commission recognized the importance of conducting testing to ensure that whatever standards are ultimately adopted will protect incumbent radio services from interference and indicated

²⁵ See, for example, National Cable and Telecommunications Association (NCTA) *Notice* reply comments at 4, National Association of Broadcasters and Association for Maximum Service Television (NAB/MSTV) *Notice* reply comments at 6, Society of Broadcast Engineers (SBE) *Notice* reply comments at 1, Community Broadcasters Association (CBA) *Notice* reply comments at 3, National Translator Association (NTA) *Notice* comments at 1, Entravision Holdings *Notice* comments at 2, Southwest Colorado TV Translator Association *Notice* comments at 1, Syncom Media Group *Notice* comments at 1, Cox Broadcasting (Cox) *Notice* comments at 8, Pappas Telecasting (Pappas) *Notice* comments at 8, and Region 1 Translator Association *Notice* comments at 2.

²⁶ Direct pick-up interference occurs when undesired signals are received on the internal circuitry of a receiver, rather than at its input terminal as received from an attached antenna. See NAB/MSTV reply comments at 14, CEA comments at 10, and NCTA comments at 5.

²⁷ See, for example, Shure *Notice* comments at 9, Telex Communications *Notice* comments at 2, ATK Audiotek *Notice* comments at 2, Michael Mason *Notice* comments at 2, Total RF Marketing *Notice* comments at 6, Society of Broadcast Engineers *Notice* comments at 2, Sennheiser Electronic Corporation *Notice* comments at 2, National Systems Contractors Association *Notice* comments at 3, and Professional Audio Manufacturers' Alliance *Notice* comments at 3.

²⁸ See Motorola reply comments at 4, Land Mobile Communication Council (LMCC) *Notice* reply comments at 3, Industrial Telecommunications Association (ITA) *Notice* comments at 1, County of Los Angeles *Notice* comments at 2, and Association of Public Safety Communications Officials (APCO) *Notice* comments at 3.

that it intended to conduct extensive testing to assess the potential interference from low power devices operating in the TV bands. It also requested further comment and information on the means that TVBDs, both fixed and personal/portable, should be required to use to determine the availability of unused spectrum. It specifically requested comment on whether it should allow personal/portable devices to rely on spectrum sensing and, if so, the technical features and parameters of the sensing capability to be required. The Commission observed that IEEE 802.22 is considering different sensing threshold detection levels depending on the nature of the source signal, with levels as low as -116 dBm, and invited comment on this value or alternative values for the detection threshold. It also made specific proposals for additional parameters of spectrum sensing capabilities and other technical requirements. The Commission sought comment on whether TV band devices should be permitted to operate on TV channels 2-4, and whether fixed TV band devices should be permitted to operate on TV channels 14-20. The Commission also sought additional comments on several issues relating to the geo-location/database access and control signal approaches discussed in the *Notice*.

21. The comments responding to the *First R&O/Further Notice* are again divided on certain of the major issues in this proceeding. Two groups, one a coalition of hardware and software companies consisting of Dell, Google, HP, Intel, Microsoft and Phillips (the White Space Coalition) and the other a group of public interest/consumer organizations and wireless internet service providers (WISPs), led by the NAF, strongly support low power, unlicensed use of the TV bands. In addition, some other manufacturers and a number of WISPs express support for that approach separately from these groups. Proponents of unlicensed devices believe that the Commission should allow both fixed and personal/portable devices. They also support allowing personal/portable devices to rely solely on spectrum sensing to determine the available channels at their location. The White Space Coalition supports limiting unlicensed operation to channels 21-51 (excluding 37), while the group led by the NAF believes that operation should be permitted on as many channels as possible, including channels 2-4 and channels 14-20 in locations where public safety and land mobile services are not using them.

22. Full service and low power TV broadcasters and cable TV interests generally state that any new services in the TV bands should be licensed to reduce the likelihood of interference to incumbent services. They oppose the introduction of personal/portable devices at this time and believe that any new services should be limited to fixed operation. Broadcasters contend that spectrum sensing alone is inadequate to protect against interference to broadcast operations and that sensing must be combined with geo-location/database access to ensure that low power devices do not operate inside the protected service contours of co-channel or adjacent-channel TV stations.²⁹ Low power TV and translator operators express concern that low power unlicensed devices would cause interference to viewers who rely on reception outside their stations' protected service contours, while cable interests express concern about possible interference to reception of TV signals by cable headends that are located outside TV stations' protected contours. Both broadcast and cable interests express concern about direct pick-up interference to TV receivers, particularly from personal/portable devices.

23. Wireless microphone manufacturers and users again recommend that the Commission adopt a number of requirements to prevent interference to wireless microphones, including: 1) limiting new low power devices to fixed operation, 2) prohibiting new low power devices from operating on

²⁹ The protected service contour for DTV and analog TV stations are contours that define the edge of a station's service area where the availability of service is limited by noise. The DTV and analog protected service contours are generally termed the "noise-limited" and "Grade B" contours, respectively; the definitions of these contours are set forth in Sections 73.622(e) and 73.683 of the rules, respectively. See 47 C.F.R. §§ 73.622(e) and 683. The definitions of the protected service contours of low power DTV and analog stations are specified at signal strength levels that are higher than the noise-limited levels. See Sections 73.6010, 74.707 and 74.792 of the rules; see also 47 C.F.R. §§ 73.6010 and 74.707 and 792.

channels adjacent to occupied TV channels and/or reserving six vacant TV channels in each market for wireless microphones to ensure that spectrum is available for their use, 3) requiring new low power devices to incorporate spectrum sensing to detect wireless microphones, and 4) requiring new low power devices to sense for the presence of a “smart beacon” that would be operated when wireless microphones are in use in an area (Shure has since repudiated its support for a beacon requirement).³⁰ Public safety/land mobile interests believe that new low power devices should not be allowed to operate on channels 14-20 anywhere in the country because of the difficulties in enforcing geographic restrictions on operation.

24. On March 30, 2007, the Commission’s Office of Engineering and Technology released a report on the results of its DTV receiver testing program.³¹ This testing program examined the out-of-channel interference rejection performance of a representative sample of eight DTV receivers with fifth generation tuners that were available in 2005 and 2006. A total of 2055 individual measurements were performed on these receivers. Each test involved feeding a desired signal to the television under test and injecting an interfering signal on a different channel or combination of channels. The different tests varied the level of the desired signal and interfering signal(s). In these tests, no receiver appeared to fully achieve the Advanced Television Systems Committee’s (ATSC) recommended guidelines for interference rejection performance—guidelines that are generally more stringent than the receiver performance assumptions on which current DTV interference protection criteria are based.³²

25. On July 31, 2007, the Office of Engineering and Technology released a technical report on an initial study of prototype TV band devices that were submitted to the Commission’s Laboratory for testing.³³ This report evaluated the performance of two samples of prototype devices; one device had both sensing and transmitting capabilities (although the two functions were not linked) and the other had only sensing capability. This testing found that one of the two devices was generally able to reliably detect TV signals in the laboratory bench tests at the claimed -114 dBm sensing level, but did not perform well sensing wireless microphones. This device was not tested in the field at the manufacturer’s request. The other device was not able to reliably sense either TV or wireless microphone signals at the -114 dBm level in either the Laboratory bench tests or in field tests. The builder of this device subsequently determined that the device’s sensing function was not operating properly. In an anecdotal observation, the transmitter of the second device was found to cause co-channel and adjacent channel interference to TV service at distances of 87 meters and 47-50 meters, respectively.

³⁰ See Shure *ex parte* comments in ET Docket No. 04-186 submitted May 6, 2008.

³¹ See Office of Engineering and Technology, “Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006,” OET Report FCC/OET 07-TR-1003, March 30, 2007 (DTV Receiver Study). Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

³² The ATSC provides recommended guidelines for DTV receiver performance in its document, “ATSC Recommended Practice: Receiver Performance Guidelines,” ATSC Doc. A/74, 17 June 2004. The DTV Receiver Study found that, after taking into account differences between the Gaussian-noise interferer used for most of the tests and the 8-VSB interferer specified by the ATSC, the best-performing receiver failed to meet the guidelines at only one channel offset, and by only 1 dB. A second receiver failed to meet the voluntary guidelines by 1 to 2 dB at two channel offsets. The remaining five receivers failed to meet the guidelines at two to 16 channel offsets; the worst failure for each of those receivers ranged from about 8 to 24 dB.

³³ See Office of Engineering and Technology “Initial Evaluation of the Performance of Prototype TV-Band White Space Devices,” OET Report FCC/OET 07-TR-1006, July 31, 2007 (Initial Measurements Report). Devices were submitted for this initial testing by Microsoft Corporation and Philips Electronics North America Corporation. Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

26. Also on July 31, 2007, the Office of Engineering and Technology released a second technical report describing direct pick-up interference tests of three digital cable ready television receivers.³⁴ In these tests, three digital cable ready (DCR) receivers connected directly to cable service were examined for their susceptibility to interference from devices such as might operate within the TV white spaces. Tests were performed with the interfering signal source separated from the DCR receiver by distances of 2 meters or ten meters and, in most observations, by a residential wall. These tests showed that a signal as low as 6.3 dBm EIRP could cause interference at a distance of two meters and that a signal as low as 15.3 dBm could cause interference at a distance of 10 meters.³⁵ While these tests were limited in scope (only three receivers were tested), they nonetheless provide an empirical demonstration of the potential for such interference at relatively low power levels.

27. On October 15, 2008, the Office of Engineering and Technology issued a technical report on a second phase of its study of sample prototype TV band devices.³⁶ This second phase study examined the performance of prototype devices from five parties. All of these devices had capabilities for sensing TV signals, three had capabilities for sensing wireless microphones and one (that of Adaptrum) had a transmit capability (this transmit capability was not linked to the devices sensing capabilities). One of the devices (that of Motorola) also had a geolocation/database access capability.

28. In the laboratory tests of TV signals, the Phase II prototype devices were able to detect a “clean,” *i.e.*, unfaded, DTV signal on a single channel at levels in the range of -116 dBm to -126 dBm. The detection threshold sensitivity of the devices varied from -106 dBm to -128 dBm when recorded off-air DTV signals, which included multi-path fading and other “real-world” distortion, were used. When the devices were tested with DTV signals present in adjacent channels, the staff found that in the presence of moderate-to-strong signals in a first adjacent channel, the detection threshold sensitivity of all of the devices was severely impacted. For some of the devices, the degradation in the detection sensitivity was as much as 60-70 dB. In some cases, the degradation was such that the detection threshold could not be measured. The Phase II Measurement Report indicates that this could impact significantly the ability of the devices to reliably detect TV signals within stations’ service areas.

³⁴ See Office of Engineering and Technology “Direct-Pickup Interference Tests of Three Consumer Digital Cable Television Receivers Available in 2005,” OET Report FCC/OET 07-TR-1005, July 31, 2007 (Direct Pickup Report). Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005).

³⁵ The tests for two meters separation were conducted both with and without an intervening wall between the interferer and the TV receiver. The tests with ten meter separation distances were only conducted with an intervening wall between the interferer and the TV receiver.

³⁶ See Office of Engineering and Technology “Evaluation of the Performance of Prototype TV-Band White Space Devices Phase II,” OET Report FCC/OET 08-TR-1005, October 15, 2008 (Phase II Measurement Report). Devices were submitted for the Phase II measurement study by Adaptrum, the Institute for Infocomm Research (I2R), Microsoft Corporation, Motorola, and Philips Electronics North America Corporation. The report is available at <http://www.fcc.gov/oet/projects/tvbanddevice/Welcome.html> under Published Reports. The release of this report was announced by Public Notice. See “The FCC’s Office of Engineering and Technology Releases Report on Tests of Prototype TV White Space Devices,” Public Notice, DA 08-2243, ET Docket No. 04-186, rel. Oct. 15, 2008. Peer review of this report was undertaken in accordance with OMB Final Information Quality Bulletin for Peer Review, 70 Fed. Reg. 2664 (Jan. 14, 2005). The peer review was announced by Public Notice. See “The FCC’s Office of Engineering and Technology Releases Peer Review Panel Report on Tests of Prototype TV White Space Devices,” Public Notice, DA 09-2390, ET Docket No. 04-186, rel. Oct. 28, 2008.

29. TV sensing field tests were performed at nine locations with four of the prototype devices.³⁷ In most cases, the devices correctly reported channels as occupied when the device was operated within the service contour of the stations broadcasting on those channels and viewable signals were observed on the channels. In some instances, however, three of the devices incorrectly reported channels as unoccupied (available) when the device was operated within a station's service contour and the signal was viewable. All of the devices reported some channels as occupied when the WSD was operated outside of the service contours of stations broadcasting on those channels whether the signal was viewable or not. In addition, one device generally reported most channels occupied, whether the device was operating inside or outside any service contours and whether the signal was viewable or not. During the field tests, the Motorola device's geolocation/database access feature was used in combination with its sensing capabilities. In those tests, the Motorola device correctly reported all occupied channels used by stations within whose contours the WSD was operated.

30. The second phase study also examined the ability of devices to sense wireless microphones designed to operate under Part 74 of our rules. The two operating devices with wireless microphone sensing capability, those of Philips and I2R, were tested in the laboratory for their ability to detect wireless microphones (models using both FM/analog and digital) operating within UHF TV channels. With no other signals present, the devices were able to detect wireless microphones at levels ranging from -103 dBm to -129 dBm depending on the type of microphone, and the device. However, in the presence of DTV signals in adjacent channels, the detection threshold of both devices was degraded such that it affected the ability of the devices to reliably detect the microphone signals.

31. Finally, the second phase study conducted tests with the Adaptrum device's transmitter. The device's transmitter was characterized in the laboratory and then used to investigate interference potential to DTV signal reception. Anecdotal tests demonstrated that co-channel interference would occur at line-of-sight distances of up to 360 meters at an EIRP level of approximately +7 dBm when the DTV set was receiving a weak signal off-the-air using a receive antenna at a height of 9.3 meters. No interference was observed when the device transmitted on an immediate adjacent channel even with the transmitter in close proximity to the receiver with a roof-top antenna. No other configurations were tested for interference. Anecdotal tests with the Adaptrum transmitter were performed at two field sites to assess the interference potential from a TVBD transmitter to cable television reception via direct pick-up of signals by cable system components. These tests showed that under certain circumstances, when the transmit antenna was placed in close proximity to a cable connected TV, direct pick-up interference occurred. The report indicated that the direct pick-up interference potential appears to be highly dependent on the interconnection among the various receive system components (e.g., cable amplifiers, splitters and set-top boxes) being used.

IV. DISCUSSION

32. As supported by the record in this proceeding, we conclude that low power devices can and should be allowed to operate in the TV bands on frequencies that are not being used by authorized services. This decision will provide significant benefits for the public by enabling the development and operation of a wide range of new unlicensed wireless communications devices and systems in spectrum where signals are less subject to propagation losses than they are in the bands currently available for such devices. The propagation characteristics of these bands will allow the development of devices that can provide service at greater ranges than existing unlicensed devices. Proponents of broadband devices and services in particular indicate that there is need for new broadband devices that will take advantage of the more desirable propagation characteristics of the TV bands. As indicated above, we believe that the

³⁷ The Microsoft sample devices ceased functioning during the test process and were not repaired or replaced. As a result, only limited tests were conducted on these devices.

propagation advantages of this spectrum will make it possible for WISPs and others to improve or extend their reach to customers in rural and other less densely populated area. We also anticipate that these new devices will have economic benefits for consumers and businesses by facilitating the development of additional competition in the broadband market.

33. It is, of course, most important that we ensure that new unlicensed devices do not interfere with the incumbent licensed services in the TV bands. We now conclude that, with appropriate requirements and conditions on their operation, it is possible for both fixed and personal/portable low power devices to use the TV white spaces without disrupting the important television, public safety, and other services that use these frequencies. Because unlicensed broadband devices will share spectrum with broadcast TV and other licensed services, they will need the capability to avoid causing harmful interference to licensed services in the TV band. Specifically, an unlicensed device will need to be able to determine whether a TV channel or portion of a TV channel is unused before it transmits.³⁸ Additionally, an unlicensed device will need features that enable it to avoid occupying a frequency band or to cease operation on a frequency when a licensed user commences transmission on a channel that was previously unused by a television band licensed service. The rules we are adopting will require that unlicensed TVBDs include these capabilities.

34. The specific provisions of our plan for authorizing unlicensed TVBDs, including our decision to authorize these devices on an unlicensed basis, the requirements for fixed and personal/portable devices, methods and standards for protection of incumbent services, and the technical parameters for operation are described in the following sections; descriptions of the analyses and methods used in defining the operating characteristics of protected signals, the required minimum sensing capabilities, the permissible power levels, and the minimum distances that unlicensed devices must be from a licensed operation are also provided in the text below. The rules for these devices are set forth in Appendix B.

A. Licensed vs. Unlicensed Operation

35. In the *Notice* in this proceeding, the Commission proposed to allow low power devices to operate in the TV bands on an unlicensed basis.³⁹ In their responses, a number of parties suggested that such devices should instead operate on a licensed basis. In the *First R&O/Further Notice*, we sought further comment on whether the proposed TV band devices should operate on an unlicensed, licensed, or hybrid basis.⁴⁰ The record compiled in response to both the *Notice* and *First R&O/Further Notice* includes support for regulating TV band devices as unlicensed, licensed and a hybrid of the two approaches, as discussed below.

36. A number of commenters submit that vacant spectrum in the TV bands should be licensed and that this regimen is necessary in order to enable the use of that spectrum for providing wireless broadband and mobile data services.⁴¹ These parties argue that companies need the assurance

³⁸ We note that the ability to make this determination is unrelated to the determination of whether a household is “served” or “unserved” for purposes of the Satellite Home Viewer Improvement Act. See 17 U.S.C. § 119(a)(2)(B) and (d)(10).

³⁹ See *Notice* at ¶ 14.

⁴⁰ See *First R&O/Further Notice* at ¶¶ 26-32.

⁴¹ See Charles L. Jackson and Dorothy Robyn (Jackson/Robyn) *Further Notice* comments at 26-32; Cox Broadcasting *Further Notice* comments at 6; Qualcomm Inc. *Further Notice* comments at 2; MSTV *Further Notice* reply comments at 31; FiberTower Corp. and the Rural Telecommunications Group, Inc. (RTG) *ex parte* comments at 4-10 (urging that the vacant TV band spectrum be licensed for fixed services to promote broadband deployment in rural areas and to meet the urgent need for wireless backhaul facilities); Sprint Nextel Corp. and T-Mobile USA, Inc. (continued....)

that they will be entitled to protection from harmful interference before they will make the investments necessary to provide these services. They claim that licensing would encourage innovation because a licensee would receive all of the benefits of its innovation instead of having to share those benefits with others. Other parties continue to argue that this spectrum would be more effectively used on an unlicensed basis.⁴² For example, the NAF responds that the existing unlicensed bands have been used for a large number of innovative products, that innovation is encouraged by the low barriers to entry in an unlicensed regime, and that the TV bands have better propagation properties than currently available unlicensed bands, which would cause innovation to flourish.⁴³ It further states that many unlicensed uses such as community networks and rural service do not require a large infrastructure investment, so licensing is not needed to ensure the provision of service. Tropos Networks adds that the expense of acquiring licenses can make providing wireless broadband services prohibitive in rural and Native American tribal areas.⁴⁴ Those supporting the licensed and unlicensed approaches argue a number of additional points and counter points as described below.

37. Jackson/Robyn argue that the TV bands are not well suited to the low-power uses planned by unlicensed advocates.⁴⁵ They contend that under an unlicensed approach, devices would likely have to operate in 6 megahertz channels – which are far smaller than the available bandwidth in the 2.4 GHz or 5.0 GHz unlicensed bands – because the TV band white spaces occur in 6 megahertz increments. Jackson/Robyn further argue that the use of this spectrum for low-power unlicensed devices would fail to take advantage of the better propagation properties of the TV bands compared to those of higher frequencies and to exploit the capability that it is easier to manufacture equipment that generates significant power in the TV bands than at higher frequencies.⁴⁶ The White Space Coalition disputes these views, arguing that Jackson/Robyn’s claim that the TV band is not suited to unlicensed uses is premised on the assumption that future unlicensed uses will be identical to the current uses of those unlicensed

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ex parte comments; National Telecommunications Cooperative Association *ex parte* comments; GE Healthcare *ex parte* comments; CTIA *ex parte* comments at 2 (suggesting that the Commission adopt a licensing approach while reserving a portion of the TV band spectrum for future unlicensed use); CTIA and Rural Cellular Association *ex parte* comments at 2-4; Comptel, RTG, Sprint Nextel Corp., FiberTower Corp. *ex parte* comments (suggesting that vacant TV band spectrum be licensed for fixed services using the Commission’s Part 101 rules) and the Wireless Internet Service Providers Association *ex parte* presentation July 31, 2008 at 7.

⁴² See White Space Coalition *Further Notice* comments at 21-23; IEEE 802.16 *Further Notice* comments at 5; NAF *Further Notice* comments at 9-58; and Tropos Networks *Further Notice* at 5.

⁴³ See NAF *et al. Further Notice* comments at 42. NAF also contends that under the First Amendment the Commission has no right to prevent people from speaking via the use of radio communications by requiring exclusive licensing where the threat of interference does not exist. *Id.* at 53-58.

⁴⁴ See Tropos Networks *Further Notice* comments at 4.

⁴⁵ See Jackson/Robyn *Further Notice* comments at 24-25.

⁴⁶ *Id.* at 24. See also FiberTower Corp. and RTG *ex parte* comments at 16-17; CTIA *ex parte* comments at 15-16. Jackson/Robyn also hypothesize that low-power personal devices such as those the unlicensed advocates envision could be supported under a licensed model. They state that device manufacturers could contract with a licensee to allow consumers who purchase the devices to use them in the white space spectrum. Jackson/Robyn *Further Notice* comments at 6. NAF argues that no manufacturer has expressed an interest in such an arrangement, licensees would avoid such an arrangement because it would be difficult for them to prevent unauthorized use of their spectrum, and consumers would be limited to buying equipment from a single manufacturer (instead of the large number of choices, for example, available with Wi-Fi). NAF *Further Notice* comments at 40.

bands.⁴⁷ It contends that the better propagation properties of the TV bands would make it likely that new unlicensed applications would be developed in the future that would not be possible in other bands.

38. Supporters of a licensed approach also hold that there is no need for additional spectrum for unlicensed devices. In this regard, Qualcomm submits that there is no evidence that consumers have had to return unlicensed devices because the unlicensed spectrum is too crowded.⁴⁸ The Association for Maximum Service Television and the National Association of Broadcasters, in joint comments (MSTV/NAB), add there is over 100 megahertz of unlicensed spectrum below 2 GHz and that 255 MHz of spectrum in the 5 GHz band was made available for unlicensed use in 2003 and so there is plenty of spectrum available for unlicensed use.⁴⁹ The White Space Coalition counters these arguments, stating that the propagation characteristics of the TV band are superior to the other unlicensed bands for many applications and that none of the other unlicensed spectrum is below 900 MHz.⁵⁰

39. Some commenters claim that a large amount of revenue could be generated for the U.S. Government by auctioning licenses for the TV band whitespaces.⁵¹ Based on the value of recent transactions in the 2.5 GHz BRS/EBS band, Jackson/Robyn give an estimate of \$3.7 billion to \$6 billion for the TV white spaces. Commenters supporting an unlicensed approach argue that Jackson/Robyn's estimates of auction proceeds are over-inflated. NAF states that the uncertainty for bidders in this band with respect to the availability of spectrum would be huge.⁵² It observes that there are currently over 5000 low power TV and TV translator stations that have no post-DTV spectrum assignment yet. It further points to the fact that low power auxiliary stations such as wireless microphones have the right to transmit in the whitespaces on any unoccupied TV channel in a possibly wide geographic area. NAF also argues there would be high transaction and coordination costs in using the licensed white spaces because the operating parameters will be different everywhere and that this would further depress the value of the white space spectrum.⁵³

40. Jackson/Robyn claim that licensed use of the TV band would allow up to 50% more of the TV band to be used by TV band devices than unlicensed use would afford.⁵⁴ According to Jackson/Robyn, this efficiency would come from two sources. First, they submit that the use of directional antennas and power control would enable licensees to operate devices up to the edge of a TV station's Grade B/noise-limited contour, whereas unlicensed use of the band would require a buffer zone from 17-46 miles to ensure that unlicensed devices do not interfere with TV receivers within the station's service contour. Secondly, they submit that licensees would be able to negotiate with TV broadcasters to relax the interference requirements in individual situations, and thereby allow greater use of the white spaces. Jackson/Robyn state that if the Commission would allow TV band device licensees to negotiate

⁴⁷ See White Space Coalition *Further Notice* comments at 25.

⁴⁸ See Qualcomm Inc. *Further Notice* comments at 6.

⁴⁹ See MSTV/NAB *Further Notice* comments at 38. FiberTower Corp. and RTG *ex parte* comments at 16.

⁵⁰ See White Space Coalition *Further Notice* comments at 23.

⁵¹ See Jackson/Robyn *Further Notice* comments at 56-57; MSTV/NAB *Further Notice* reply comments at 32-33. FiberTower Corp. and RTG *ex parte* comments at 24-26.

⁵² See NAF *et al.* *Further Notice* comments at 47-50.

⁵³ The National Telecommunications Cooperative Association believes that the unused TV band spectrum should be licensed but not auctioned because the resources of rural carriers are better spent on providing services rather than on buying spectrum. See National Telecommunications Cooperative Association *ex parte* comments.

⁵⁴ See Jackson/Robyn *Further Notice* comments at 15-16.

interference rights with broadcasters, the use of the television bands could evolve over time to more efficient uses as market conditions and technology change dictate.⁵⁵ According to NAF and the White Space Coalition, Jackson/Robyn's claims in this regard are not valid since there is no reason to believe that licensed devices will be able to operate any closer to broadcasters' Grade B contours than unlicensed devices because the same interference protection would have to be provided to broadcasters in either case.⁵⁶ Furthermore, NAF states, allowing broadcasters to negotiate to allow greater interference from white space devices would be contrary to broadcasters' public interest obligations to provide free TV service to viewers because some TV viewers would lose the ability to receive over the air TV service.

41. MSTV/NAB are concerned about possible interference to TV broadcasters from unlicensed devices.⁵⁷ They submit that if unlicensed devices were to cause interference to TV reception, it would be impossible to track down the source of the interference.⁵⁸ They further argue that, as experience with other unlicensed uses has shown, modified devices and nonconforming amplifiers and directional antennas would be sold that would allow unlicensed devices to cause greater interference than allowed under the rules that the Commission adopts.⁵⁹ MSTV/NAB state that a licensed regime would provide accountability for interference in that the licensee would be responsible for any interference that occurs. They submit that the identity of the licensee would be a matter of public record so the party responsible for resolving the interference could be easily located. Jackson/Robyn submit that the infrastructure-based architecture that licensees would be most likely to deploy would reduce the probability of interference compared to low-power unlicensed devices.⁶⁰ On the other hand, the White Space Coalition states that the parameters it has proposed for unlicensed operation would allow unlicensed devices to avoid interference to broadcasters and avoid transmitting at maximum powers.⁶¹

42. A number of parties, including the WISPA, support using a hybrid or "light" licensing model rather than an exclusive licensing model.⁶² They suggest an approach that would be similar to the Commission's rules for non-exclusive licensing of the 3650-3700 MHz band.⁶³ Under their plan, fixed base stations would be registered in a database and registrants would not have exclusive use of the

⁵⁵ *Id.* at 49-50.

⁵⁶ See NAF *et al.* *Further Notice* technical reply comments at 12; the White Space Coalition *Further Notice* comments at 19, 23.

⁵⁷ See MSTV/NAB *Further Notice* comments at 2-5. See also FiberTower Corp. and the RTG *ex parte* comments at 18-21 ("Overcrowding and interference would be much worse in the TV white spaces because of the excellent propagation characteristics."); CTIA *ex parte* comments at 2-3; CTIA and Rural Cellular Association *ex parte* comments at 4-5.

⁵⁸ See MSTV/NAB *Further Notice* reply comments at 31-32 noting that interference is avoided in 2.4 GHz band by the fact that the propagation distances are short so in effect property owners are acting as their own interference coordinators. They state that the propagation properties of the TV band are such that this will not be the case in unlicensed white space operation.

⁵⁹ See MSTV/NAB *Further Notice* comments at 30.

⁶⁰ See Jackson/Robyn *Further Notice* comments at 41.

⁶¹ See White Space Coalition *Further Notice* reply comments at 4-16.

⁶² See Nextwave Broadband Inc. reply comments at 2-3; IEEE 802.16 comments at 5 (IEEE would prefer a completely unlicensed approach but supports a hybrid scheme as an acceptable and viable alternative), WISPA *ex parte* presentation of July 31, 2008 at 7-16.

⁶³ The rules for licensed operation in the 3650-3700 MHz band on a non-exclusive basis are set forth in 47 C.F.R. §§ 90.1301-.1337.

spectrum. These parties suggest that a database system would aid in the resolution of interference problems among the registered users by allowing potential sources of interference to be identified. Supporters of a hybrid approach argue that this plan would present a low barrier to entry, so that innovative low-cost use of the spectrum would still be possible.

43. In their Petition for Reconsideration, NAF/CUWN argues that the Commission should restore its previous tentative conclusion in favor of unlicensed use that was set forth in the *Notice* in this proceeding.⁶⁴ They argue that the Commission provided no explanation for its change of course to give consideration to licensing use of the TV white spaces.

44. *Discussion:* As we stated in the *First R&O/Further Notice*, our goal in this proceeding is to allow new uses of radio on unused television channels at locations where such operations will not result in harmful interference to, or disrupt, TV and other authorized services.⁶⁵ For the reasons discussed below, we conclude that it is in the public interest to allow TV band devices to operate in these bands on an unlicensed basis pursuant to restrictions carefully designed to protect users of incumbent licensed services. This approach permits us to introduce new innovative uses while protecting the continued operation and growth of the TV broadcast and other authorized services in these bands. Because unlicensed operations are not allowed to cause interference to authorized services, the interference protection status of existing services operating in these bands will not be affected, consistent with the Commission's goals in this proceeding.

45. The record developed in response to the *Notice* and *First R&O/Further Notice* indicates that there is a need for additional spectrum for unlicensed broadband devices, particularly in the lower frequency bands. A number of WISPs have noted that the TV frequencies would provide improved signal coverage over other unlicensed bands, including improved in-building penetration properties which other unlicensed bands lack. We disagree with Jackson/Robyn that the 6 megahertz size of TV channels and propagation characteristics of these bands make them inappropriate for unlicensed use. Unlicensed devices will not be limited to 6 megahertz bandwidth, as they will be allowed to operate across multiple channels in locations where the bandwidth is available. The signal coverage afforded by the propagation characteristics of this spectrum is also desired by proponents of unlicensed devices in that it will facilitate the provision of improved and/or more economical wireless Internet service to consumers, particularly in rural areas where transaction costs may be higher than elsewhere. Further, as argued by comments filed by the White Space Coalition and other parties who have expressed interest in developing or operating low power devices in these bands, other innovative uses for this spectrum may emerge once it is made available for unlicensed use.

46. While we recognize the arguments in the record in support of a licensed approach for making the TV white space spectrum available for new uses, we conclude that such an approach is not practicable for many kinds of devices that could use these bands, and thus would reduce the benefits available. As we noted in the *First R&O/Further Notice*, a licensed model tends to work best when spectrum rights are clearly defined, exclusive, flexible and transferable.⁶⁶ When spectrum rights lack these attributes, potential licensees face uncertainty and may lack incentives to invest in a license or offer service. We conclude that attributes supporting the successful use of licensing would be difficult to accomplish here, particularly if we want to maintain our stated goal of not affecting the interference protection status of existing services. The frequencies and amount of unused TV band spectrum will vary from location to location and could change over time as additional television stations and other primary

⁶⁴ See *Notice* at ¶¶ 14-16.

⁶⁵ See *First R&O/Further Notice* at ¶ 1.

⁶⁶ *Id.* at ¶ 27.

and secondary operations are licensed or as existing operations change frequency. For example, the assignment of channels for digital operation to low power television stations is not scheduled to be complete by the end of the DTV transition in February 2009. Also, currently authorized DTV stations have recently been permitted to submit applications asking to modify their facilities and/or change channels.⁶⁷ These changes could complicate licensing of the white spaces spectrum, particularly if the Commission were to license the spectrum pursuant to auction. Because we have decided to require that TV band devices protect other types of licensees in the bands, a licensed TV band device could potentially lose its ability to operate on some, or even all, of its authorized frequencies when new operations with higher allocation status are authorized to operate in the same area.⁶⁸

47. As discussed below, we are adopting a number of requirements for TV band devices that will significantly reduce the potential for these devices to cause harmful interference to authorized services and will make it possible to identify the source of any interference that might occur. In particular, TV band devices will be allowed to operate only after they have identified which channels in their area are available for their use. To ensure that devices adhere to this requirement, we are requiring that fixed and personal/portable TV band devices that do not operate in client mode to access a central database system and that fixed devices register with the database system. Registration of fixed TV band devices will facilitate locating the source of an interference problem should it occur from these higher power devices. We are not requiring registration of personal/portable devices, as the lower operating power and non-directional antennas of personal/portable devices will limit the potential interference range of those devices to the immediate vicinity of a device. We are also concerned that a registration requirement for personal/portable devices could significantly limit the types of devices that could operate by necessitating that a device includes the capability to input alphanumeric data. Thus, this scheme addresses the interference concerns of those commenters who support licensing of TV band devices.

48. With regard to the argument that a licensing regime would encourage investment in the provision of services using wireless spectrum, we observe the stability normally provided by exclusive licensing would be difficult to achieve for TV band device operation. To avoid affecting the interference protection status of incumbent services, the licenses here would afford no right to interference-free operation. Instead, the licensee would merely have the right to operate on those television channels that are not currently in use by other higher-priority users. The specific channels and amount of available spectrum available at a given location could change over time as additional television channels are

⁶⁷ On August 3 2004, the Commission imposed a freeze on the filing of certain requests for changes to TV and DTV channels and service areas. See Public Notice, "Freeze on the Filing of Certain TV and DTV Requests for Allotment or Service Area Changes," 19 FCC Rcd 14810, 14810-11 (2004) ("*August 2004 Filing Freeze PN*"). This freeze was imposed prior to the commencement of the channel election process, in order to provide a stable database for developing the post-transition DTV Table. The freeze precluded parties from filing the following: (i) petitions for rulemaking to change DTV channels within the current DTV Table; (ii) petitions for rulemaking to establish a new DTV channel allotment; (iii) petitions for rulemaking to swap in-core DTV and NTSC channels; (iv) applications to change DTV channel allotments among two or more licensees; (v) petitions for rulemaking by licensees/permittees to change NTSC channels or communities of license; (vi) applications to maximize DTV or analog TV facilities; and (vii) certain Class A television station applications. The freeze did not prevent the processing of pending applications. See *id.*; see also 47 C.F.R. §§ 73.1690, 73.3533, 73.3538. On May 30, 2008, the Commission lifted this freeze. That action effectively allowed stations to file applications for maximization of their facilities and any desired channel changes, immediately and the Commission encouraged stations to file promptly. That action did not, however, lift the current freeze on filing of petitions for allotment of DTV channels for new stations, or for changes in community of license. See Public Notice, "*Commission Lifts the Freeze on the Filing of Maximization Applications and Petitions for Digital Channel Substitutions, Effective Immediately*," DA-1213, released May 30, 2008.

⁶⁸ See *First R&O/Further Notice*, at ¶ 14.

allocated, as low power auxiliary devices make use the channels, and the other services that use these bands similarly initiate new or modify existing operations. Hence, we do not believe that the issuance of licenses would necessarily provide the benefits that the proponents of licensing claim because of the tenuous nature of the rights that would actually be granted by the license. Furthermore, there has been tremendous growth in the development of new technologies and the introduction of new services that rely on unlicensed devices, which belies the assertion that a licensing regime is needed to encourage investment in spectrum development.

49. We are also not persuaded by other arguments raised in support of a licensing regime for TV band devices. We note that a number of parties draw attention to the potential revenue that could be raised by auctioning the unused television bands under a licensing regime. We believe that these arguments are misplaced and do not address our goal in this proceeding, which is to allow new uses on unused television channels in locations where such operations will not result in harmful interference to or disrupt TV and other authorized services. Thus, the regulatory model used here must be appropriate to facilitate new uses while protecting the various types of incumbent uses, not chosen merely because it could provide revenue from auctioning licenses. We are also not persuaded by Jackson/Robyn's claim that licensing TV band devices would allow the television bands to be used more efficiently — *i.e.*, licensed users could negotiate interference protection arrangements and thus increase the use of available spectrum for TV band devices, which in turn would allow the use of the bands to evolve over time to more efficient uses as market conditions and technology change dictate. As discussed above, licensing TV band devices is not practicable while also protecting the present and future use of the band for broadcasting and other incumbent uses. Allowing licensed TV band devices to negotiate interference requirements with licensed users as Jackson/Robyn suggest would signal a fundamental shift from our stated goal to avoid disruption of TV and other authorized services by TV band devices.

50. We also find that a hybrid licensing scheme such as that which the Commission adopted in the 3650 MHz proceeding would not be appropriate here.⁶⁹ In the 3650 MHz band, the Commission decided to issue non-exclusive licenses for stations providing fixed and mobile service. These 3650 MHz stations will be registered in a database which will aid the licensees in resolving interference problems among themselves by allowing them to identify potential sources of interference. However, because that band is allocated to the fixed and mobile services on a primary basis, the registered stations have no interference protection from existing stations of those services in the band. Although the 3650 MHz fixed and mobile stations must protect the previously existing satellite earth stations operating in that band, satellite earth station licenses in the band issued after 2000 are secondary and therefore have no right to interference protection from the new fixed and mobile stations.⁷⁰ The situation in the TV bands is different. Here, future broadcast uses of the television band will have the right to interference protection from TV band devices. Not only must future primary use of the band by broadcasters be protected, but secondary uses such as low power auxiliary devices and broadcast auxiliary service (BAS) must also be protected. Thus, although the non-exclusive licensing approach would address the interference status among TV band devices, it would not resolve the interference rights between TV band devices and other licensed users in the bands. We find that unlicensed operation under Part 15 of our rules is a better fit for TV band devices because Part 15 devices must not cause harmful interference to licensed users, whether primary or secondary. Accordingly, we will authorize new devices on vacant spectrum in the TV bands on an unlicensed basis. Such use will be allowed under the rules discussed in the following sections.

⁶⁹ See *Wireless Operations in the 3650-3700 MHz Band*, ET Docket No. 04-151, *Report & Order*, 20 FCC Rcd 6502 (2005); *see also Rules for Wireless Broadband Services in the 3650-3700 MHz Band*, WT Docket No. 05-96; *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket No. 02-380, *Memorandum Opinion and Order*, 22 FCC Rcd 10421 (2007).

⁷⁰ *Id.* at ¶ 7.

51. With respect to NAF/CUWN's request that we reconsider our decision to reopen the issue of whether use of the TV white spaces should be allowed on a licensed or unlicensed basis, we note that, notwithstanding the petitioners' argument that this issue had been decided, the Commission's position on this issue in the *Notice* was that of a proposal, not a final decision, and it requested comment on that proposal and its tentative conclusions favoring unlicensed use.⁷¹ The Commission decided to request additional comment on this question in the *First R&O/Further Notice* after some parties responding to the *Notice* suggested that this spectrum should be assigned on a licensed basis. Specifically, in the *First Report and Order*, the Commission sought comment on whether the proposed low power operations in the TV bands should be allowed on a licensed, unlicensed, or hybrid basis in the interest of obtaining a further record on this issue. We find nothing arbitrary or otherwise inappropriate in that action. Accordingly, we are denying NAF/CUWN's request that we reverse our decision to seek further comment on the issue of whether to allow low power devices to operate in the TV white spaces on a licensed or unlicensed basis.

B. Plan For Unlicensed Use Of The TV Bands

52. As we observed in the *Notice*, the development of industry standards for broadband unlicensed devices in other frequency bands has enabled the introduction of a host of new unlicensed wireless broadband products that can be divided into two distinct types of operations.⁷² The first type of operation involves the provision of broadband services to homes and businesses. This type of operation uses higher power, is primarily fixed and operated outdoors, may cover a substantial geographic area, and may be part of a service infrastructure. In this regard, Wireless Internet Service Providers (WISPs) are now using unlicensed devices to provide broadband service on a point-to-point basis over distances of several kilometers. The second type involves wireless portable computing devices, such as laptops and personal digital assistants (PDAs), wireless home and local area networks (LANs), and other short-range applications within a home or a business. Unlike the first type of operations, these personal/portable devices generally transmit with very low power and are used indoors or within a small localized area. Portable devices can be used for: broadband wireless connectivity between a cable modem, DSL modem, or other internet connection and in-home computing devices; broadband wireless home entertainment applications, such as video/home theater use; business applications such as wireless inventory control and wireless cash registers; and personal applications such as wireless headphones. Fixed and personal/portable operations may also be used together.

53. For the purpose of developing operating rules and interference protection criteria, we are, as proposed, classifying the unlicensed broadband devices to be used in the TV bands into these two general functional categories. The first category will consist of higher power "fixed" unlicensed devices that are operated from an installed outdoor location that does not change and may be used to provide a commercial service such as wireless broadband Internet access (non-commercial operations will also be permitted). The second category will consist of lower power "personal/portable" unlicensed devices, such as Wi-Fi-like cards in laptop computers or wireless in-home LANs. We find that both of these types of devices can be accommodated in the TV spectrum if they comply with appropriate regulatory measures to ensure that their operations are limited to TV channels where interference will not result. Both types of devices will be allowed to transmit broadband data as well as other types of communications.

54. We recognize that different measures are appropriate for achieving those protections from the two types of devices, given the differences in their uses and interference potential. Therefore, as discussed below, we are adopting different interference avoidance requirements for fixed and personal/portable unlicensed devices. In addition, we are providing for operation of personal/portable

⁷¹ See *Notice* at ¶ 16.

⁷² See *Notice* at ¶ 18.

devices under two different modes: 1) controlled by a fixed device or a Mode II personal/portable device and 2) independent. In each of these cases, our goal is to make the technical requirements as simple and as reliable as possible. We believe that this approach will provide flexibility to permit a wide range of unlicensed broadband uses and applications and while ensuring that the most appropriate and effective mechanisms are in place to protect TV and other licensed services. One of the most important factors in avoiding interference is how to reliably determine the channels that are unused at the location of an unlicensed device. That subject has been a major issue between the incumbent licensed services and the proponents of unlicensed devices. We will first discuss our decision with respect to the methods for determining which channels are occupied at a given location and then address the basic elements of plans for operation of fixed and personal/portable device.

1. Methods For Determining Occupied And Unoccupied Channels

55. With the technologies currently available, there are three principal methods that could be used to determine whether a portion of the TV band is unused at a specific time and/or location. The first approach involves determining the location of an unlicensed device and then accessing a database of licensed services to identify active services at that location. The device's location could be determined by a professional installer or by a geo-location technology, such as GPS, incorporated within the device. Once the device's location is known, an analysis would be performed for each channel using either an internal or external database to determine whether the unlicensed device is located far enough outside the protected service contours of licensed stations to avoid causing harmful interference. This would yield a list of available channels on which the unlicensed device could choose to operate.

56. A second method would be for an unlicensed device to receive information transmitted on a control signal by an external source, such as a broadcast station, CMRS base station, or another unlicensed transmitter, indicating which channels are available at its geographic location. Under the control signal method, a device would be allowed to transmit only after it receives a signal with information that positively identifies which TV channels are available for use. Control signals could be transmitted by any number of sources, such as broadcast TV and radio stations and/or licensed wireless communications providers.

57. A third method would be to incorporate spectrum listening or "sensing" capabilities in the unlicensed device to detect whether other transmitters are operating in an area. For example, a fixed unlicensed transmitter could incorporate an antenna and a receiver capable of detecting signals down to a certain threshold level that would be the standard for determining if a particular TV channel is actually in use. Generally, such sensing would have to be much more sensitive than the receivers used in the licensed service.⁷³ The sensing function would examine each channel and those channels on which it detected no signals above the threshold would be considered available for operation, subject to any additional limitations that might be appropriate. If signals were detected above the threshold on a particular channel, that channel would not be eligible for operation. As the Commission has previously noted, there are techniques that can be used to increase the ability of a sensing receiver to reliably detect

⁷³ Spectrum sensing is also susceptible to a potential shortcoming that is sometimes referred to as the "hidden node problem." In the case of unlicensed devices in the TV band, this problem could arise when there is signal blockage between the unlicensed device and a TV station, but no blockage between the TV station and a TV receiver and no blockage between the unlicensed device and the same TV receiver. In such a case, the sensing receiver in the unlicensed device may not detect the presence of the TV signal because it is blocked, and the unlicensed device may therefore commence transmissions on an occupied channel, thus causing interference at the TV receiver. See *ex parte* presentation by Shared Spectrum Company in ET Docket No. 02-380, on September 29, 2003.

other signals in a band which rely on the fact that it is not necessary to decode the information in a signal to determine whether a signal is present.⁷⁴

58. In the *Notice*, the Commission proposed to require that fixed unlicensed TV band devices incorporate a geo-location method such as a GPS receiver and that they access a database to identify vacant channels at their location.⁷⁵ To ensure that fixed/access devices operate only on unused TV channels, it proposed to require that such devices incorporate a method for determining geographic location with a minimum accuracy of 10 meters. Alternatively, the Commission proposed to allow fixed unlicensed devices to be professionally installed by a party that would determine a device's geographic location and contact the database system to determine the available unused channels at that location. It further proposed to require that personal/portable devices operate only when they receive a control signal from a source such as an FM or TV station or a CMRS provider that identifies the vacant TV channels in that particular area.⁷⁶ The Commission also sought comment on the possibility of using spectrum sensing to identify vacant TV channels, but did not propose any specific technical criteria for that method.⁷⁷

59. In the *First R&O/Further Notice*, the Commission sought additional comment and information on issues related to the appropriate geo-location method, including the means by which devices employing the geo-location/database approach would protect certain authorized services, such as wireless microphones, the location of which may not be included in the databases.⁷⁸ The Commission also recognized that a number of parties suggested that spectrum sensing could be used to identify TV channels that would be available for use by unlicensed TVBDs, but noted that no party had provided sufficient technical information for it to adopt rules. The Commission therefore sought comment on whether unlicensed TV bands devices should be allowed to use spectrum sensing as a means to determine the availability of unused frequencies in the TV bands, and, if so, the technical features and parameters of the sensing capability to be required.⁷⁹ It also requested comment on whether devices should be permitted to rely on spectrum sensing as the sole means of identifying vacant channels, or whether a device should be required to use both geo-location and spectrum sensing to identify vacant channels at its location.⁸⁰ In considering the spectrum sensing approach, the Commission did observe that some parties responding to the *Notice* raised concerns about whether a GPS receiver incorporated in a TV band device would be a reliable method for performing geo-location because it may not work indoors or at outdoor locations where the GPS signal is obstructed.⁸¹

⁷⁴ For example, a TV band spectrum sensing function could be made more sensitive, *i.e.*, made to detect lower signal levels, by using bandwidths much smaller than a 6 MHz TV channel and/or looking for specific features of the TV signal such as the pilot for digital TV or the visual and audio carriers for analog TV. *See Notice of Proposed Rule Making and Order* in ET Docket No. 03-108, 18 FCC Rcd 26859 (2003).

⁷⁵ *See Notice* at ¶ 26.

⁷⁶ *Id.* at ¶ 21.

⁷⁷ *Id.* at ¶ 20.

⁷⁸ *See Further Notice* at 12285.

⁷⁹ *Id.* at ¶ 33.

⁸⁰ *Id.* at ¶ 30.

⁸¹ *See NAB/MSTV Further Notice* comments at 14, IEEE 802 comments at 8, and Society of Broadcast Engineers *Further Notice* comments at 3.

60. A number of the comments received in response to the *First R&O/Further Notice* support the use of a geo-location/database approach for fixed TV band devices.⁸² Those supporting the geo-location/database approach generally state that this method would provide a means to reliably determine occupancy of TV channels by fixed services, but acknowledge that it does not provide for identifying channel occupancy by portable and/or intermittent services such as wireless microphones. MSTV/NAB claim that use of geo-location coupled with a database is the only way to ensure that television stations are protected from interference from TV band devices. Motorola notes that the geo-location/database approach offers flexibility for protection of licensed services as it would allow the restricted radius around TV stations and other protected coverage areas to be changed without changing the TV band devices.⁸³ Motorola believes that the same general techniques that allow fixed devices to operate in the TV bands can also work for personal/portable deployment. It states that an “anchor” personal/portable or fixed device could use geo-location and database techniques to determine its location and send an enabling signal to associated personal/portable devices.⁸⁴

61. In addition, Motorola believes that the database should be flexible enough to vary the applied protection levels depending on the transmit power of the TV band device since the interference potential of TV band devices will vary with transmitted power. It submits that officially established protection levels should be contained in the database to make sure that consistent calculations are performed by various manufacturers’ equipment. Motorola also supports the Commission’s suggestion that a private party be engaged to develop and maintain such a database.⁸⁵ The Communications Research Centre Canada (CRCC) describes a geo-location method that it states will work indoors, in which a TV band device determines its position by identifying the DTV stations that can be received at its location.⁸⁶

62. IEEE 802, Intel, Josephson Engineering, Motorola, and the NAF all believe that the proposed 10 meter accuracy requirement is more stringent than necessary.⁸⁷ IEEE 802 recommends an accuracy standard of 30 meters as being comparable to that required by the Commission for fixed stations. Intel recommends an accuracy standard of 100 meters, stating that this distance is a small fraction of the required protection distance from TV stations. Motorola similarly recommends an accuracy of 100 meters because TV signal strength varies only a fraction of a dB over this distance. The NAF recommends 100-200 meters on the basis that this range is consistent with the accuracy of station

⁸² The geo-location/database method is supported by the American Society for Healthcare Engineering of the American Hospital association (*Further Notice* comments at 5-6), Communications Research Centre Canada (*Further Notice* comments at 1), IEEE 802.18 comments at 21, Motorola *Further Notice* comments at iii and reply comments at 5-6, MSTV/NAB *Further Notice* reply comments at 16-17, NCTA (*Further Notice* comments at 6), and the WISPA (*Further Notice* reply comments at 3).

⁸³ See Motorola *Notice* reply comments at 6.

⁸⁴ See Motorola *Further Notice* reply comments at 6.

⁸⁵ See Motorola *Notice* comments at 20.

⁸⁶ See Communications Research Centre Canada *Notice* comments at 1.

⁸⁷ See IEEE 802 *Notice* comments at 9, Intel *Notice* comments at 19, Motorola *Notice* reply comments at 8 and NAF *Notice* reply comments at 24.

coverage predictions.⁸⁸ Commenting parties generally believe that the Commission should not require the use of a specific geo-location method such as GPS.⁸⁹

63. The NCTA suggests that rather than requiring Internet access in order for the TV band device to access the database, each television broadcaster could transmit a portion of the database to the TV band device.⁹⁰ Nextwave Broadband supports registration of the location of unlicensed TV band devices in the database as a means to facilitate coordination among the users of these devices and to allow for monitoring of spectrum usage.⁹¹ IEEE 802.18 believes that fixed TV band base stations should be professionally installed, with site surveys, propagation/coverage predictions, and geo-location of the base station.⁹² The White Space Coalition submits that outdoor devices could incorporate a GPS capability in lieu of professional installation.⁹³ Other parties raised questions about who should be considered a professional installer.⁹⁴

64. Several parties express reservations about the use of a geo-location/database approach. The NAF and the White Spaces Coalition are concerned that requiring use of a database will increase costs by increasing the complexity of the TV band devices and requiring payments to a third party to develop and maintain the database.⁹⁵ Tropos Networks argues that no complete and accurate database of broadcast operations currently exists and that the costs of developing one and the associated computational software would be large.⁹⁶ WISPA believes that the wireless Internet service provider market is too dynamic for a registration scheme to ever be current and accurate.⁹⁷ These parties also reiterate their previous concerns that GPS does not function reliably indoors.⁹⁸ For example, the White Space Coalition believes that requiring use of a geo-location/database approach would eliminate the flexibility to create decentralized networks and would restrict indoor use of TV band devices, as unassisted GPS does not function indoors.⁹⁹ Shure, Inc. notes that a database would not protect wireless microphones as these devices are portable and often moved on short notice.¹⁰⁰ Advance Broadband contends that a geo-location/database approach would not be effective because consumers would override

⁸⁸ See IEEE 802 Notice comments at 9, Intel Notice comments at 19, Josephson Engineering Notice comments at 4, Motorola Notice reply comments at 8 and NAF Notice reply comments at 24.

⁸⁹ See Intel Notice comments at 19, Josephson Engineering Notice comments at 3, Motorola Notice reply comments at 8 and NAF Notice reply comments at 24.

⁹⁰ See NCTA Notice reply comments at 13-14.

⁹¹ See Nextwave Broadband Notice comments at 5.

⁹² See IEEE 802.18 Notice comments at 21. This approach requires that each DTV station transmit a unique identification code or “watermark” that can be detected by the TV band device.

⁹³ See White Space Coalition Notice comments at 10.

⁹⁴ See Tropos Notice comments at 4 and Harris Notice comments at 8.

⁹⁵ See Coalition Notice comments at 10; NAF Notice technical comments at 13. The NAF believes that use of geo-location and a database should not be required, but instead should be one option of several possible ways TV band devices could avoid interference. NAF Notice comments at 69.

⁹⁶ See Tropos Networks Notice comments at 12.

⁹⁷ See WISPA Notice comments at 3.

⁹⁸ See Coalition Notice comments at 10 and Thomas C. Smith Notice comments at 10.

⁹⁹ See White Space Coalition Notice comments at 9-11.

¹⁰⁰ See Shure Notice comments at 10.

or disable it or that the equipment might malfunction and result in interference to broadcasters.¹⁰¹ WISPA argues that use of a database isn't appropriate because it wouldn't take into account attenuation of the signal from the TV band device due to vegetation, buildings, or terrain.¹⁰²

65. Other comments express support for use of the spectrum sensing method to determine available channels.¹⁰³ Supporters of spectrum sensing submit that signal detectors in the TV band are capable of high degrees of detection sensitivity and can detect and avoid broadcast signals that have undergone high attenuation in a hidden node situation.¹⁰⁴ They further state that spectrum sensing can protect incumbent licensees and facilitate spectrum sharing with other low power devices in the TV white spaces and would be more cost effective and efficient than the geo-location/database approach.¹⁰⁵ Several parties argue that spectrum sensing alone is adequate to determine when a TV channel is available. In statements representative of these parties' positions, the White Space Coalition argues that spectrum sensing does not depend on third party assisting technologies such as databases of available channels and would better facilitate the creation of a mass market for devices. It claims that spectrum sensing is a proven, well understood technique and that the concern raised by incumbent licensees that this approach is unproven is simply not the case.¹⁰⁶ NAF argues that spectrum sensing shows great promise, would be cost effective to implement, and that detectors in TV band devices are capable of high degrees of sensitivity and can detect and avoid signals that have undergone 37 dB of attenuation due to the hidden node problem.¹⁰⁷ Tropos Networks states that spectrum sensing could be used in both fixed and personal/portable devices.¹⁰⁸ WISPA believes that a distributed sensing model, whereby interconnected devices would share sensing information, would be far superior to geo-location, especially over time as the number of sensors in an area increases.¹⁰⁹

66. The White Space Coalition argues that the Commission should allow personal/portable devices that rely on spectrum sensing alone to determine when a channel is vacant. It argues that spectrum sensing will protect incumbent licensees and facilitate spectrum sharing with other low power devices in the white spaces, while avoiding the operational difficulties and economic burdens associated with the other interference avoidance mechanisms identified in this proceeding. The White Space Coalition states that because spectrum sensing does not depend on third-party assisting technologies such as databases of available channels or broadcast beacons to implement, a spectrum sensing approach would better facilitate the creation of a mass market for devices, resulting in more affordable consumer

¹⁰¹ See *Advanced Broadband Notice* comments at 4.

¹⁰² See *WISPA Notice* comments at 2.

¹⁰³ The spectrum sensing method is supported by CEA (*Further Notice* comments at 3-5), the White Space Coalition (*Further Notice* comments at 5-7), NAF, *et al.* (*Further Notice* comments at 63-67), and Tropos Networks (*Further Notice* comments at 10).

¹⁰⁴ See for example, NAF, *et al. Notice* comments at 63-64. A "hidden node" is a location where an obstruction is present between the sensing receiver and the signal to be detected. In this case, the sensing receiver may fail to detect that a channel is occupied and begin transmitting, thus causing interference to other nearby parties attempting to receive that channel along an unobstructed path.

¹⁰⁵ See for example, NAF, *et al. Notice* comments at 65 and White Space Coalition *Notice* comments at 3.

¹⁰⁶ See White Space Coalition *Further Notice* comments at 3-4.

¹⁰⁷ See NAF *Further Notice* comments at 65-66.

¹⁰⁸ See Tropos Networks *Further Notice* comments at 10.

¹⁰⁹ See WISPA *Further Notice* comments at 3.

products and more attractive prospects for wireless broadband, including in rural areas.¹¹⁰ The NAF and a number of consumer and public interest groups believe that the Commission should authorize personal/portable devices, arguing that mobile applications will provide a key driver for economies of scale, and that fixed applications promoted by IEEE and others offer little hope for the economies of scale needed to produce genuinely affordable equipment.¹¹¹ The NAF also argues in separate technical comments that sensing can provide adequate interference protection to DTV receivers.¹¹²

67. Parties representing TV broadcast and other licensed service interests argue that spectrum sensing alone is insufficient to adequately protect licensed services.¹¹³ They contend that sensing alone would be ineffective for preventing devices from operating within the protected contours of co-channel and adjacent channel TV stations and that any sensing capability must be combined with geo-location.¹¹⁴ MSTV/NAB state that the current sensing proposals are inadequate to protect against co-channel interference and that a -116 dBm minimum threshold for sensing licensed signals would not guarantee that an unlicensed device would be outside a protected TV station's service area rather than in an area of weak signal strength within its service area.¹¹⁵ They further argue that the White Space Coalition's recommended detection threshold level of -114 dBm fails to account for important differences in antenna height between outdoor TV antennas and TV band devices, disregards real world propagation and building attenuation, and ignores the potential interference distance of a TV band device over which protection is actually required.¹¹⁶ MSTV/NAB also submitted a report on a signal measurement study in the Washington, D.C.-Baltimore, MD area (MSTV Study) that it states found signal levels below the -114 dBm and -116 dBm levels that have been discussed in this proceeding. The MSTV reports that it measured signal levels below -120 dBm.¹¹⁷ In its reply comments, the NAF argues that the measurements in the MSTV Study are unreliable due to issues with the way that the measurements were taken and systematic methodological errors.¹¹⁸

68. Motorola, McGraw Hill Broadcasting, and Media General also argue that spectrum sensing by itself would not provide adequate protection to users and devices that warrant protection.¹¹⁹ Motorola is also concerned that the sensing capabilities in devices would need to adapt to detect waveforms that may be devised in the future. The Grand Ole Opry and the Microphone Interests Coalition, the Professional Audio Manufacturers Alliance, and Shure submit that spectrum sensing is promising, but as yet unproven with respect to how it would work in the TV bands to protect incumbents,

¹¹⁰ See White Space Coalition *Further Notice* comments at 3.

¹¹¹ See NAF, et al. *Further Notice* comments at 83.

¹¹² See NAF *Further Notice* technical comments at 17.

¹¹³ See for example, Grand Ole Opry and Microphone Interests Coalition *Further Notice* reply comments at 4, IEEE 802.18 *Further Notice* comments at 6-7, and MSTV/NAB *Further Notice* comments at 9-10.

¹¹⁴ See MSTV and NAB *Further Notice* reply comments at 11.

¹¹⁵ See MSTV/NAB *Further Notice* comments at 11-13.

¹¹⁶ See MSTV and NAB *Further Notice* reply comments at 14.

¹¹⁷ See "DTV Signal Measurements in the Washington-Baltimore Area" MSTV, attachment to the MSTV/NAB comments on Commission's Initial Prototype Devices Report, August 15, 2007 (MSTV Field Study).

¹¹⁸ See NAF reply comments to the Commission's Initial Prototype Devices Report, September 4, 2007 at 12-17.

¹¹⁹ See Motorola *Further Notice* reply comments at 5, McGraw Hill Broadcasting *Further Notice* comments at 3, and Media General *Further Notice* comments at 2.

including wireless microphones.¹²⁰ These parties believe that the Commission should carefully study any use of spectrum sensing.¹²¹ GE Healthcare is not confident that spectrum sensing technology would provide adequate protection to medical telemetry equipment that operates in the TV bands.¹²² Shure initially recommended a detection threshold of -107 dBm for detection of wireless microphones, but in a subsequent *ex parte* submission stated that it now supports the White Space Coalition's lower recommended threshold of -114 dBm.¹²³

69. Several parties submit that spectrum sensing should be used as an adjunct to the geo-location method. For example, MSTV/NAB and IEEE 802.18 state that spectrum sensing is needed, but is insufficient on its own to adequately and completely protect licensed services. These parties argue that the geo-location and database approach are essential to ensure that unlicensed TVBDs operate outside the protected contours of both co-channel and adjacent channel TV stations and that sensing could be used to detect the presence of wireless microphones, which operate intermittently.¹²⁴ NCTA states that cable headends located outside a TV station's protected contour may receive signals that are undetectable at ground level using regular receiver technology. It believes that sensing alone is highly imprecise and will not ensure interference protection, so that sensing must be combined with some type of geo-location/database approach.¹²⁵

70. With the exception of the Community Broadcasters Association (CBA), there is very little support in the record for adopting a plan that would rely on control signals to provide unlicensed devices with a list of channels on which they could operate. The parties that addressed the control signal option generally submit that this approach would require the establishment of an expensive infrastructure.¹²⁶ The White Space Coalition and others are further concerned that potential control signal providers might not offer service unless they believe that the number of unlicensed devices would make it profitable to do so.¹²⁷ Opponents of the control signal approach also argue that there would be an inherent conflict of interest for TV licensees responsible for a database and signaling information that controls access to the band.¹²⁸ CBA supports the control signal approach and offers to have its member stations transmit control information.¹²⁹

71. *Discussion.* We find that the geo-location/database and spectrum sensing methods offer the most practical solutions for identifying unused TV channels and are therefore incorporating both of these methods into the rules for unlicensed TVBDs. Both of these approaches can be implemented using relatively cost effective technologies, although we do recognize that the database/system could involve an

¹²⁰ See Shure *Further Notice* reply comments at 5.

¹²¹ See Professional Audio Manufacturers Alliance *Further Notice* reply comments at 4.

¹²² See GE Healthcare *Further Notice* comments at 6.

¹²³ See Shure *Notice* comments at 14 *Notice Reply* comments at 7.

¹²⁴ See IEEE 802.18 *Further Notice* comments at 6, NAB and MSTV *Further Notice* reply comments at 11, and Shure *Further Notice* comments at 14-16.

¹²⁵ See NCTA *Further Notice* reply comments at 12-13.

¹²⁶ See for example, White Space Coalition *Notice* comments at 9-10.

¹²⁷ *Id.*

¹²⁸ See NAF, *et al*, *Notice* comments at 68-69, Tropos Networks *Notice* comments at 12-13, and White Space Coalition *Notice* comments at 9-10.

¹²⁹ See CBA *Further Notice* comments at 4.

ongoing cost for users of unlicensed TVBDs. We also find that spectrum sensing, as currently presented in our measurement studies of prototype devices, is not sufficient by itself to enable unlicensed devices to reliably determine the TV channels that are available for use at a location. However, we believe that spectrum sensing offers significant potential for use in detecting the signals of protected services and therefore should be included as part of the required means for identifying available channels.

72. At this time, the geolocation/database approach appears best able to reliably identify unoccupied TV channels. Geolocation methods such as GPS can accurately determine the location of an unlicensed device and a database system can compare that information to the location and service areas of fixed transmitters used by broadcast television and other licensed services. Once the distances between an unlicensed device and protected transmitters/service contours are established, adequate and reliable protection can be provided by applying standardized protection criteria.¹³⁰

73. We recognize the significant and pioneering work of those parties who developed and submitted devices for testing as part of our investigation of spectrum sensing in this proceeding. Their efforts and that process has contributed greatly to our understanding of the challenges involved in use of spectrum sensing to determine occupied channels in the TV bands. From our examination of the prototype devices we conclude that while signal detection can and should be used in identifying vacant spectrum for use by TVBDs, spectrum sensing with capabilities as presented in the record of this proceeding would not, by itself, be sufficient to adequately protect from interference television and other licensed services that use the TV bands. In this regard, we observe that sensing the signals of transmitters operated in the licensed services that use the TV bands is a challenging task, as reception of those signals is often limited by shielding from terrain and structures and by multipath and other fading phenomena. This task is especially difficult in the case of personal/portable unlicensed devices, which can be expected to be used indoors and at ground level.

74. As we observed in the *First R&O/Further Notice*, the facts that personal/portable devices have antennas that are less efficient for sensing and may be in a less advantageous position for sensing incumbent signals (*e.g.*, a short, non-directional antenna located in an interior room rather than a high gain antenna on a 10 meter mast) increases the difficulty of reliably detecting incumbent transmissions. With devices operating in such situations, the signal strength that appears at the receive antenna of a sensing device can be very weak, and in particular below the -114 dBm and -116 dBm minimum sensing levels suggested by the proponents and on which we requested comment in the *First R&O/Further Notice*.

75. Our conclusions on this issue are based on the following information and analysis for digital television service, the principal service that will operate in the TV bands on an ongoing basis. The basic principles and results of this analysis are also valid for the signals of wireless microphones and other services that use these bands. While we recognize that the DTV, analog TV, and wireless microphones each operate at minimum received signal levels, we are not specifying separate minimum sensing threshold levels for detection of their signals.¹³¹ Rather, we are adopting a single minimum required sensing detection threshold value for all TV band services at the minimum sensing level that appears to be technically feasible at this time that is adequate to protect authorized services operating in the TV band. We note that the commenting parties did not specifically address detection of analog TV signals. The rules will, however, require that the sensing feature of unlicensed TV band device detect and

¹³⁰ The specific protection criteria for licensed services are discussed in the section below on protection of broadcast television and other services.

¹³¹ The service threshold values for signals in the UHF TV band are: DTV signals -84 dBm, analog TV -63 dBm, and wireless microphones -87 dBm.

protect analog TV services because low power analog TV stations will continue to operate after the end of the DTV transition.

76. As discussed above, the threshold signal level for digital TV service in the UHF band is -84 dBm/6 MHz at the terminal of a DTV receiver.¹³² The DTV service model assumes that signals are received off-the-air by an antenna with 10 dBd gain that is mounted at 10 meters above ground (about 33 feet).¹³³ To model an unlicensed personal/portable device, we assume that the device will be used indoors on a first floor location and receive signals with an omnidirectional (0 dBi gain) antenna. Several models for assessing the difference in TV signal levels between an outdoor TV and an indoor personal/portable device were presented in the record. For example, NAB/MSTV submit that signals received by a personal/portable device will be 27-32 dB below those received with an outdoor TV antenna (10 dB antenna gain + 7 dB antenna height + 10-15 dB for building penetration = 27-32 dB).¹³⁴ The White Space Coalition bases its proposal for a sensing threshold of -114 dBm/6 MHz on the assumption of up to 30 dB difference between the location of a TV antenna and an unlicensed device.¹³⁵ The NAF appears to indicate, based on an engineering assessment submitted with its technical comments, that this difference is 26-31 dB.¹³⁶ Motorola submits that the received signal level at an indoor white space device would be 18-39.5 dB lower than that received by an outdoor TV antenna (10-16.5 dB antenna height + 3 dB polarization mismatch + 5-20 dB or more building penetration = 18-39.5 dB).¹³⁷ As reflected in these different models and empirical studies, there will plainly be significant variation in the signal attenuation from rooftop to indoor locations across different sites (and even at different locations indoors at the same residential site). To simplify our analysis here, we will begin by assuming a moderate level of attenuation as represented by these models, or 30 dB (we do recognize that in many cases this difference can be significantly higher). Thus, the -84 dBm DTV minimum service threshold less the 30 dB difference between an outdoor TV antenna and an indoor white space device antenna yields a signal level that corresponds to the -114 dBm/6 MHz minimum sensing threshold suggested by some parties in the record.

77. If a TV station's signal were always at or above 41 dB μ V/m (-84 dBm) within its service area and the difference in received signal level between an outdoor antenna and an indoor white space device antenna were always 30 dB or less, it could be anticipated that a white space device with a

¹³² Most DTV stations operate on UHF frequencies. Other analytical values are appropriate for use in evaluating a minimum sensing threshold for the high VHF and low VHF bands (see below), but our conclusion on the issue of whether sensing should be permitted to be used as the only means of determining the availability of channels for use by white space devices can be adequately explained by only examining signals in the UHF band.

¹³³ See *Sixth Report and Order* in MM Docket No. 87-268, 12 FCC Rcd 14558 (1997) at ¶¶ 183-195 and Appendix B; see also "OET Bulletin No. 69, Longley-Rice Methodology for Evaluating TV Coverage and Interference," FCC Office of Engineering and Technology, February 6, 2004 at Table 4 (OET-69 is available at http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet69/oet69.pdf). Using this receive system model, the -84 dBm signal strength (in milliwatts) needed for UHF service at the receiver terminal means that the minimum field strength (in microvolts) needed to receive a signal is 41 dBu. The formula for this model and the conversion of received field strength into signal strength is provided in OET-69, page 4.

¹³⁴ See *MSTV Further Notice* comments at footnote 29 and written *ex parte* submission, May 21, 2007.

¹³⁵ See *White Space Coalition Further Notice* comments at 6

¹³⁶ See *NAF Further Notice* technical comments at 17. The NAF specifically states that it "believes a sensitivity level in the range of -110 to -115 dBm should be adequate to protect TV receivers given mobile powers of 100 mW." We subtracted -84 dBm from these figures to obtain the values indicated above, but recognize that the NAF may have considered other factors in their suggestion for a minimum sensing threshold.

¹³⁷ See *Motorola* written *ex parte* presentation of October 18, 2007 at 17-20.

minimum sensing level of -114 dBm would be able to reliably detect the presence of a TV station's signal within the station's service area. However, in practice there will be cases where 1) a station's signal is below 41 dBu within its service area, and 2) the difference in received signal level between an outdoor and indoor antenna at the same structure/location will exceed 30 dB. In either case, if the deficiency in signal level is not offset by an equal or greater signal level in the other component, then the signal level of the TV station received at the white space device will be below -114 dBm. For example, a signal as received at an outdoor antenna is 35 dB μ V/m (6 dB less than the service threshold), then the signal could still be detected at -114 dBm if the signal attenuation between the outdoor and indoor receive antenna positions were 24 dB rather than 30 dB.

78. With regard to the variability of signal levels across different sites, it is well established that there are locations within DTV stations' F(50,90) noise-limited service contours where their signals are below the level needed for service such that service is not available. Such locations are likely to occur in more distant portions of TV station service areas and certain other locations within a station's service area where, due to shielding by terrain or structures ("hidden nodes"), the station's signal will not be strong enough to be received under the standard TV service model. The definition of the service area of a DTV station in Section 73.622(e) of the rules specifically recognizes that a TV station's signal will not be available everywhere within its service area. That definition provides that "[t]he service area of a DTV station is the geographic area within the station's F(50,90) contour where its signal strength is predicted to exceed the noise-limited service level."¹³⁸ Congress also recognized that TV signal levels will be below the service threshold at individual locations in the Satellite Home Viewer Extension and Reauthorization Act of 2004 (SHVERA).¹³⁹ Section 204 of the SHVERA directed the Commission to conduct an inquiry on whether the Commission should revise its digital TV signal strength standards and signal measurement procedures used to identify if a household is "unserved" for purposes of the satellite copyright license for distant signals.¹⁴⁰ In response to this statutory charge, the Commission issued a *Notice of Proposed Rulemaking* proposing to amend its rules to include procedures for measuring the field strength of digital television signals at individual locations.¹⁴¹ The variability of TV signal strengths across different nearby locations recognized in these established regulatory and statutory provisions is also apparent from the field studies in the record of this proceeding.¹⁴²

79. Further, as demonstrated by the various field measurement studies in the record of this proceeding, the signals of TV stations in particular vary substantially over short distances within the

¹³⁸ 47 C.F.R. § 73.682(e). Section 73.622(e) further provides that "[w]ithin this contour, service is considered available at locations where the station's signal strength, as predicted by the Longley-Rice propagation model, exceeds [the noise-limited service levels]."

¹³⁹ The Satellite Home Viewer Extension and Reauthorization Act of 2004, Pub. L. No. 108-447, § 204, 118 Stat 2809, 3393 3423-24, (2004), codified at 47 U.S.C. §339(c)(1). The SHVERA was enacted as title IX of the "Consolidated Appropriations Act, 2005."

¹⁴⁰ On December 9, 2005, as required by Section 204(b) of the SHVERA, the Commission issued a *Report to Congress, "Study of Digital Television Field Strength Standards and Testing Procedures"* (SHVERA Report), ET Docket No. 05-182, 20 FCC Rcd. 19504 (rel. Dec. 9, 2005).

¹⁴¹ See *Notice of Proposed Rulemaking* in ET Docket No. 06-94, 21 FCC Rcd 4735 (2006) at ¶ 5. Therein, the Commission indicated that while these measurement procedures would be generally applicable for measuring digital TV signal strengths, they would specifically be used in determining if a household is served by a digital television signal as part of an evaluation of the household's eligibility to receive a distant digital network signal from a satellite television provider.

¹⁴² See The White Space Coalition's written *ex parte* presentation "Microsoft/Philips Field Tests" Report of September 20, 2007; see also MSTV Field Study.

station service areas. These studies provide empirical indication that there is considerable variability in the difference in signal levels received with an outdoor antenna at about 9 meters and with an indoor antenna at differing positions within a structure. For example, the MSTV Study (notwithstanding the concerns expressed with respect to certain aspects of its methodology), a study of DTV signals at residences submitted by the NAF, and White Space Coalition's Microsoft/Philips Field Tests report consistently show that there is substantial variation in the DTV signal levels outdoors and indoors at a residence that are consistent with the models discussed above.¹⁴³ These studies also show variation within residences of as much as 20 dB and in a few cases more. If we take the middle of this range of variation to be the signal level as that which would be determined using the 30 dB difference between an indoor and an outdoor antenna, then some locations would receive signals 10 dB higher and some would see signals 10 dB lower.¹⁴⁴ At those positions within a structure where the signal level is below the middle level (up to 10 dB lower, taking half the 20 dB range), the signal level in our model would be lower than -114 dBm and as low as -124 dBm or less. At any of these levels, the signal would plainly not be detectable by a device that can only sense down to -114 dBm; a device that could sense as low as the -116 dBm level we suggested in the *First R&O/Further Notice* would also not be adequate to reliably detect TV signals. As discussed below, it is also possible that the station's signal at a nearby location would be strong enough to provide service, in which case interference could occur if an unlicensed device were to transmit.

80. The White Space Coalition contends that interference protection should not be afforded at locations where a TV signal is too weak to be received.¹⁴⁵ It argues that the touchstone of a claim of interference is whether that interference negatively impacts a signal that would otherwise produce a viewable picture. We generally agree that interference protection should not be afforded where service is unavailable and our rule defining DTV service areas does not include areas within a station's noise-limited contour where its signal is predicted to be below the threshold of service.¹⁴⁶ However, we also recognize that the signals of a low power unlicensed device operating at a location within a TV station's noise-limited contour where the station's service is not available also could reach areas where service is in fact available and thereby cause interference. The information above establishes that the distances between locations where service can be received and those where service cannot be received can be short. We therefore conclude that a device operating within a TV station's noise-limited contour at a location

¹⁴³ With respect to its indoor measurements, the MSTV Study showed significant variations in the field strength of local TV stations in different rooms and outdoors at ground level at residential locations within the stations' service areas, while at the same time reception was generally available on the homes' DTV receiving system. *See also* Attachment to NAF Technical comments, "White Spaces Engineering Study: Can Cognitive Radio Technology Operating in the TV White Spaces Completely Protect Licensed TV Broadcasting?" Working Paper #16, (NAF Study) Mark Sturza and Farzad Ghazvinian, January 2007. The NAF conducted field tests at three residences located 25-26 miles from local DTV station transmitters (these sites would be expected to be moderate field strength locations) and found variations in DTV field strengths within individual residences of 39.1 dB, 35.3 dB, and 22.4 dB. The White Space Coalition's "Microsoft/Philips Field Tests" Report of September 20, 2007 indicated a number of instances in which DTV signal strengths varied by more than 20 dB at different locations within a building/residence and one site where the DTV signal variation within a room was more than 30 dB. *See* "Microsoft/Philips Field Tests," presented to OET September 20, 2007 (PowerPoint presentation).

¹⁴⁴ We understand that an argument could be made for using the highest level of the 20 dB range in indoor measurements as the signal level that would be determined using the 30 dB difference between an indoor and an outdoor antenna. However, use of the middle of this range provides a conservative analysis and does not change the basic conclusion of our analysis in any case.

¹⁴⁵ White Space Coalition *Further Notice* reply comments at 9-10.

¹⁴⁶ 47 C.F.R. § 73.622(e).

where the station's service is not available could nonetheless cause interference at locations where the station's service is available.

81. The variability of propagation over short distances also makes it impractical to evaluate the likelihood that a device located at any given location would cause interference. There will also be cases where, due to the approximate nature of predictive models, service will be available and received at locations within a station's noise-limited contour where service is not predicted to be available. We find that service to these viewers should be protected the same as viewers in locations where service is predicted to be available. Therefore, to ensure that TV service is properly protected, we will assume that a device operating on the same channel as a TV station could cause interference if it were located anywhere within a station's noise-limited contour.

82. In considering the role of spectrum sensing in detecting licensed signals in the TV bands, we are aware that sensing technology for consumer products, including the minimum threshold level needed to detect licensed signals in these bands and algorithms for reliably detecting DTV, analog TV, and wireless microphone signals at any sensing level, is still in its nascent stage. The performance of the white space development devices that we tested showed significant potential but also demonstrated the need for additional work on solutions for handling the significant dynamic range of signal field strengths that characterize the service in the TV bands. The devices examined in our Laboratory's measurement program were not able to sense with a high degree of accuracy both TV and wireless microphone performance in different real world environments where signals are subject to different levels and forms of fading, multipath, and other degradations. In particular, our measurement studies found that while the prototype devices were generally able to detect "clean" TV and wireless microphone signals on a channel with no other signals present, their ability to reliably detect unoccupied channels degraded to levels we consider unsatisfactory when the test signals included multipath and other fading effects and when signals were present on other channels. The performance of the devices was observed to degrade substantially and at increasing levels as the level of the signals on adjacent channels was raised. Both fading and relatively stronger signals on adjacent channels are a normal part of the signal conditions in the environment of the TV bands and any device that uses spectrum sensing to determine whether a channel is occupied will have to be able to perform reliably when such conditions are present.

83. We also find unconstructive sensing performance that incorrectly determines all or nearly all unoccupied channels to be occupied, that is the device finds all occupied channels and all or nearly unoccupied channels to be occupied. While a device that returns such results could be seen as minimizing the potential for interference to authorized services, it would not be practically viable because it would allow its transmitter to operate on very few channels or perhaps none.

84. In view of these results, we believe that much more developmental work needs to be accomplished before the spectrum sensing technique can be implemented as the principal means of identifying unoccupied channels in the TV bands, even in the case of fixed unlicensed devices that use outdoor antennas. Thus, we are not convinced that spectrum sensing as currently presented could adequately serve as the only means to protect TV services and other fixed protected contour services from interference by unlicensed TVBDs operating at the power levels proposed in the *Notice*. Coupled with this concern, we also observe that the significant distances at which interference could occur from an unlicensed TVBD operating at greater than 100 mW would make it very difficult to identify the TVBD as the source of the interference.¹⁴⁷

¹⁴⁷ Using the TM90 propagation model (this model is for short distances and low antennas), for the situation in which an indoor unlicensed TV band device would impact an outdoor DTV antenna at 30 feet, our staff calculates that a 100 mW signal could cause interference at a distance of 1400 meters in locations where the DTV co-channel D/U ratio is 23 dB and at a distance of 900 meters in locations where the DTV co-channel D/U ratio is 15 dB. *See* (continued....)

85. In view of these concerns, we will rely principally on the geo-location/database method to protect incumbent fixed services from interference from TVBDs. The service areas of fixed transmitter TV and low power TV stations, PLMRS/CMRS operations, production locations that use wireless microphones, and other operations with defined operating areas do not change often and their channel numbers, transmitter geographic coordinates, and other operating parameters can be stored in a database. The protected service contours of these fixed transmitter services are clearly defined and can be calculated from information in the database. Therefore, it is a relatively straightforward for an unlicensed TVBD with geo-location capability to access a database system which would determine whether the TVBD is sufficiently far outside the protected service areas of licensed TV band services to ensure that it will not cause interference to those services. Accordingly, we will require that all TV band devices use a geo-location and database approach to determine unused TV channels in their area on which to operate or to operate as a client to a device that has obtained a list of the unused channels using that method.

86. As the location of a fixed device does not change, it is only necessary to determine the device's location once, at the time of installation and first activation, after which the device's coordinates can be stored internally. We will therefore allow the geo-location function for fixed devices to be performed by either an incorporated geo-location capability or a professional installer. In the case that the stored coordinates in a fixed device become corrupted, it will be necessary for the operator to re-activate the devices internal geo-location function or for a professional installer to re-enter those coordinates in the device. Personal/portable devices operating on an independent basis (which will require use of a geo-location capability) will be required to re-establish their position each time they are activated and to re-verify their position with the database on a regular basis. Personal/ portable devices operating on a client basis (which will not require use of an internal geo-location capability) will also be required to receive the list of available channels in their area from a fixed device or personal/portable device operating in Mode II that has determined the available channels in the area through the geo-location and database method and controls the frequencies on which the personal/portable device operates.

87. We also recognize that a personal/portable device operating independently and on battery power could be relocated from its activation point to a different location where the available channels are different without being deactivated in the period before it re-verifies its location with the database. In such cases, the device could operate on a channel in use by a licensed service and cause interference. We will therefore require that personal/portable devices operating in Mode II access the database each time their geolocation feature detects that the device has been moved. In addition, to ensure that personal/portable devices operating in Mode II are always under control of geolocation, we will require that they cease transmitting at anytime they are not able to determine their location.

88. We recognize that requiring access of and, in the case of fixed devices, registration with a database will increase the costs of unlicensed TV band devices, both from the increased complexity of the devices and the potential for the database administrator to charge fees necessary to support its operations and will also reduce the manufacturer's flexibility in designing these devices. However, we believe that given the available alternatives, requiring use of geo-location and a database for fixed TV band devices is necessary to ensure protection of the licensed television and other services that operate in the TV bands. We will also permit parties to petition us to review any fees that appear to be excessive.

89. As discussed below in the Database Requirements section, we will require that the database administrator include in the database records on the fixed incumbent licensed users of the television band,

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"Propagation in Suburban Areas at Distances less than Ten Miles," William Daniel and Harry Wong, January 25, 1991. We also note that the anecdotal transmitter tests at our Laboratory showed co-channel interference at 360 meters (1180 feet), which was the maximum possible separation that could be achieved at the Laboratory.

including full service and low power television stations, PLMRS/CMRS, BAS links, and Offshore Radiotelephone Service stations. We also understand that there are many facilities that use low power auxiliary devices such as wireless microphones on a regular basis. In addition, cable headends and low power TV receive sites located outside of TV station protected service contours often use high gain antennas mounted on towers and/or at high elevation to receive TV signals and then distribute them to large numbers of subscribers and viewers. We believe that it would be appropriate to extend the protection afforded by the database system to cable headends and will therefore provide for registration of such facilities in the database. In addition, we will allow the operators of event and production facilities where low power auxiliary devices such as wireless microphones are regularly used to register those sites in the database.

90. Fixed and Mode II personal portable unlicensed TV band devices will access the database over the Internet and provide it with their location. The database system will then calculate which television channels are available for use by TV band devices at their location based on the information in the database and return a list of those channels to the TV band device. The database will register unlicensed fixed devices and record appropriate information, including the devices' location and user contact information. Personal/portable devices operating on either a client or independent basis will not need to be registered in the database. The registration information for fixed stations will be available to entities recognized by the Commission to assist TV band device users in coordinating efficient use of the available television channels at a particular location. In addition, the registration information could be used to assist the Commission or its designated agents in the identification of the source of any interference to licensed services from TV band devices. We are not specifically requiring professional installation of fixed unlicensed TVBDs or the use of GPS or any particular location technology in a fixed station. Our concern is with the accuracy and reliability of the location information, rather than the method used to obtain the information, and we believe that the requirement that a device not operate until and unless the geo-location/database process has been completed will be sufficient to ensure that devices are provided a reliable list of the channels used by TV and other licensed fixed transmitters in their area.

91. In order to ensure that fixed unlicensed TV band devices with radio-based geolocation capabilities are able to receive GPS or other location signals, we are requiring that the receive antenna for the geo-location function be located outdoors and at the same location as its subject TVBD transmitter. Personal/portable devices operating in Mode II with radio-based geolocation capabilities in most cases will also need to be located outdoors to receive geolocation signals; we will allow these devices to receive such signals through a separate antenna that is located outdoors.¹⁴⁸ We also find that the 10 meter accuracy we proposed to specify for the geo-location capability, while well within the capabilities of the GPS system, would be more accurate than is needed for purposes of identifying the locations of unlicensed TVBDs. We are also concerned that requiring accuracy to 10 meters might preclude the use of other options for geo-location that are less accurate than GPS but would still provide an adequate degree of accuracy. We believe that 50 meters is a reasonable degree of accuracy for the geo-location capability used to determine the coordinates of unlicensed TV band devices. The effectiveness of the separation distances we are providing for TV and other services are adequate to provide protection in an environment where location errors of up to 50 meters may occur. Also, an accuracy of 50 meters is readily achievable using commonly available methods such as GPS and will also provide flexibility for use of alternative geo-location methods. In the case of professional installation, the party who registers the fixed station in the database will be responsible for assuring the accuracy of the entered coordinates.

¹⁴⁸ If the separate antenna became detached such that the Mode II personal/portable device is no longer able to determine its location it will be required to cease transmitting.

92. We will require that unlicensed TVBDs incorporate spectrum sensing capabilities to complement their geolocation/database access capabilities in determining channel availability. TVBDs that sense wireless microphone operations on a TV channel will not be allowed to transmit on that channel. We will also require that devices that detect a TV signal on a channel must cross-check with the channel availability report from the database to verify that the device is within the service area of a TV station on that channel at the device's location. If the channel is reported by the database as available at that location, *i.e.*, the device is not within the service areas of any TV stations that use that channel, then the device will be required to notify the user that the channel appears to be occupied.

93. We also recognize the position of IEEE 802.18, Shure, and others that the geolocation/database method is not suitable for identifying channel occupancy by devices such as wireless microphones that operate on an intermittent, occasional, or one-time basis at locations not identified in the database. Wireless microphones are licensed on an area basis, rather than specific geographic coordinates. A wireless microphone user may operate anywhere in that area and choose a frequency from multiple vacant channels available for operation. It is not practical to require that the locations of wireless microphones that are used in this manner be included in the database. There may also be TV stations and other regularly operating TV band licensed stations on the air in an area that for some reason are not in the database. We agree with Shure and others that spectrum sensing is the most reasonable and appropriate approach for detecting the presence of TV band services that operate on an intermittent basis or are not in the database. The prototype devices developed by the White Space Coalition, Motorola, Google and others indicate that work is under way to improve the performance of this technology in sensing wireless microphones and we believe that, at this time, it is satisfactory as a complement to the database system and for providing a capability for the detection of unregistered wireless microphone operations. Accordingly, we will require that all unlicensed TV band devices incorporate a spectrum sensing capability to detect wireless microphones and to use that capability in determining the available channels in their area.

94. Television signals and wireless microphone signals use different amounts of bandwidth and modulation methods and TVBDs can thus differentiate between them.¹⁴⁹ In cases where a TVBD detects a wireless microphone operation on a TV channel, the device will not be allowed to operate on that channel. In cases where a TVBD detects the signal of a digital or analog TV station, we recognize that it is possible that the signal is being detected outside of the station's service area. In such cases we will not protect the TV service; rather, we will only require TVBDs to protect TV signals within a station's service areas, except relative to cable head-ends and translator sites as indicated below. Thus, if a device detects a TV signal we will require the device to avoid operation on that channel only if the database also provides information that the device is within the protected range of a TV station. Where a TVBD detects a TV signal outside of the protected range of any TV station, we will require that the device notify the user and provide a capability for the user to manually, at his or her discretion, set the device to avoid operating on that channel. This feature will allow users to avoid operating their TVBDs on channels where out-of-service area TV signals are being received locally. Thus, the geolocation/database process will control the list of available channels at a location within a TV station's service area and device users will have the option of avoiding additional channels detected outside of any station's service area.

¹⁴⁹ A TV signal occupies essentially all of a 6 MHz TV channel whereas a wireless microphone occupies only a 200 kHz segment of a TV channel (multiple wireless microphones can use a single TV channel). In addition, wireless microphones use different analog and digital modulation methods than the analog and digital modulation methods used for television transmissions.

95. Based on the submissions of Shure and IEEE.802.18 on the minimum sensing thresholds needed, our testing of the prototype devices, and the practical limits of sensing indicated in *ex parte* discussions with representatives of the White Space Coalition and other prototype developers, we conclude that sensing at a -114 dBm minimum detection threshold is appropriate and feasible to protect wireless microphones and the signals of other services that operate in the TV bands on an intermittent basis and for detecting TV stations that do not appear in the database for whatever reason.¹⁵⁰ This minimum sensing threshold will provide the maximum likelihood of detecting the signals of licensed services, and particularly wireless microphones, in the area of an unlicensed TVBD that is consistent with manufacturing economics. In this regard, we believe that it is best to require use of the most sensitive level of detection capability that is economically feasible for sensing the signals of all services. Given that wireless microphones operate in relatively narrow bandwidths and that both wireless microphones and analog TV signals have distinctive signal characteristics, we also believe that the -114 dBm level we are adopting will provide the same or better protection in detecting wireless microphones and analog TV signals as digital television signals. Additional discussion of our decision on the minimum spectrum sensing threshold is provided in the section below on technical requirements.

96. We also anticipate that use of sensing under both the client and independent mode approaches for personal/portable devices will allow manufacturers to gain experience with sensing that could be used to develop improvements in such capabilities that could then perhaps justify greater reliance on spectrum sensing for determining whether TV channels are occupied. Personal/portable devices operating in the client mode will also be required to pass information on any signals that they sense back to the master device and the master device will then take appropriate steps with respect to its list of available channels to avoid the channel sensed by client devices. That is, if the client device senses a wireless microphone on an otherwise available channel the master device will be required to remove that channel from its list of available channels. If the client device senses a TV station on a channel outside the service areas of any TV stations, the master will be required to notify the operator and provide the option to remove that channel from the devices list of available channels. In the sections below, we present the specific provisions of our rules for operating under the above plans for determining whether TV channels are occupied or unoccupied, including the minimum required distances that devices using the geo-location/database method must be from the protected contours of licensed services and the requirements for spectrum sensing of wireless microphones.

97. While we continue to believe that the control signal approach has merit as a means to communicate available channels to unlicensed TVBDs, we also recognize the practical constraints that lead the commenting parties to oppose this approach and will not include a control signal element in the rules we are adopting.¹⁵¹ We would, however, revisit this option if the economics or other circumstances develop in a manner that would favor the viable operation of a control signal system.

¹⁵⁰ See Shure Notice comments at 14 and IEEE 802.18 Further Notice comments at 9. We also note that the White Space Coalition recommended a minimum sensing threshold level of -114 dBm in their comments responding to the Further Notice, at 7. While a sensing threshold of -114 dBm may not identify a TV station not in the database at every location within the station's service area, the station's signal will be above that level at enough locations that its presence will be identified and reported to the database administrator so that the database can be corrected. We note that a -114 dBm detection threshold in 6 MHz is equivalent to -132 dBm in a 100 kHz bandwidth.

¹⁵¹ Although we appreciate the CBA's offer that its member stations could serve as control signal transmitters, its member stations could not provide the near ubiquitous coverage that would be needed to support a viable control signal system for unlicensed TVBD devices.

98. We also do not believe it is necessary to require that unlicensed devices recognize and respond to beacon signals that would carry information on channels to avoid at events using wireless microphones, as requested by Shure and others representing wireless microphone interests. We believe that other actions we are taking in this matter, including restricting unlicensed personal/portable devices from operation on channels 2-20 and adjacent channels used by TV and providing for registration of sites that use wireless microphones in the database, will ensure that wireless microphones are able to operate without receiving interference from unlicensed TV band devices. We are concerned that such beacon signals would occupy spectrum that could better be used for radio service operations themselves and would impose an additional and unnecessary cost on licensees.

2. Fixed Devices

99. In the *Notice*, the Commission anticipated that fixed unlicensed TVBDs would, in general, be used by WISPs and others as base stations to provide Internet access and other broadband data services to homes and businesses, including service to both fixed and personal/portable services. It therefore proposed to allow fixed TVBDs to operate under the same technical provisions as digital transmission systems that operate under Section 15.247 of the rules.¹⁵² Under those provisions, fixed unlicensed TV band devices would be permitted to operate with transmitter output power up to 1 watt and to employ higher gain directional antennas, with requirements for transmitter output reductions for antennas with gains above 6 dBi. This would allow fixed devices to operate with the equivalent to an EIRP of 4 watts. The Commission further proposed to require that such devices automatically and periodically transmit a unique identification so that any harmful interference situation, should one occur, could be quickly identified and remedied. It also sought comment on whether these devices should be subject to routine evaluation for RF exposure.¹⁵³ The Commission requested comment on whether additional requirements would be appropriate for fixed unlicensed TVBD operations. In particular, it asked whether it should require that all fixed devices be registered with an industry-accepted entity, such as a frequency coordinator, that maintains a registration database of all fixed transmitters along with their operating frequencies.

100. As indicated above, in the *First Report and Order* the Commission decided to allow fixed low power devices to operate in the TV bands, subject to final technical rules to be adopted in this subsequent action to ensure that they do not cause interference to authorized services within the TV bands.¹⁵⁴ It gave several reasons for reaching this decision. First, there will be significant unused spectrum available in many parts of the country after the DTV transition, either because of the minimum separations required between authorized stations to avoid interference or because available TV channels have not been assigned (due to lack of demand) and other services are not using those vacant channels. The Commission also found it reasonable to expect that existing technology can be adapted to allow devices to identify unused spectrum in a given geographic area, and noted that the IEEE 802.22 Working Group was in the process of developing a standard to enable fixed devices to successfully share spectrum with authorized services in the TV bands.

101. With respect to transmit power, Shure believes that fixed devices should be limited to 1 watt conducted power and 4 watts EIRP.¹⁵⁵ IEEE 802 supports the proposed power limits and states that

¹⁵² See *Notice* at ¶ 25; see also 47 C.F.R. § 15.247(b)(3).

¹⁵³ See 47 C.F.R. §§ 1.1307(b) and 2.1091.

¹⁵⁴ See *First Report and Order* at ¶ 17.

¹⁵⁵ See Shure *Notice* reply comments at 20.

it may be possible to increase them in the future.¹⁵⁶ CWLab believes that a fixed system using an antenna with a beamwidth of less than 120 degrees should be allowed an EIRP of 25 watts, while Shared Spectrum Company believes that fixed network systems should be permitted peak power levels of 10 watts.¹⁵⁷ The Society of Broadcast Engineers, on the other hand, argues that 4 watt EIRP devices are not low power products and that they would not be suitable for unlicensed Part 15 operation because they would inevitably cause interference to broadcast TV and other stations operating in the TV bands. It believes that the proposed power limit should be reduced by a factor of 100 (20 dB) for TV band devices to be rightfully characterized as Part 15 products.¹⁵⁸ A number of parties express support for the IEEE 802.22 model for fixed operation.

102. MSTV/NAB believe that the Commission should develop rules for fixed operation based on IEEE 802.22's draft plan for fixed access, including its prohibition on co-channel and first adjacent channel operation and use of a combination of geo-location and spectrum sensing to determine channel availability. In that plan, spectrum sensing would be employed as an added rather than sole protection. MSTV/NAB state that this approach would enable a broadband plan without endangering television reception.¹⁵⁹ Cox Broadcasting, ION Media Networks, McGraw-Hill Broadcasting and Media General also believe that if the Commission allows fixed operation, then it should follow the IEEE 802.22's recommendations.¹⁶⁰

103. Microsoft believes these devices should be exempt from routine evaluation for radiofrequency (RF) exposure. It states that the proper RF exposure context for unlicensed TV band fixed devices is a device with 1 W transmit power and a $5\lambda/8$ vertical antenna in an occupational/controlled environment and mounted on a tower or roof. Microsoft states that to reach the maximum permissible exposure (MPE) limit, an individual would have to remain within one inch (six inches for a high power device) of the antenna of a device operating at maximum transmit power and at 100% duty cycle for a period of 6 minutes. It states that this is not likely to happen in the real world.

104. *Discussion.* We are adopting rules for fixed TV band devices that are based on a system architecture model that is generally similar to the model being developed in the IEEE 802.22 Working Group. Under the plan we are adopting, unlicensed TVBDs will be allowed to provide wireless broadband services, *e.g.*, wireless Internet access, and other services using multiple vacant TV channels and will be permitted to operate on a fixed, point-to-point or point-to-multipoint basis. A fixed system will consist of a permanently located base station transmitting to one or more fixed devices or to personal/portable end user devices.

105. As proposed, we will generally limit fixed unlicensed TV band devices to a peak transmitter output power of one watt with a maximum antenna gain of 6 dBi and require that transmitter power be reduced by the same amount in dB that the maximum antenna gain exceeds 6 dBi. This will allow fixed unlicensed TVBDs to operate with the equivalent of 4 watts EIRP. If the maximum antenna gain exceeds 6 dBi, the transmitter power will be required to be reduced by the amount in dB that the antenna gain exceeds 6 dBi so that the EIRP does not exceed 4 watts. Transmitter power will be

¹⁵⁶ See IEEE 802.18 *Notice* comments at 6.

¹⁵⁷ See CWLab *Notice* comments at 3 and Shared Spectrum Company *Notice* reply comments at 5.

¹⁵⁸ See Society of Broadcast Engineers *Notice* comments at 1.

¹⁵⁹ See MSTV/NAB *Further Notice* comments at 33.

¹⁶⁰ See Cox Broadcasting *Further Notice* comments at 4, ION Media Networks *Further Notice* comments at 3, McGraw-Hill Broadcasting *Further Notice* comments at 3, and Media General *Further Notice* comments at 2.

measured at the antenna input to account for any cable losses between the transmitter and the antenna. We continue to believe that 4 watts EIRP is sufficient to allow fixed devices to communicate at ranges that will serve community and rural users while minimizing the potential for interference to broadcast television and other authorized services in the TV bands. These power/antenna limits are the same as those permitted for spread spectrum transmitters operating in the 915 MHz band under Section 15.247 of the rules and have proven sufficient for WISPs to provide broadband services in that higher frequency band. Because the TV band frequencies are below 915 MHz and have better propagation characteristics than higher frequencies, operation at the power levels we are adopting will allow improved coverage for wireless broadband service providers.

106. We also recognize that there are advantages, such as reduced infrastructure costs and increased service range, to operation of unlicensed TVBDs at even higher power levels. We will not, however, generally allow operation of these devices at power levels greater than 4 watts EIRP for two reasons. First, operation at higher power levels would increase the risk of interference in congested areas and thus could make sharing spectrum between TV band device users more difficult. This concern extends to higher EIRP levels using high gain antennas with narrow beamwidths, as such effective power levels would pose greater interference potential in the direction of the antenna's main beam. Second, inasmuch as we do not have experience with unlicensed wireless broadband operations in the TV bands, we find it prudent to take a more cautious approach in setting power limits to minimize the risk of interference to authorized users of the TV bands. Nevertheless, the Commission will further explore in a separate Notice of Inquiry whether higher powered unlicensed operation might be accommodated in the TV white spaces in rural areas.

107. With respect to SBE's concern that 4 watts EIRP is too high for an unlicensed device and could possibly result in interference to broadcast and auxiliary stations, we believe that other aspects of the plan we are adopting adequately address this concern. In particular and as discussed below, we are requiring TV band devices to incorporate specific interference avoidance features to prevent interference to authorized users in the TV bands and the technical parameters for those features were developed based on the 4 watt EIRP power level. We also believe that the requirement for fixed devices to operate at outdoor locations will provide sufficient separation from consumer TV receivers to avoid direct pick-up interference from their operations to cable service.

108. In order to ensure that unlicensed TV band fixed devices can be identified if interference occurs, we are requiring that all such devices transmit identifying information and be registered with the database system. The identification signal will be required to conform to a standard established by a recognized industry standards setting organization. We will expect the identification signal to carry sufficient information to identify the device and its location.

109. Devices must be designed so that they will not transmit (beyond the brief messaging necessary to complete the registration process in the case of a device connecting to the internet through another fixed device) unless they are currently registered and have received an authorizing response from the database system. To register a fixed device, the party responsible for the device will be required to provide the database system the device's FCC identifier (FCC ID) and serial number, the geographic coordinates of the device's location (from the geo-location capability), the responsible party's name, the name of a contact person, and the contact's address, e-mail address and telephone number. The required registration can be accomplished the first time the device accesses the database to determine the available channels in its area. While registration in the database system will pose some additional burden, we observe that manufacturers of internet access equipment and computing software now typically request that users register their equipment or software purchase with its manufacturer/producer. Thus, systems with registration capability are already widely in use and both manufacturers and users are familiar with registration procedures. The process to be implemented by the database operator for registering unlicensed TV band fixed base stations is expected to be similar to these existing registration procedures.

We therefore do not believe that it will be unduly burdensome to develop or comply with this registration procedure.

110. We note that the IEEE 802.22 draft standard does not provide for fixed devices to communicate with personal/portable devices. However, under the rules we are adopting, fixed TVBDs will be allowed to communicate with personal/portable devices operating independently or using a master/client model. We believe that allowing communications between fixed and personal/portable devices will significantly enhance the service benefits of both types of TV white space devices. In this regard, a fixed base will be able to provide direct internet access and other services that may be developed to a large number of personal/portable devices within its service range.

111. For purposes of these devices, we are defining the terms “master” and “client” as we have for other types of Part 15 devices.¹⁶¹ That is, a master device is one that operates in a mode in which it has the capability to transmit without receiving an enabling signal, to select a channel, and to initiate a network by sending enabling signals to other devices. A client device is one whose transmissions are under the control of the master and is not able to initiate a network. A network always has at least one device operating in master mode and also some devices that may be capable of operating only in client mode and some devices that may be capable of operating in either mode. All fixed TVBDs will be allowed to operate in master mode. Those personal/portable devices communicating on a master/client basis with a fixed device will be required to use channels/frequencies as directed by the fixed device. Thus, a personal/portable device operating under this arrangement will pose no more risk of interference to a licensed service than the fixed device, and because it will use less power will generally pose less risk of causing such interference. We note that, because the fixed master device will not transmit if its service area would cause harmful interference to a licensed user in the database, the client devices would by definition be within that service area and would likewise not cause harmful interference.

112. If a fixed unlicensed TV band device that does not have a direct connection to the internet (that is a connection provided by a source other than another TV band fixed device) has not yet been initialized and registered with the database system and can receive the transmissions of another fixed TV band device, we will allow the device needing initialization to transmit on either a channel that the other TV band device has transmitted on or on a channel which the other TV band device indicates is available for use.¹⁶² The TV band device needing initialization must then immediately use its communications link with the other TV band device to access the database to register its location and receive a list of channels that are available for it to use. From that point on, the newly registered TV band device must only use the television channels that the database indicates are available for it to use and not the channels indicated or used by the other TV band device.¹⁶³

¹⁶¹ See *Report and Order* in ET Docket No. 03-133, 18 FCC Rcd 24484 (2003) at Appendix C; see also 47 C.F.R. § 15.202.

¹⁶² In this context, “not initialized” means that the TV band device has not yet registered with and accessed the database to determine a list of available channels.

¹⁶³ Because of the relatively low power that TV band devices will be permitted to use, both of the TV band devices will be located fairly close to one another. The lists of television channels available for use by the two devices are therefore likely to be the same in most cases. There will, however, be cases where a fixed device that obtains its internet connection through another fixed device may be located in the service area of a different group of licensed stations. This is particularly likely to occur if a fixed device obtains service from another fixed device that itself does not have a direct connection to the internet.

113. Unlicensed TV band fixed devices must also comply with the Commission's RF exposure guidelines.¹⁶⁴ As Microsoft observes, we recognize that it is likely that the radiating antennas of these devices will generally be the same as their receive antennas and therefore be located outdoors and at some height above ground. However, there are no requirements that those locations be in areas where they are restricted from persons who do not understand that a radiating structure is present and the need to avoid that area or minimize the time spent there. Accordingly, we will apply to these devices our exposure guidelines for publicly accessible/uncontrolled locations. The maximum permissible exposure (MPE) for a 4 W EIRP transmitter operating in the frequency range from channels 5-51 (76 MHz to 698 MHz) varies from an exposure level of 0.2 to 0.47 mW/cm². The required separation distance from people for safe exposure when the exposure limit is 0.2 mW/cm² (the most restrictive limit over the 76 MHz to 698 MHz range) is about 40 cm, or 15.7". We believe that RF exposure from devices operating at 4 W EIRP in this band can be effectively controlled by measures that can be taken by the party installing the device to ensure that persons maintain a distance of at least 40 cm from a device's the radiating antenna. We therefore will not require that unlicensed TV band fixed devices be subject to our requirements for routine evaluation for compliance with our RF exposure guidelines. Rather, we will require that new units of such devices be accompanied by instructions on measures to take to ensure that persons maintain a distance of at least 40 cm from the device, as well as any necessary hardware that may be needed to implement that protection.

114. As indicated above, we are requiring that all unlicensed fixed TVBDs register with the database system. This registration will provide a means of identifying devices in investigations of any cases of interference that may arise. We believe that registration with the database system using the on-line method presented in the section below on Database System Requirements will minimize the impact of this requirement on operators of fixed unlicensed TV band devices.

115. The rules we are adopting will allow TVBDs to communicate with each other in various network configurations. For example, multiple fixed TVBDs could be organized into a service network comprised of a base station and associated customer premises equipment that communicate through the base station, as described in the IEEE draft standard. Alternatively, a fixed TVBD could initiate communication directly with any other fixed TVBD, without designating any one fixed TVBD as a central relay point. The specific technical requirements and standards for fixed devices are discussed in the Technical Standards section below.

3. Personal/Portable Devices

116. In the *Notice* and *First R&O/Further Notice*, the Commission observed that non-fixed personal/portable devices generally pose a greater risk of harmful interference to authorized operations than fixed devices because the locations where non-fixed devices are used change, making identification of both unused TV frequencies and the devices themselves, if they cause interference, substantially more difficult.¹⁶⁵ It also noted that such devices may not be able to sense transmissions of licensed services as well as fixed devices because they will have antennas that are less efficient and may be located in less advantageous positions.¹⁶⁶ In view of these concerns, the expected ubiquitous use of such devices, and the importance of protecting television service, the Commission proposed to limit personal/portable unlicensed TVBDs to 100 mW and to require that they have a permanently attached antenna with a maximum gain of 6 dBi, for a maximum EIRP of 400 mW. The Commission also requested comment on

¹⁶⁴ See 47 C.F.R. § 1.1307(b).

¹⁶⁵ *Id.*

¹⁶⁶ See *Further Notice* at ¶ 18.

whether personal/portable devices should be required to transmit an identifying signal and the information to be carried on that signal.¹⁶⁷

117. In the *First R&O/Further Notice*, the Commission further noted that the IEEE 802.22 standard under development is limited to fixed point-to-point and point-to-multipoint operations and does not address the non-fixed personal/portable class of devices the Commission proposed to allow in the *Notice*. The Commission therefore sought comment on how non-fixed unlicensed devices could operate in the TV bands under the different sharing schemes under consideration in this proceeding.¹⁶⁸ It further requested comment on whether such devices should be subject to routine evaluation for RF exposure.

118. Harris Corporation (Harris) supports the Commission's proposal to allow personal/portable devices to operate with a maximum power of 100 mW and to incorporate a permanently attached 6 dBi gain antenna.¹⁶⁹ The White Space Coalition also supports a maximum power of 100 mW for personal/portable devices, but with a maximum antenna gain of 0 dBi, which is 6 dB less than proposed by the Commission.¹⁷⁰ The Consumer Electronics Association believes that the maximum power for personal/portable devices should be 20 mW with a 0 dBi gain antenna to minimize direct pick-up interference to TV receivers, while NCTA believes the maximum power should be in the range of 10-20 mW to avoid that type of interference.¹⁷¹ Wireless microphone manufacturers recommend reducing the proposed power level for personal/portable devices to minimize the possibility of interference to wireless microphones. In this regard, ATK Audiotech suggests 50 mW, Telex suggests 20 mW, and Shure suggests 10 mW with a maximum antenna gain of 0 dBi.¹⁷² These parties did not provide an analytical basis for their suggested parameters.

119. TV broadcasters argue that unlicensed personal/portable devices should not be allowed to operate in the TV bands. MSTV/NAB claim that personal/portable devices are not compatible with existing operations in the broadcast TV spectrum because no method exists today or the foreseeable future for preventing interference from such devices to the reception of DTV services.¹⁷³ Other broadcast interests, including Cox Broadcasting, McGraw-Hill, and Media General, also state that the Commission should not allow personal/portable TV band devices at this time due to the potential for interference to DTV reception.¹⁷⁴

120. Manufacturers and users of wireless microphones also express concerns about permitting personal/portable devices to operate in the TV bands due to the potential for interference to wireless microphones. Shure believes that it would be premature to consider allowing personal/portable devices in the TV bands because these devices pose a greater risk of harmful interference than fixed devices. It states that personal/portable devices are inherently unpredictable for frequency coordination and sharing

¹⁶⁷ See *Notice* at ¶ 22.

¹⁶⁸ See *Further Notice* at ¶ 18.

¹⁶⁹ See *Harris Notice* comments at 6.

¹⁷⁰ See *White Space Coalition Further Notice* comments at 5.

¹⁷¹ See *Consumer Electronics Association Notice* comments at 5 and *NCTA Further Notice* comments at 12.

¹⁷² See *Telex Notice* comments 4 and *Shure Notice* reply comments at 7.

¹⁷³ See *MSTV and NAB Further Notice* comments at 34.

¹⁷⁴ See *Cox Broadcasting Further Notice* comments at 4, *McGraw-Hill Further Notice* comments at 3, and *Media General Further Notice* comments at 3.

purposes, may be in a less advantageous position for sensing transmission, change locations randomly, and are impossible for incumbent users to identify as a source of interference.¹⁷⁵ It further notes that neither the IEEE nor any other technical group has offered any comprehensive analysis and proposal for protecting incumbent operations from interference caused by personal/portable devices.¹⁷⁶ The Professional Audio Manufacturers' Alliance and Audio Technica believe that the Commission should not allow personal/portable devices in the TV bands until after it has experience with fixed devices, while Grand Ole Opry and Microphone Interests Coalition believe that personal/portable devices are unsuitable for the white spaces and should be prohibited.¹⁷⁷

121. Microsoft submits that personal/portable unlicensed TV band devices should be exempt from routine evaluation for RF exposure. It states that the appropriate RF exposure context for personal/portable devices is for public/uncontrolled exposure from a device with 100 mW transmit power and a $\lambda/4$ vertical antenna. Microsoft indicates that to reach the MPE limit set forth in our rules, an individual would have to remain within 1 inch (7 inches for a high power device) of the device antenna when the device is operating at full power and 100% duty cycle for a period of 30 minutes.¹⁷⁸ It contends that the likelihood of that happening in the real world approaches zero. Microsoft further observes that the Commission routinely exempts mobile devices in bands below 1.5 GHz that radiate less than 1.76 dBW ERP (3.9 dBW EIRP) from environmental evaluation for RF exposure.¹⁷⁹

122. *Discussion.* We understand the concerns of parties representing broadcast TV and other TV band licensees with respect to the potential for interference to their operations from unlicensed personal/ portable broadband devices, and are adopting technical requirements for personal/portable devices to control interference which are accordingly rigorous. We believe that with the safeguards we are adopting, these types of devices can operate successfully on TV white spaces without causing interference to licensed services. As we observed previously in this proceeding, personal/portable devices pose a greater risk of interference to licensed TV band service because the locations where these non-fixed devices are used will change, making the task of determining unused TV frequencies by the devices more complicated. In addition, the transitory nature of such devices makes it difficult for others to identify the devices if they cause interference. As a number of the commenting parties observe, the fact that a non-fixed personal/portable broadband device (*e.g.*, a device installed in laptop computer) is likely to be moved around with some frequency is likely to make it difficult for TV and other users to locate the device if it causes interference. For example, a device operating indoors for a short period of time in a neighborhood might cause interference that disrupts TV service for the households in that neighborhood while it operates. Because personal/portable devices will generally operate intermittently and their antennas will generally not be located where they are visible, the interference from such operations would be very difficult to identify and control.

¹⁷⁵ See Shure *Further Notice* comments at 6.

¹⁷⁶ See Shure *Further Notice* comments at 8.

¹⁷⁷ See Professional Audio Manufacturers' Alliance *Further Notice* comments at 8, Audio Technica *Further Notice* comments at 9 and Grand Ole Opry and Microphone Interests Coalition *Further Notice* comments at 2.

¹⁷⁸ The standards for RF exposure are contained in Section 1.1310 of the rules. See 47 C.F.R. § 1.1310.

¹⁷⁹ For the purpose of radiofrequency radiation exposure evaluation, mobile devices are defined as a transmitting device designed to be used in other than fixed locations and to generally be use in such a way that a separation distance of at least 20 centimeters (7.9 inches) is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. See 47 C.F.R. §2.1091(b). The Commission routinely exempts mobile devices in bands below 1.5 GHz that radiate less than 1.5 watts ERP (3.9 dBW EIRP) from environmental evaluation for RF exposure. See 47 C.F.R §2.1091(c).

123. At the same time, we recognize the significant benefits that unlicensed wireless communications in other bands have brought to both businesses and consumers using personal/portable digital devices and believe that propagation advantages of the TV bands would further enhance the capabilities of those products. Accordingly, we have developed a plan that will allow operation of unlicensed personal/portable devices in the TV bands in a manner that provides manufacturers and users considerable flexibility in design and use of products, subject to conservative controls on their operation to protect TV and other licensed services. As discussed below, this plan provides for use of spectrum sensing, but at the present time not as the sole means of determining whether channels are occupied or unoccupied. We have sought to make the controls and technical requirements of this as simple and as reliable as possible to encourage the development of new products and assure the operators of licensed services that they will be protected. We are also providing for certification of devices that rely on spectrum sensing alone to determine available channels under a separate plan, as discussed in a subsequent section.

124. As discussed above, we will allow personal/portable devices to operate under two alternative approaches: Mode I client and Mode II independent. In Mode I, client devices will be under control of a fixed or a Mode II personal/portable device that has determined the available channels in the area. In Mode II, devices operating independently will use their own internal geo-location/database access capabilities to determine the channels available for location in the area. In either mode, the list of available channels that can be used by a device will be determined through the geo-location/database method. For the reasons indicated above, we are not requiring that personal/portable devices register with the database system.

125. Personal/portable devices operating in either mode will also be required to perform spectrum sensing that can detect wireless microphone, TV and other authorized signals at levels as low as -114 dBm over the 6-MHz channel bandwidth to determine whether channels are vacant. We believe several purposes are served by requiring spectrum sensing. Although spectrum sensing did not perform consistently in our testing, we expect it will continue to develop and improve. While the principal means of protecting TV service will be through the geo-location and database requirements, sensing can serve as a back-up for detecting TV signals inside the protected service areas where there may be errors in the database. As such and as further explained below, this function will advise the user of the presence of a signal so that they can take appropriate action. We are aware that TV signals are often present at levels below -114 dBm within a station's service area and that sensing at this level may not reliably detect TV signals in such cases. However, given that the geo-location and database access approach provides a reliable means for protecting TV service, we believe that it is not critical that the sensing function be capable of detecting signals below the -114 dBm level. Further, while we are establishing provisions to ensure that channels are available for operation of wireless microphones, a sensing capability provides at least some means to detect such devices that may be operating on an itinerant basis on virtually any channel. We find that detection at a level as low as -114 dBm is appropriate for detection of wireless microphone signals in a 200 kHz bandwidth. We believe that this level of sensitivity is also acceptable detection of ATSC digital signals in a 6 MHz bandwidth and NTSC analog television signals in a 100 kHz bandwidth as a complement to the geolocation and database requirement.

126. We will permit personal/portable devices operating in either mode to transmit with up to 100 mW EIRP. We recognize the concerns of the cable interests that there is a potential for direct-pick-up interference and their position that power levels should therefore be limited to a lesser value. We appreciate that the tests described on our report on direct pick-up interference to three digital cable ready receivers and the anecdotal tests performed by our engineers in the laboratory and field in our second series of tests of white space developmental devices indicated that there is some potential for direct pick-up (DPU) interference to cable service from TV white space transmitters. We also note, however, that this occurred at relatively close spacings within the user's premises and could be corrected by removing

consumer-installed splitters and wiring that effectively reduce the shielding to interfering signals as well as reduce the desired signal levels available at the TV receiver. Further, when just the cable converter box was used to connect directly to the TV receiver, interference declined dramatically and was virtually non-existent on the digital tier of channels. Cables systems are rapidly moving to digital technology which should further alleviate the potential for interference. Consumers generally should be able to correct any interference to their own devices by increasing the separation, re-orienting the devices, or using wiring with improved shielding. We also note that, in our tests, with a 10 meter separation between devices on separate sides of a wall, such as in a townhouse, the interference did not occur at signals below 100 mW for two receivers and a bit under 50 mW for a third. The interference was also a function of the physical relationship between the devices, such as whether the interfering signal was located towards the front or rear of the TV receiver. In addition, as discussed below, we are requiring that TVBDs use dynamic power reduction, and in locations in townhouses and apartments where the operating distances are apt to be relatively short, the power level would typically be adjusted automatically to less than the maximum permitted power of 100 mW. In contrast, reducing the permitted power of the device could make it unviable in locations where the separations are greater. Accordingly, we are not persuaded at this time that the risk of DPU interference is sufficiently great to warrant a reduction in power that could impede the viability of certain TVBD applications. Nevertheless, we will closely monitor for any reports of this type of interference and will expect the equipment suppliers to cooperate in helping consumers to rectify any such interference.

127. We are adopting the White Space Coalition's recommendation to limit the EIRP of personal/portable devices with antenna gain to a maximum of 0 dBi in either case in order to further reduce the potential for interference. That is, if the gain of a device's antenna exceeds 0 dBi, we will require a reduction in the maximum transmitter power to below 100 mW by the same amount in dB that the antenna gain exceeds 0 dBi. We will further require the antenna to be permanently attached to prevent user substitution of higher gain antennas.

128. We will not require that unlicensed TV band personal/portable devices transmit basic identifying information when they are operating. We find that an identifying signal will not be of significant value in identifying the source of or, more importantly, resolving any interference that these devices might cause. In this regard, the identifying code will not serve to identify a device, its operator, or its location as that information will not be recorded in the database system. We also believe that the range of potential interference from personal/portable devices will be sufficiently short that any persistent interference that might occur from a device that is regularly used at the same location could be resolved by traditional methods of local knowledge from those TV viewers receiving the interference and/or direction finding. In addition, these devices will operate on a transient basis such that a device could be relocated and its interference resolved before steps could be taken to identify and locate the device using information transmitted in its signal.

129. The plan for Mode I client operation by personal/portable devices will protect licensed services in a manner similar to the master/client provisions the Commission adopted for unlicensed U-NII devices operating in the 5 GHz band and is supported by the various parties, including broadcasters.¹⁸⁰ This approach will allow personal/portable TV band devices to be built into laptop computers and other portable devices and operate whenever they are in close proximity to a fixed or Mode II personal/portable device or are able to independently perform geo-location and contact the database. Personal/portable devices will be allowed to communicate with other personal/portable devices on a master/client basis,

¹⁸⁰ See 47 C.F.R. § 15.407(h)(2)(i). Master and client modes are defined in the U-NII compliance measurement procedure found in the appendix of the *Memorandum Opinion and Order* in ET Docket No. 03-122, 21 FCC Rcd 7672, 7682 (2006).

with a device that incorporates geo-location/database access and sensing to determine the available channels serving as the master unit. Personal/portable devices operating as client devices in such cases will again be required to use channels/frequencies as directed by the master device. Devices that both make use of geo-location/database access and sensing may, of course, also (and preferably) communicate with one another and share their sensing information.

130. If the user of a personal/portable unlicensed TV band device that does not have a geo-location capability intends to operate the device in Mode I as a client to another unlicensed TV band device (either a fixed device or a personal/portable device that uses a geo-location/database access capability) and the personal/portable device can receive the transmissions of such other TV band device, we will allow the personal/portable device to initiate contact by transmitting on either a channel that the TV band device with a geo-location/database access capability has transmitted on or on a channel which the other device indicates is available for use. The personal/portable TV band device will be required to immediately use its communications link with the other TV band device to obtain a list of channels that are available for it to use.

131. Personal/portable devices operating in a Mode II independent basis will protect licensed services using the same geo-location/spectrum sensing and database access/registration plan as fixed devices. Such devices will be required to obtain a list of available channels at its location from the database.

132. The rules we are adopting will allow personal/portable devices to communicate with each other in network configurations over short distances. For example, a Mode II independent device could communicate directly with other Mode II independent devices or with several Mode I client devices. We will permit personal/portable TVBDs to be used in the operation of “mesh” networks, only where a means is provided to ensure that each device is operating consistent with the channels available at its particular location. That is, we will not permit personal/portable devices operating on a client basis to relay information from one client device to another unless some means is used to ensure that each device is operating within the parameters for its particular location. This will allow use of personal/portable devices in that manner and such operation could facilitate the expansion of broadband service in a community. Nonetheless, we are concerned and need to ensure that that the range of a mesh network of client devices does not extend out to distances where the available channels would change, with the result that some licensed services would be subject to interference.

133. We envision that both the Mode I and Mode II approaches will often be incorporated into the same personal/portable device. That is, a personal/portable device could function as a master device when it is able to use geo-location/sensing and database access to identify unused TV channels in its area. If it cannot rely on these techniques but is near a fixed device or another personal/portable device that can act as a master, it could operate in client mode if it makes contact with a master station.

134. With respect to RF exposure, we first observe that personal/portable TV band devices could operate as either “mobile” or “portable” devices as defined in Sections 2.1091 and 2.1093 of the rules, respectively.¹⁸¹ Under Section 2.1091, a mobile device is a transmitter designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter’s radiating structure(s) and the body of the user or other nearby persons. Such devices that operate on frequencies below 1.5 GHz are subject to routine environmental evaluation for compliance with the RF exposure guidelines only if their effective radiated power (ERP) is 1.5 watts or more. The 100 mW EIRP limit for personal/portable TV band

¹⁸¹ 47 C.F.R. §§ 2.1091 and 2.1093

devices is equivalent to 61 mW ERP; therefore personal/portable devices that are designed for operation in mobile exposure conditions such that the radiating structure(s) are maintained at distance of at least 20 centimeters from the body of the user or other persons will not be subject to our requirements for routine evaluation for RFE.¹⁸²

135. Section 2.1091 provides that a portable device is a transmitter designed to be used so that the radiating structure(s) of the device is/are within 20 cm of the user. The MPE standards for such devices are specified in terms of the Specific Absorption Rate (SAR) of RF energy by the body as specified in Section 2.1093(d). Inasmuch as users of unlicensed TV band devices cannot generally be expected to be aware of the potential effects of RFE, we believe it is appropriate to apply the standards for general population/ uncontrolled exposure in Section 2.1093(d)(2). Under those standards, the SAR limits are 0.08 W/kg as averaged over the whole body, with spatial peak SAR not exceeding 1.6 W/kg as averaged over any 1 gram of tissue, except for the hands, feet, wrist, and ankles, where the spatial peak SAR shall not exceed 4 W/kg as averaged over any 10 grams of tissue. In order to avoid unnecessary SAR testing for low output power personal/portable devices, we find it is desirable to establish an average power threshold whereby devices operating below that threshold will not be subject to such testing. In developing a threshold, we first observe that SAR is proportional to the average power absorbed in tissues and does not generally have clear and direct relationships with either the average or peak power of a TVBD. However, the energy absorption characteristics of tissues for energy on frequencies in the 76 - 698 MHz range, are relatively flat, as compared to higher frequencies (above 1 GHz); therefore, a single conservative average power threshold can be sufficient as a threshold for all TVBD frequencies.

136. Based on the absorption characteristics of tissues in the 76 - 698 MHz range, we are applying a source-based time-average output power threshold of 20 mW as the triggering point for routine SAR evaluation for personal/portable TVBDs. This standard also allows margin to account for simultaneous transmissions by transmitters in the device operating in other frequency bands that may increase exposure potentials. Accordingly, personal/portable TVBDs that meet the definition of portable devices under Section 2.1093 and operate with time-averaged output of less than 20 mW will not be subject to routine evaluation for compliance with the RFE guidelines; such devices that operate with time-average output power greater than that level will be subject to the routine evaluation requirements. The specific technical requirements and standards for personal/portable devices are discussed in the Technical Standards section below.

C. Permissible Channels For Unlicensed Operation

137. In the *Notice*, the Commission stated its belief that unlicensed TV band devices should be allowed access to the largest practicable number of the 68 television channels. It also indicated that certain channels did not appear suitable or appropriate for use by unlicensed devices. In this regard, the Commission proposed to exclude unlicensed devices from operating on TV channels 2-4 to avoid possible interference to TV interface devices such as VCRs, DVDs, DVRs, satellite and cable boxes that operate on or adjacent to those channels.¹⁸³ It further proposed to exclude unlicensed devices from channel 37, which is used for radio astronomy and the wireless medical telemetry service (WMTS), and from channels 52-69, which have been reallocated for new non-broadcast, uses. In addition, it tentatively concluded that channels 14-20 are not suitable for use by unlicensed devices in markets where they are

¹⁸² EIRP is referenced to a theoretical point source radiator, whereas ERP is referenced to a dipole radiator. Power measurements of EIRP are 1.64 (2.15 dB) times higher than measurements of ERP for the same transmit output power level. Therefore, 400 mW EIRP is equivalent to 244 mW ERP (400 mW/1.64).

¹⁸³ *Notice* at ¶¶ 33-37.

used for PLMRS and CMRS operations.¹⁸⁴ Using the same criteria specified in the rules for protection of land mobile operations from low power TV, TV translator, TV booster, and Class A TV (LPTV) stations, the Commission therefore proposed not to allow unlicensed devices to operate within 134 km or 131 km from the center coordinates of metropolitan areas where PLMRS/CMRS services operate on co- and adjacent channels, respectively.¹⁸⁵ With the exception of these channels, the Commission proposed to allow unlicensed TV band devices to operate on any unused TV channel. Thus, it proposed to make TV channels 5-36 and 38-51 generally available for unlicensed operation and channels 14-20 available in locations where they are not used by the PLMRS or CMRS. In the *Notice*, the Commission also sought comment on the possibility of designating one or two locally vacant channels for use only by wireless microphones.¹⁸⁶

138. In the *First Report and Order and Further Notice*, the Commission adopted its proposals to exclude unlicensed TV band devices from channel 37 in order to protect radio astronomy and medical telemetry, and from channels 52-69 as those channels have been reallocated to new uses.¹⁸⁷ With respect to channels 14-20, it decided to prohibit personal/portable TV band devices on these channels everywhere in order to protect public safety and other PLMRS/CMRS operations, as such devices could be easily transported and used anywhere, including within the service areas of PLMRS/CMRS and other licensed operations. The Commission did, however, not make a decision on whether to allow fixed unlicensed devices to operate on channels 14-20 in areas of the country where those channels are not being used for PLMRS/CMRS or other authorized services. It noted that prohibiting operation of fixed TV band devices on channels 14-20 everywhere would preclude operation of such devices in many areas where these channels are not used since PLMRS/CMRS operations only use one to three channels in 13 metropolitan areas and other services on those channels, such as the Offshore Radiotelephone Service, similarly operate only in a few areas. The Commission therefore sought additional comment on whether fixed unlicensed TV band devices should be allowed to operate on channels 14-20 in areas where those channels are not used by PLMRS/CMRS and other operations.¹⁸⁸

139. The Commission sought further comment on whether it should exclude channels 2-4 from use by TV band devices because of possible interference to TV interface devices such as VCRs, DVRs and MVPD terminal devices that typically use those channels in output connections to TV receivers.¹⁸⁹ In particular, it sought comment on whether TV interface devices would be more susceptible

¹⁸⁴ See 47 C.F.R. § 90.305 and 47 C.F.R. § 22.625. PLMRS/CMRS base stations must be located within 80 kilometers (50 miles) of the center of the cities where they are permitted to operate on channels 14-20 (470-512 MHz), and mobile units may be operated within 48 kilometers (30 miles) of their associated base station or stations. Thus, mobile stations may be operated at up to 128 kilometers (80 miles) from the city center. We also note that there are numerous licensed land mobile operators, including public safety entities that currently operate, pursuant to waiver, on defined channels in channels 14-20 at specified locations outside those markets specifically designated in the Part 90 rules. See, e.g., *Goosetown Enterprises Inc.*, 16 FCC Rcd 12792 (2001).

¹⁸⁵ Under this approach, PLMRS/CMRS operations would be protected within a circle of radius 130 kilometers from the city center coordinates. This is the area in which such operations are permitted under the rules. As is the case for LPTV stations, the field strength from an unlicensed device on a co- or adjacent channel would not be permitted to exceed 52 dBu or 76 dBu, respectively, at the 130 km protected contour of the PLMS/CMRS metropolitan area. See 47 C.F.R. § 74.709(d).

¹⁸⁶ *Id.* at ¶ 38.

¹⁸⁷ *First Report and Order and Further Notice of Proposed Rulemaking* at ¶¶ 19-21.

¹⁸⁸ *Id.* at ¶ 56.

¹⁸⁹ *Id.* at ¶ 57.

to interference from low power TV band devices than other TV receivers; on whether the cabling between a TV interface device and a TV receiver typically provides adequate shielding from unwanted signals on channels 2-4; and the extent to which such signals may be picked-up directly within the TV receiver. It also sought comment on how much longer consumers can be expected to use TV interface devices that connect to a TV through the tuner (antenna or cable television input) rather than an alternative interface connection. A number of parties commented on these issues. In addition, several parties submitted comments regarding additional channels on which the operation of TV band devices should be restricted.

140. In their Petition for Reconsideration, NAF/CUWN ask the Commission to reconsider its decision to prohibit personal/portable TV band device operation in channels 14-20.¹⁹⁰ They argue that the Commission should defer a decision on this issue until it is more familiar with the available technologies for mobility. NAF/CUWN is concerned that no parties will develop the necessary technologies to permit use of channels 14-20 for mobile devices if the Commission forecloses this possibility now. They contend that the Commission's decision to exclude personal/portable devices from channels 14-20 is imposing unnecessary costs on the public through an overabundance of caution.

141. The NAF and the CEA submit that fixed unlicensed TV band devices can operate on channels 14-20 without interfering with PLMRS/CMRS operations through the use of geo-location capabilities and a database containing the markets where these channels are used.¹⁹¹ These parties submit that not allowing use of these channels in other areas would needlessly remove a large amount of white space since PLMRS/CMRS operations only make use of one to three channels in a small portion of the United States. Motorola suggests that channels 14-20 be reserved for TV band devices used by public safety agencies.¹⁹² It believed that this would prevent interfering uses and satisfy a great need in the public safety community.

142. The Land Mobile Communications Council (LMCC) argues that unlicensed TV band devices should not be allowed to operate on channels 14-20 anywhere in the country.¹⁹³ The LMCC believes that even if these devices are banned from an "exclusion zone" around the area used for PLMRS/CMRS operations, some users of the devices will not adhere to the restrictions. It states that there would be no way to identify nonconforming unlicensed devices in the dense urban areas where these channels are used. LMCC furthermore submits that spectrum sensing would not be effective in identifying PLMRS/CMRS channels because radios in those services are used only intermittently. Los Angeles County adds that fixed devices can always be moved to areas where they would interfere with PLMRS/CMRS operations.¹⁹⁴ Comm Enterprises claims that PLMRS/CMRS use of these channels may expand after the end of the digital transition and that such growth warrants prohibiting unlicensed devices from operating on them.¹⁹⁵

¹⁹⁰ See NAF/CUWN Petition for Reconsideration at 7-8.

¹⁹¹ See NAF et al. comments at 78; CEA comments at 6.

¹⁹² See Motorola comments at 10-11.

¹⁹³ See LMCC comments at 9.

¹⁹⁴ See The County of Los Angeles *Further Notice* comments at 2.

¹⁹⁵ See Comm Enterprises, LLC *Further Notice* comments at 6.

143. Most of the commenting parties that address this issue continue to oppose the use of channels 2-4 for TV band devices in order to avoid interference with TV interface devices.¹⁹⁶ For example, CEA states that there is potential to cause interference to the installed base of analog receivers which might be connected to digital-to-analog converter boxes or receiving their content from a terminal device of a multichannel video program distributor such as cable or satellite that uses channels 3 or 4.¹⁹⁷ However, the NAF appears to suggest that channels 2-4 could be used by TV band devices if shielded cables are used to connect the interface device to the TV.¹⁹⁸ The National Cable Television Association (NCTA) counters that the interference to TV interface devices in fact generally results from leakage into the television receiver, so that use of shielded cables would not prevent interference.¹⁹⁹ NCTA submits that leakage into television receivers will occur on all VHF channels and that TV band devices should therefore be limited to only UHF frequencies.

144. GE Healthcare (GE) requests that TV band devices not be allowed on channels 33-36 until February 18, 2010 in order to allow medical facilities time to replace grandfathered medical telemetry systems that operate on those channels.²⁰⁰ GE and The American Society of Healthcare Engineering note that medical telemetry devices that operate on channels 33-36 are currently being sold in areas where those channels are vacant.²⁰¹ GE also argues that stricter spurious emissions limits are needed to protect WMTS devices that operate on channel 37. In addition, GE asks that the Commission restrict operations of TV band devices on channels 36 and 38 or require that professional installation and coordination with WMTS systems to ensure that the emissions in channel 37 are kept below 50 microvolts/meter at WMTS facilities. GE further requests that we require fixed TV band device operators to notify nearby hospitals before beginning operation.²⁰² The White Space Coalition responds that granting GE's request to protect channels 33-36 would only serve to encourage more grandfathered devices on those channels.²⁰³ GE subsequently submitted an emissions mask for TVBDs that it states would address its concerns about adjacent channel overload and spurious emissions interference from TVBDs to WMTS devices on channel 37.²⁰⁴

¹⁹⁶ See CEA *Further Notice* comments at 6; NCTA *Further Notice* comments at 13-15; Echostar *Further Notice* comments at 2; IEEE 802.18 *Further Notice* comments at 23-24.

¹⁹⁷ See CEA *Further Notice* comments at 6.

¹⁹⁸ See NAF et al. *Further Notice* comments at 83. The NAF notes that the use of channels 2-4 would result in significantly more whitespace because these channels are considered undesirable for DTV. *Id.*

¹⁹⁹ See NCTA *Further Notice* comments at 13-15.

²⁰⁰ See GE Healthcare *Further Notice* comments at 5. As indicated above, wireless medical telemetry devices operate on channels 7-13 (174-216 MHz) and channels 14-46 (470-668) MHz on an unlicensed basis under Sections 15.241 and 15.242 of the rules; WMTS devices operate on channel 37 (608-614 MHz) on a licensed basis under Sections 95.1101-1113 of the rules. WMTS devices are also authorized to use the frequency bands as 1395-1400 MHz and 1427-1429.5 MHz. See 47 C.F.R. § 15.241-.242 and 47 C.F.R. § 95.1101-.1113. Section 15.37(i) also provides that new equipment approvals may no longer be obtained for medical telemetry devices operating under Sections 15.241 or 15.242 after October 22, 2002. See 47 C.F.R. § 15.37(i).

²⁰¹ See GE Healthcare comments at 3; American Society of Healthcare Engineering *Further Notice* comments at 4.

²⁰² See GE Healthcare *Further Notice* comments at 6, 8-9.

²⁰³ See White Space Coalition *Further Notice* reply comments at 34.

²⁰⁴ See GE Healthcare *ex parte* submission of May 6, 2008.

145. The National Radio Astronomy Observatory (NRAO) requests that we place additional limits on channel use by unlicensed TV band devices to protect radio astronomy.²⁰⁵ Specifically, it requests that TV band devices be prohibited on channels 4, 5, 36, and 38 in the vicinity of the Very Large Array (VLA) radio telescopes and on channel 36 and 38 near the Very Long Baseline Array (VLBA) in order to protect radio astronomy operations in bands between channels 4 and 5 and in channel 37.²⁰⁶ In addition NRAO requests that the Commission require that all TVBDs operating in the vicinity of certain radio astronomy sites such as the National Radio Quiet Zone,²⁰⁶ the individual VLA installations, and the VLBA be coordinated with the NRAO.

146. In its reply comments in response to the *First Report and Order and Further Notice*, the White Space Coalition suggests that unlicensed TV band devices (both fixed and personal/portable) be allowed to operate only on unoccupied channels in the range 21-51. The White Space Coalition indicates that this plan would avoid any direct pick-up interference problems on VHF channels, accommodate public safety operations on channels 14-20 and provide reserved spectrum for operation of wireless microphones.²⁰⁷

147. Shure suggests that the Commission designate six television channels in each market for use by wireless microphones.²⁰⁸ Shure notes that wireless microphones can use channels adjacent to broadcast television stations, and states that if unlicensed TV band devices were prohibited from using adjacent channels, those channels would be available for wireless microphones. It also observes that in rural areas there are fewer television stations and hence will be fewer adjacent channels so that wireless microphones would be assured of available channels for their use.²⁰⁹

148. *Discussion.* As indicated in the *Notice*, we believe it is important that TV band devices be allowed to operate on the largest practicable number of television channels.²¹⁰ This will maximize the opportunities for operation of unlicensed devices in all areas, and will be particularly important for the successful implementation of unlicensed devices in areas where the TV bands are congested with other services. As discussed throughout this proceeding, however, there are certain channels that are not suitable or appropriate for use by unlicensed by TV band devices. Accordingly, as discussed below we will allow both fixed and personal/portable unlicensed TV band devices to operate on channels 21-36 and 38-51. In addition, we will allow fixed devices to operate on channels 2 and 5-13 and channels 14-20 outside of areas where PLMRS/CMRS services operate.²¹¹ Thus, fixed TVBDs will be allowed to operate on a total of 48 channels and personal/portable TVBDs will be allowed to operate on 30 channels. In prohibiting personal/portable devices from operating on channels 14-20, we are maintaining our previous decision not to allow personal/portable devices on those channels and thereby denying NAF/CUWN's request for reconsideration of that decision.

²⁰⁵ See NRAO *Further Notice* comments at 8.

²⁰⁶ See Section 15.712(h) of the rules in Appendix B for the locations of these radio astronomy facilities.

²⁰⁷ See White Space Coalition *Further Notice* reply comments at 29-31.

²⁰⁸ See Shure *Further Notice* reply comments at 8.

²⁰⁹ See Shure *Further Notice* comments at 12-14.

²¹⁰ See *Notice* at ¶ 17.

²¹¹ Conversely, fixed devices will be excluded from channels 3 and 4, channels 14-20 in areas where PLMRS/CMRS services operate, and channel 37; personal/portable devices will be excluded from channels 2-20 and channel 37.

149. We will prohibit operation of TVBDs on channels 3 and 4 in order to prevent direct pick-up interference to TV interface devices such as VCRs, DVRs, and MVPD terminal devices. Those devices typically modulate their output signals on TV channels 3 or 4 and pass the signals to a receiver through a shielded cable. Depending on the effectiveness of the shielding on TV interface devices, modulation and, where included, TV reception circuitry, emissions from an unlicensed TV band device on channels 3 or 4 could cause interference to the output of the TV interface device. In addition, as indicated in the tests conducted by our engineers, TV receivers themselves appear to be more susceptible to direct pick-up interference on channels 3 and 4. While there was not a significant amount of other new empirical information in the record on the susceptibility of TV interface devices or TV receivers, NCTA does provide credible information indicating that most analog TV receivers have been seriously lacking in shielding at channels 3 and 4.²¹²

150. We also have no information that the shielding of new DTV receivers and TV interface devices has improved significantly. In addition, we note that such devices are invariably used with shielded cables, and we see no indication that the shielding on the connecting cables used with such devices is the principal source of the susceptibility to interference; rather, the potential for interference arises from inadequacies in the shielding within the devices themselves. Thus, we see no basis for concluding that such interference can be prevented through the use of shielded cables as NAF suggests. In view of the fact that there are many millions of VCRs, DVDs, DVRs, satellite and cable set-top boxes now in service, interference to the operation of those devices from unlicensed TV band devices interference could result in widespread disruption of consumers' video services. We therefore find that it necessary to take a cautious approach and place channels 3 and 4 off-limits to unlicensed TV band devices.

151. One of our considerations in this matter is to ensure that channels remain available for use by wireless microphones. While we are aware that many wireless microphones are now operated, without the required license, we nonetheless understand the important function that wireless microphones serve and find that it is in the public interest to preserve spectrum in the TV bands that is available for their use. As discussed below, we conclude that the Coalition's suggestion to preserve unoccupied TV channel space below channel 21 for wireless microphones is an appropriate solution for providing spectrum to meet wireless microphone needs while also satisfying the needs of unlicensed TVBDs.²¹³ We also recognize that there is interest by WISPs and others in using fixed TVBDs to reach rural and other underserved areas that are at distances not reachable with lower power devices operating at higher frequencies. The VHF and lower UHF bands appear particularly well suited for those purposes. We believe that if we restrict use of channels 5-20 to fixed devices on those channels to communications with other fixed devices we can meet the needs of those desiring to provide service at a distance and also limit the number of TVBDs that could potentially conflict with wireless microphone use.

152. We also remain concerned about possible interference from unlicensed TVBDs to public safety and other important communications operations in the PLMRS. While the geo-location/database and client operation provisions of the rules we are adopting herein will serve to provide a high degree of

²¹² NCTA *Further Notice* comments at 10-11. NCTA includes in Appendix II of its comments a study of the shielding effectiveness analog TV receiver performed by Carl T. Jones Corporation in 1993, "Customer Premises Equipment Performance and Compatibility Testing," Section 3. This study examined the direct-pickup performance of 35 television sets that comprised a representative sample of various manufacturers and models and found that the television receivers provided very poor shielding at the low VHF channels.

²¹³ We emphasize that in this proceeding we are not altering the channels on which wireless microphones may operate.

assurance that PLMRS/CMRS, Offshore Radiotelephone Service and other authorized services on channels 14-20 are protected, we continue to believe that the nomadic nature and expected high numbers of personal/portable devices poses some potential for interference to those services. Given that parties who are expected to manufacture TVBDs anticipate that channels 21-51 will provide adequate spectrum resources for their products, we choose to be conservative in protecting the PLMRS/CMRS services and will prohibit personal/portable devices from channels 14-20 and are therefore denying NAF/CUWN's request for reconsideration in this regard. We do not have the same concerns with regard to fixed point-to-point or point-to-multipoint operations that will be fewer in number and remain in place. Accordingly, we will only allow fixed devices that communicate with other fixed devices to operate on channels 5-20.

153. We will therefore allow operation of fixed TV band devices on channels 14-20 in those areas of the country where the channels are not being used for PLMRS/CMRS or other authorized services, including the Offshore Radiotelephone Service. As we describe elsewhere in this Second Report and Order, we are requiring that fixed TV band devices avoid operating on channels that will interfere with PLMRS and CMRS operations. The TVBD database will contain information on the locations and channels used for PLMRS/CMRS, the Offshore Radiotelephone Service and other authorized services to prevent TV band devices from operating on the channels used by those services.²¹⁴

154. We will allow all unlicensed TV band devices to operate on unoccupied television channels in the channel range 21-51, with the exception of channel 37. This will provide a large number of channels within the same area of the spectrum that can potentially be used for unlicensed TVBDs, and thereby maximize the opportunities for operation of unlicensed devices in all areas. Allowing TVBD operations on two large blocks of UHF spectrum will increase the likelihood of locating blocks of available channels. This plan would also comport in large degree with the channel availability plan for TVBDs suggested by the White Space Coalition.

155. We reaffirm our decision not to allow TVBDs to operate on channel 37 in order to protect radio astronomy and WMTS operations. As indicated above, medical telemetry devices used in hospitals and other healthcare facilities also operate on other channels in the television bands on a noninterference basis under Part 15 of our rules. As discussed below, we are adopting strict out-of-band emissions limits for TVBDs operating on channels 36 and 38. We are applying these to both fixed and personal/portable TVBDs. Given these very strict limits, we do not believe it is necessary to require coordination fixed TVBDs with medical facilities.

156. We understand the NRAO's concerns with respect to protection of radio astronomy operations from potential interference from TVBDs and also recognize that there is need to protect the Table Mountain Radio Receiving Zone that is used by the Federal Government for sensitive radio research. To ensure that these sensitive facilities are protected from potential interference, we will not allow unlicensed TV band devices to transmit on any channel within and in the vicinity of radio astronomy observatories. These facilities include the Allen Telescope Array, the Arecibo Observatory (which includes the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra), the Green Bank Telescope (which is in the National Radio Quiet Zone), the Very Large Array (VLA) and the Very Long Baseline Array (VLBA) stations. We will also prohibit TV band devices from operation on any TV channel within and in the vicinity of the Naval Radio Research Observatory (which is in the National Radio Quiet Zone) and within the vicinity of the Table Mountain Receiving Zone to protect the sensitive

²¹⁴ If use of these channels by PLMRS/CMRS and other services is expanded in the future, we will require that the database be updated to include those expansions.

radio research efforts at those facilities.²¹⁵ As recommended in the NTIA letter, we will apply these restrictions to operation of both fixed and personal/portable unlicensed devices within 2.4 km of the coordinates of the radio astronomy observatories, the Naval Radio Research Observatory and the Table Mountain Radio Receiving Zone. We do not find it necessary to restrict operation of TVBDs within the boundaries of National Radio Quiet Zone except within and in vicinity of the two research facilities therein. We observe that these facilities are generally located in less populated areas so that prohibiting TVBDs from operating in the local areas around them will affect a relatively few potential users of TVBDs.

157. We also recognize that many wireless microphones now in licensees inventories are configured to operate on UHF channels and that manufacturers and users of those devices will need to migrate their systems that are currently configured for operation on channels in the 700 MHz range (channels 52-69) to channels within the DTV core spectrum. These considerations will necessitate access to and use of a significant number of the UHF channels by wireless microphones. In a recent *ex parte* statement, Shure requested that we reserve several channels in the UHF spectrum for wireless microphones.²¹⁶ In general, we believe that it is not necessary to reserve spectrum to protect fixed uses of wireless microphones such as studios because those facilities may register with the database. However, it is not practical to register the locations of electronic news gathering crews and other media activities that operate on an itinerant basis. We believe that our decision to prohibit personal/portable TVBDs from operation on channels below channel 21 will generally ensure that an adequate number of UHF channels are available for interference free operation of these important itinerant wireless microphone uses. However, the number of UHF channels available will be more restricted in markets where there are PLMRS/CMRS operations in addition to TV and other authorized uses. We will therefore reserve two channels where TVBDs will not be permitted in each of the markets where PLMRS/CMRS operations are present in order to preserve spectrum for wireless microphone operation. For such cases, we are adopting Shure's plan that the reserved channels in each market be the first channels open on either side of channel 37. For example, if channels 36 and 39 were used by local TV stations, the reserve channels would be channels 35 and 38. The reservations of these channels will be recorded in the database.

D. Protection of Broadcast Television and Other Services

158. In this section, we describe the technical criteria that will be used for determining when a TV channel can be considered vacant for the purpose of allowing operation of an unlicensed device on that channel. We first address full service TV stations, which will all operate with digital signals after the end of the DTV transition, and low power TV stations, which may be either analog or digital after the end of the transition because there is as yet no requirement for analog low power TV stations to convert to digital by a specific date. We also address the specific criteria to be used for protection of other licensed services that use the TV bands, including the PLRMS/CMRS, cable headends and translator receive sites, the Offshore Radiotelephone Service, and wireless microphones and other Part 74 services.

159. *Protection of TV services.* Full service TV stations and Class A TV, low power TV, TV translator and TV booster stations are generally protected from interference within defined signal contours. The signal level defining a television station's protected contour varies depending on the type

²¹⁵ See letter of March 1, 2005 from Frederick R. Wentland, Associate Administrator, Office of Spectrum Management, National Telecommunications and Information Administration to Edmond J. Thomas, Chief, Office of Engineering and Technology, Federal Communications Commission (NTIA letter).

²¹⁶ See *ex parte* submission of Shure

of station, *e.g.*, analog or digital TV, and the band in which a TV station operates.²¹⁷ Different protected contour values are specified for both analog and digital stations that operate in the low VHF band (channels 2-6), the high VHF band (channels 7-13) and the UHF band (channels 14-69). In the *Notice*, the Commission proposed to use the criteria from the Part 73 and Part 74 rules to define the areas that unlicensed TV band devices must protect from harmful interference.²¹⁸ The Commission proposed to require that all such unlicensed operations protect TV service within the contours defined by these criteria, which are set forth in Table 1:

Table 1
Criterion for Definition of TV Station Protected Contours

Type of station	Protected contour ²¹⁹		
	Channel	Contour (dBu)	Propagation curve
Analog TV	Low VHF (2-6)	47	F(50,50)
	High VHF (7-13)	56	F(50,50)
	UHF (14-69)	64	F(50,50)
Analog Class A, LPTV, translator and booster	Low VHF (2-6)	62	F(50,50)
	High VHF (7-13)	68	F(50,50)
	UHF (14-69)	74	F(50,50)
Digital TV	Low VHF (2-6)	28	F(50,90)
	High VHF (7-13)	36	F(50,90)
	UHF (14-51)	41	F(50,90)
Digital Class A	Low VHF (2-6)	43	F(50,90)
	High VHF (7-13)	48	F(50,90)
	UHF (14-51)	51	F(50,90)

160. The Commission proposed to prohibit fixed/access devices from operating on the same channels used by TV services (co-channel) and on the first adjacent channels to channels used by TV services (adjacent channels).²²⁰ It also proposed to prohibit personal/portable devices only from operating co-channel to channels used by TV services. The Commission indicated that it believed that the potential for harmful interference to adjacent channel television operations from personal/portable devices (which would operate with lower power) would be sufficiently low that it would not need to impose adjacent channel restrictions on these devices.

161. Whether or not interference to TV reception occurs depends on the desired-to-undesired (D/U) signal ratio needed for acceptable service. This D/U ratio will vary depending on the type of station and the nature of the undesired signal. In the *Notice*, the Commission stated that it expected the

²¹⁷ As indicated above, the protected contours are defined by 47 C.F.R. § 73.683(a) for analog TV stations, 47 C.F.R. §§ 73.6010(a) for Class A TV stations, 47 C.F.R. § 74.707(a)(1) for low power TV, TV translator and TV booster stations, 47 C.F.R. § 73.622(e) for digital TV stations, 47 C.F.R. § 74.792 for digital low power TV and TV translator stations, and 47 C.F.R. § 73.6010(d) for digital Class A stations.

²¹⁸ See *Notice* at ¶¶ 29-32.

²¹⁹ The methodology for determining station protected contours and the propagation curves are described and presented in Sections 73.684 and 73.699 of the rules. See 47 C.F.R. §§ 73.684 and 73.699.

²²⁰ See *Notice* at ¶ 30. Adjacent channels are the first channels immediately above and below the channel on which a TV station operates.

signals from unlicensed devices to appear “noise-like” and that the carrier-related interference mechanisms that can affect analog television would not occur.²²¹ Given the expected noise-like character of signals from unlicensed devices that would make them appear similar to DTV signals, the Commission proposed to use the same protection criteria that are currently specified in the rules for digital television.²²² These criteria are set forth in Table 2:

Table 2
TV Interference Protection Criteria

Type of station	Protection ratios	
	Channel separation	D/U ratio (dB)
Analog TV, Class A, LPTV, translator and booster	Co-channel	34
	Upper adjacent	-17
	Lower adjacent	-14
Digital TV and Class A	Co-channel	23
	Upper adjacent	-26
	Lower adjacent	-28

162. The Commission proposed to require that these service and protection criteria be used in conjunction with appropriate computational software, including use of the Commission’s propagation curves, and a television station engineering database for coordination and deployment of unlicensed fixed/access devices.²²³ It also proposed not to apply the adjacent channel D/U criteria to fixed/access devices between channels 4 and 5, channels 6 and 7, and channels 13 and 14 because of the frequency separations that exist between those channels.²²⁴ That is, those channels are not actually on adjacent frequencies.²²⁵ While the commenting parties generally agree on the need for limitations on the use of both fixed and personal/portable devices to protect co-channel operations and for higher power fixed devices to avoid operating on channels adjacent to those used by TV services, there was disagreement on whether personal/portable devices should be permitted to operate on channels adjacent to those used by TV services.²²⁶ The White Spaces Coalition argues that personal/portable devices should be allowed on channels adjacent to occupied channels, and that transmit power control combined with over-the-air sensing can ensure that personal/portable devices comply with the mandated D/U ratios for protection of licensees on adjacent channels. It further states that an outright ban on adjacent channel use is not necessary or advisable and would only create an artificial scarcity of white spaces in congested areas.²²⁷ On the other hand, MSTV/NAB holds that any operation of a TV band device on a TV station’s first adjacent channel will harm reception. They calculate that operation of a 100 mW device on a first

²²¹ See Notice at 10032.

²²² See 47 C.F.R. § 73.623(c).

²²³ See Notice at ¶ 31.

²²⁴ The frequency separation between channels 4 and 5 is 4 MHz, between channels 6 and 7 is 86 MHz and between channels 13 and 14 is 254 MHz.

²²⁵ The frequencies used for the individual television channels are set forth in Section 73.603 of the rules. See 47 C.F.R. § 73.603.

²²⁶ See IEEE 802.18 Further Notice comments at 9, and MSTV/NAB Further Notice comments at 16.

²²⁷ See White Space Coalition Further Notice comments at 15.

adjacent channel could cause interference at distances up to 780 meters, and that a 400 mW device on an adjacent channel could cause interference at distances up to 1.5 kilometers.²²⁸

163. A number of parties express concern that the proposed rules would not adequately protect against interference to broadcast services because viewers may be able to receive service outside of stations' protected contours. Low power TV and TV translator operators express concern that the proposals would protect their stations to a higher field strength level, and therefore a relatively shorter service distance, than full service broadcasters, while viewers who depend on low power stations can receive service well beyond the specified protected contour.²²⁹ The Society of Broadcast Engineers (SBE) states that the *Notice* overlooked the fact that Part 74 allows operation of broadcast auxiliary links from temporary sites for up to 720 hours per year, and that no provisions were made for special temporary authorization (STA) of broadcast auxiliary links on TV channels.²³⁰

164. Some commenting parties indicate concerns over the methodology that will be used to calculate stations' protected contours and the required separation distances from unlicensed devices. Several parties state that the Commission's propagation curves by themselves are not sufficiently accurate to predict service and that the methodology in OET Bulletin No. 69 should be used.²³¹ Parties also question whether the proposed D/U ratios are appropriate. IEEE 802 believes that the D/U ratios may need to vary depending on the type of modulation used by the desired and undesired emitters, while Cohen, Dippell and Everist (CDE) believes that the Commission should update the ratios for TV band devices if the Part 73 D/U ratios are modified based upon studies of the current generation of DTV receivers.²³²

165. *Discussion.* We will require TV band devices to protect both full service and low power TV services from interference within the protected contours specified in the rules for full service TV stations. That is, TV band devices will be required to protect low power TV services their 41 dB μ V/m, the same threshold of service they protect for full service TV stations. The Commission's decision to establish higher protected service thresholds for low power stations was a compromise between providing a reasonably sized service area for the communities expected to be served by LPTV stations and accommodating the large number of expected LPTV stations.²³³ However, we recognize that that many

²²⁸ See MSTV/NAB *Further Notice* comments at 16.

²²⁹ For example, see National Translator Association *Notice* comments at 1, Entravision Holdings comments to the *Notice* at 2, and Community Broadcasters Association *Notice* comments at 5. We note that "full service" TV stations, which are subject to the public service requirements of Part 73 of the rules, 47 C.F.R. Part 73, are also sometimes referred to as "full power" stations; however in some cases low power stations actually operate with higher power and to service larger areas than some full service stations.

²³⁰ See SBE *Notice* comments at 3.

²³¹ See Entravision Holdings *Notice* comments at 3, National Translator Association *Notice* comments at 1, Syncom Media Group *Notice* comments at 1, and Pikes Peak Broadcasting Company *Notice* comments at 1.

²³² See IEEE 802 *Notice* comments at 15 and CDE *Notice* comments at 6.

²³³ See *Report and Order* in BC Docket No. 78-253, 51 R.R. 2nd 476 (1982). Section 74.792 provides that the protected contours of digital low power and TV translator stations are: 43 dBu on channels 2-6, 48 dBu on channels 7-13 and 51 dBu on channels 14-69, see 47 C.F.R. § 74.792(a). The same contour values were adopted for analog Class A TV stations in view of the provision in the Community Broadcasters Protection Act of 1999 (which enabled the Class A service) to preserve the service areas of those LPTV stations that qualified to be upgraded to Class A status. The LPTV and Class A TV digital contour values were chosen to yield digital service areas of roughly comparable size to analog LPTV areas. These signal levels compare to the full service television protected service (continued....)

people at locations beyond the specified protected contours for low power TV stations can readily receive and do rely on over-the-air reception of those services (Class A, LPTV, translators and boosters). Because we do not wish for viewers who rely on low power TV services to lose service as a result of interference from unlicensed TV band devices, we are requiring TV band devices to provide the same level of protection to low power services that they do to full service TV stations. We emphasize that the application of the full service digital TV service thresholds to low power stations herein only applies with respect to TVBDs; we are not altering the low power digital TV service thresholds in any other context or application under our rules.

166. We recognize that in some instances viewers receive TV service off-the-air at locations beyond the protected contours specified for full service stations. However, the protected contours generally define the practical limit of where TV service can be received by most people, particularly for digital TV service which is not viewable at all below a certain signal level. Beyond those contours, we do not consider service to be present and thus protected. We will therefore base the required separation between TV band devices and full and low power TV stations on the protected contours specified for full service TV stations. We note that TV receive antennas used in weak signal areas near the edge of a protected contour need to be high gain, and therefore highly directional, mounted on high masts and aimed toward the TV station being received. While it is possible that a TVBD could be within the reception pattern of such antennas, we believe that in most cases they will be in locations under those patterns and thus their signals will be attenuated relative to those of the desired television signals. These factors will help minimize the likelihood of interference to persons receiving weak over-the-air signals.

167. We will require TV band devices to protect full service and low power TV reception within their own contours using the proposed D/U ratios. We note that the protected contours for low power stations, at which the C/U ratios will apply, are generally much smaller in distance from the transmitter than for full service stations. These D/U ratios are specified in the rules to establish definitions of service and protection rights among stations consistent with the need to provide for adequate service to viewers and the considerations of the Commission's overall responsibilities for managing the radio spectrum. We believe it is reasonable and appropriate to continue to apply these same service and rights definitions with respect to unlicensed devices. None of the commenting parties argue that we should use less stringent standards for protection. We note the concerns of IEEE 802 and CDE with regard to the facts that the susceptibility of TV receivers to interference from unlicensed TVBDs could vary depending on the transmission methods used by such devices and that the receiver tests have indicated that the performance may be different from the standards in the rules. We do not expect that the susceptibility of TV receivers with respect to unlicensed TVBDs will vary much, if at all, from their susceptibility to interference from undesired TV signals, as these devices are expected to operate with signals that have wide bandwidth, noise-like characteristics similar to those of DTV signals. In the case of devices that use less than the same bandwidth as a DTV signal, we would expect the susceptibility of receivers to interference from such devices to be relatively lower than from wider bandwidth signals.

168. As proposed, and consistent with the rules for full service and low power TV stations, the protected contours of full service and low power digital TV stations will be calculated using the F(50,90) curves, and the protected contours of low power analog TV stations will be calculated using the F(50,50) curves.²³⁴ Because we are not permitting fixed or personal/portable TV band devices to operate in the same channel as a TV station within the station's protected contour, the coverage prediction elements in (Continued from previous page) _____ thresholds of 28 dBu on channels 2-6, 36 dBu on channels 7-13 and 41 dBu on channels 14-69, *see* 47 C.F.R. § 73.622(e).

²³⁴ As the Commission previously decided, TVBD devices will not be permitted to operate until after the end of the DTV transition when full service analog broadcasting ceases.

OET Bulletin No. 69 that predict locations within that contour where service might not be available are not applicable.²³⁵

169. We recognize and encourage TV receiver performance standards-setting by industry. While we do not have regulations for the sensitivity and immunity performance of TV receivers, we are encouraged that manufacturers have designed their products to performance levels that generally meet industry-developed standards, recognizing their perceptions of what is acceptable to the market. With regard to TV receiver rejection of undesired signals on first-adjacent channels, we note that ATSC Standard A/74 specifies a ratio of -33 dB, fully 5 and 7 dB more stringent than our planning factor values, and that our tests of DTV receiver performance demonstrate that those improved selectivity values are included in consumer receivers and set-top boxes. We therefore use the A/74 value in our analysis of the interference potential of TVBDs.

170. We are adopting our proposals to prohibit unlicensed devices from operating co-channel to a TV station and fixed devices from operating on a channel adjacent to a TV station in order to protect the TV service from interference. After further consideration, we have also decided to allow limited operation of personal/portable operation on channels adjacent to a TV station. Our analyses underlying these decisions and the rules for operation of personal/portable devices on adjacent channels are set forth below.²³⁶ We also recognize that prohibiting fixed devices from operating on first adjacent channels will have the effect of limiting the number of channels that are available for use by those devices in some markets. We will remain open to possible solutions for operating the higher power fixed devices on adjacent channels and will revisit this matter if such a solution is developed. We therefore encourage interested parties to continue to explore possible options for operating on first adjacent channels that will not increase the potential for interference to television service and to submit them for our consideration when they have reach a state of development that will allow for a proper evaluation.

171. *Adjacent channel interference.* The proposed D/U ratios for adjacent channel protection, which are taken from ATSC Recommendation A/74, are 33 dB for both the lower and upper adjacent channels, respectively. An interfering signal on a first adjacent channel would have to be that amount in dB higher than the desired signal to cause interference to TV service. Interference could occur whenever an adjacent channel TVBD signal is -51 dBm or higher.²³⁷ We use the same TV reception models described above for analyzing the potential for TVBDs to cause co-channel interference to TV reception to examine the potential for TVBDs to cause adjacent channel interference to TV reception. We also use two typical models of DTV indoor and outdoor reception and TVBD operation to evaluate the potential for interference from adjacent channel personal/portable devices to DTV reception.

172. In the case of a fixed TVBD in free space, a 4 W EIRP signal (36 dBm) impinging on a standard DTV receiving system (OET-69 parameters) at an antenna separation of 16 meters (approximately 50 feet, a reasonable distance between rooftop mounted TV and TVBD fixed antennas on adjacent structures) would produce a receive carrier level of -8.1 dBm. Assuming that the fixed TVBD signal is at an azimuth in the main beam of the TV receive antenna, interference could occur to TV service at any location where a TV signal is -51 dBm or less on a first adjacent channel. Under that

²³⁵ The principal function of OET Bulletin No. 69 is to calculate the area served by a DTV station. The OET Bulletin No. 69 method calculates the protected contour of a station as part of the prediction method, and it refers to the methods in the rules for calculating a TV station's protected contour, *i.e.*, the F(50,90) curves for digital TV stations and the F(50,50) curves for analog TV stations.

²³⁶ These analyses reflect the scenarios for reception of TV.

²³⁷ As stated above, the threshold signal level for digital TV service in the UHF band is -84 dBm at the terminal of a DTV receiver. Thus, using the 33 dB D/U for adjacent channel protection, -84 dBm + 33 dB yields an adjacent channel signal threshold of -51 dBm.

criterion for TV signal strength (-28 dBm is typically considered a relatively “strong” TV signal and -53 dBm is considered a medium TV signal), this essentially means that adjacent channel interference from a fixed TVBD could occur almost anywhere within a station’s service area. Therefore, at this time, we are only prepared to permit fixed TVBDs on channels that are not first adjacent to a TV channel.

173. With regard to personal/portable TVBDs, we first consider indoor reception. In general, we believe that the TVBD and a nearby DTV receiving antenna would not be located such that free space propagation conditions would apply. That is, there will generally be scattering objects (*e.g.*, furniture, persons, fixtures, conductive or dielectric constituents of wall and/or floor construction) within the Fresnel ellipsoid about the ray between the two antennas.²³⁸ Thus, we find that the variation with distance for indoor propagation is generally greater than the distance squared result applicable to free space and we therefore assume a distance variation having an exponent of 2.5. At the -84 dBm threshold for DTV service, interference could occur whenever an undesired signal is higher than -51 dBm on a first adjacent channel. In the indoor scenario, a 100 mW (20 dBm) TVBD signal at 10 meters (53 dB of non-free space attenuation) and after 10 dB of wall attenuation, and 3 dB of polarization mismatch *i.e.*, -46 dBm, would exceed that level by 5 dB. In other words, that signal level would likely not cause interference in a neighboring residence or office, except at locations only where DTV signals are relatively weak indoors, *i.e.*, where DTV signals are at or below -79 dBm.

174. We next consider outdoor TV reception and an outdoor TVBD. As indicated above, at the -84 dBm service threshold, interference could occur whenever an undesired signal is higher than -51 dBm on a first adjacent channel. We again use 16 meters as the horizontal distance between the TVBD and the outdoor antenna and this results in a slant range distance between the two of about 18 meters (60 feet) for a signal strength of -28 dBm (53 dB of free space attenuation).²³⁹ We consider that a personal/portable TVBD near ground level would be outside of the main receive pattern of the TV antenna, so that instead of receiving 10 dBd gain, the device’s signal might only receive -2 dBd gain. We again assume 3 dB of polarization mismatch. Under these conditions, the TVBD signal level at the TV receiver would be -40 dBm. That signal level would not cause interference to the outdoor DTV reception of a neighboring residence or business at locations unless DTV signals are at or below -73 dBm, *i.e.*, at fairly low levels.

175. We also consider outdoor TV reception and an indoor TVBD. Again, at the -84 dBm service threshold, interference could occur whenever an undesired signal is higher than -51 dBm on the first adjacent channels. Using the 16-meter horizontal separation distance, and -2 dBd gain of the TV antenna in the direction of the TVBD, and including 13 dB of building penetration loss and 3 dB of polarization mismatch, the signal level of the TVBD signal would be -53 dB, which is below the threshold of interference.

176. We believe that if the EIRP of these devices is limited to 40 mW and out-of-band emissions are properly controlled, as described below, these devices can operate on first adjacent channels to TV stations without posing an undue risk of interference to TV service. In particular, a 40 mW power limit would reduce the signal strength of a TVBD by 4 dB from the maximum allowed 100 mW and thereby provide adequate protection for indoor DTV reception from TVBD interference on both the first

²³⁸ A Fresnel zone or ellipsoid is defined as the area around the visual line-of-sight into which radio waves spread after they leave the antenna. Radio waves reflecting off objects within this zone generally arrive out of phase with signals that travel directly. The effect is a reduction in received signal strength compared to radio transmissions through an unobstructed Fresnel zone.

²³⁹ For the distance between the personal/portable device and the rooftop TV antenna, we assumed the antenna is 8 meters above the device at one meter and that the rooftop antenna is separated horizontally by 16 meters. We then calculated the slant-range distance between the two locations.

upper adjacent channels and marginal protection for outdoor DTV reception from such TVBD signals. We understand that the proponents of personal/portable TVBDs believe that more power is needed for those devices to operate on a mobile basis. However, from our analysis above we are concerned that if those devices were to operate at higher power the likelihood of interference to TV service would increase significantly.

177. We also observe that additional considerations will serve to further minimize the potential for a personal/portable TVBD operating at 40 mW to cause interference to adjacent channel DTV reception. First, the out-of-band emissions mask we are adopting for TVBDs is much more stringent in the first adjacent channels than the DTV emissions mask on which the adjacent channel D/U protection ratios in the rules were based. Out-of-band emissions constitute co-channel interference in a first adjacent channel that cannot be addressed by receiver selectivity. Reducing those emissions will decrease the interference potential of first adjacent channel TVBD signals to some degree. Second, the DTV Receiver Study prepared by our Laboratory indicated that DTV receivers on the market are typically able to handle adjacent channel signals at levels higher even than the -33 dB value in ATSC Recommendation A/74. That study found that the median adjacent channel D/U ratio for the sampled receivers was -38 dB when the desired DTV signal was near the threshold level for service.²⁴⁰ Finally, we observe that nearly all outdoor TV receiving antennas are horizontally polarized, while all antennas submitted for the prototype TVBDs were vertically polarized. It can be expected that some polarization mismatch beyond the assumed value of 3 dB will occur, particularly in the situation when both TVBD and TV antenna are located outdoors, reducing the level of the TVBD signal at the TV receiver. Thus, while we recognize that there will be variation in the propagation paths between DTV receivers and adjacent channel TVBD transmitters and that a minority of DTV receivers may perform at adjacent channel D/U ratios closer to those in the rules, we believe that this solution will provide adequate protection against TV interference when personal/portable devices operate on adjacent channels.

178. We observe that several commenters, including among others Google and Motorola, submitted comments stating that adjacent channel operations by fixed devices is possible. Google suggest that we allow operation of fixed TVBDs on channels adjacent to TV channels using variable transmit power up to 1 watt, where actual allowed power would be determined based on a formula and the use of a prediction of TV station signal levels using geolocation and the TVBD database.²⁴¹ Similarly, Motorola supports using D/U ratios to protect TV adjacent channel TV operations and requests that TWVS devices be permitted to vary power depending on the adjacent channel TV signal strength.²⁴² We believe that these methods may have merit in providing for more flexible operations of TVBDs. We agree in principle that fixed TVBDs could operate on an adjacent channel where the adjacent channel signal level is strong and an adequate margin is established to ensure against harmful interference to nearby viewers. However, we note that such approaches to protecting adjacent TV channels are predicated on using an appropriate means to predict the adjacent channel signal strength at each location. Propagation models that are currently available generally have a significant statistical variation and the actual TV signal strengths in an area can vary from the predicted signal strengths by as much as 20 to 30 dB due to shadowing, multipath fading and other propagation variables. The information submitted into the record thus far has not demonstrated how the prediction model could be made sufficiently reliable to ensure against harmful interference. Accordingly, we are not allowing the operation of fixed TVBDs on adjacent TV channels at this time. We recognize, however, as

²⁴⁰ See DTV Receiver Study at pp. 5-9, 15-13.

²⁴¹ See Google *ex parte* presentation of October 27, 2008.

²⁴² See Motorola *ex parte* presentation of October 28, 2008.

indicated by Google and Motorola that the availability of adjacent channels may be critical for certain applications. Therefore, we will defer a final decision on allowing operation of fixed devices on adjacent channels and will keep the record open pending the development of additional information demonstrating that a reliable method can be developed to address the above concerns.

179. *Application of TV Protection Criteria – Table of Separation Distances.* As discussed above, the Commission proposed in the *Notice* to require that the TV station service and protection criteria be used in conjunction with appropriate computational software, including use of the Commission's propagation curves and a television station engineering database, for determining whether a TV channel is vacant at a particular location. This approach would require calculation of the protected service contours for each co-channel and adjacent channel TV station analyzed at a given location and calculation of protection ranges from the TV band device to ensure that a TVBDs is far enough from the protected contours of co-channel and adjacent channel TV stations that the D/U ratios are met at locations within the contours of those stations. This is essentially the same approach that is used to ensure that low power TV stations do not cause interference to full service TV stations or to other low power TV stations.

180. In evaluating that approach, we now note that the Commission has not previously specified D/U ratios in Part 15 of the rules to protect licensed services from interference by unlicensed devices. Rather, as in the case of Part 15 medical telemetry devices that operate in the TV bands and radio frequency identification devices that operate at 433 MHz, it has adopted the simpler approach of specifying minimum required separation distances between unlicensed devices and the services being protected.²⁴³ A table of minimum required separation distances between TV station contours and TV white spaces devices would similarly be easier to implement than D/U ratios and provide certainty as to whether a particular TV band device is far enough away from TV stations' service areas to avoid causing interference. Accordingly, we are adopting this alternative approach for ensuring that fixed TV band devices do not cause interference to TV service. The table of separation distances we are specifying in the rules will provide protection that is functionally equivalent to that which would be provided under the D/U ratio approach.

181. In developing the table of separation distances, we believe it is desirable to minimize complexity for compliance. In this regard, we have balanced this goal of simplicity with the need to provide assurance that TV services will be adequately protected. Given that the power of fixed TVBDs will be limited to 4 watts EIRP, the most important variable in determining the separation distance between a particular TVBD and a TV station's protected contour is the height of the device's antenna above ground. For example, using the FCC curves in Section 73.699 of the rules and the D/U protection ratios specified above, we find that a transmit antenna at a height of 30 meters transmitting with 4 watts EIRP could cause co-channel interference to a TV receiver with an antenna 10 meters above ground at a distance of 14.4 kilometers and adjacent channel interference at 0.74 kilometers.²⁴⁴ For transmitting antennas at lesser heights, the FCC curves do not provide usable data, so the Okumura propagation model is applied.²⁴⁵ Using that same transmit antenna at less than 10 meters above ground, interference could be caused by a TVBD to a TV receiver at a distance of 8.0 kilometers to a co-channel TV station and 0.1 kilometers to an adjacent channel TV receiver. A similar calculation applied to a TVBD antenna at 3 meters above ground level calculates that interference can be avoided if separation distances of 6.0 kilometers and 0.1 kilometers are maintained for co and adjacent channel TV stations, respectively. As

²⁴³ See 47 C.F.R. §§ 15.240 and 15.242.

²⁴⁴ See 47 C.F.R. § 73.699.

²⁴⁵ See Okumura, Y., *et. al.*, "Field Strength and its Variability in VHF and UHF Land-Mobile Radio Service," Review of the Electrical Communication Laboratory, Vol. 16, Nos. 9-10, 1968.

discussed below, we are limiting the maximum antenna height of fixed unlicensed TVBDs to 30 meters above ground level and find that this will appropriately balance the needs of unlicensed fixed TVBDs to achieve adequate service range while minimizing the range at which those operations could impact licensed services. We will use these distances in our rules as shown in Table 3.²⁴⁶

Table 3
Minimum Required Separation Distances between Fixed Unlicensed TV Band Devices
and TV Service Contour Edges

Antenna Height of Unlicensed Device	Required Separation (kilometers) From Digital or Analog TV (Full Service or Low Power) Protected Contour	
	Co-channel	Adjacent Channel
Less than 3 meters	6.0 km	0.1 km
3 – Less than 10 meters	8.0 km	0.1 km
10 – 30 meters	14.4 km	0.74 km

182. *Protection of translator receive sites and cable headends.* TV translator receive sites are often located on high towers or at high elevations and use high gain antennas to receive a full service station's signal well beyond the station's service area.²⁴⁷ Cable headends are facilities that acquire and distribute video service signals over a cable television system. Broadcast TV signals are often received off-the-air at a cable headend for retransmission over the cable system. In many cases, the cable headend will use an antenna with high gain mounted high up on a tower to receive a TV station's signals well beyond the station's service area in a manner similar to that used by TV translators.

183. TV translator operators express concern that their receive sites are often outside of the service contour of the full service stations they re-transmit and request that those sites be protected no matter where they are located.²⁴⁸ The National Translator Association (NTA) recommends protecting translator reception in a keyhole shaped area in front of the translator receive site on a line to the station being received. It suggests that the Commission protect reception over a 60 degree arc to a distance of 80 kilometers for co-channel reception, and 20 kilometers for adjacent channel reception.²⁴⁹

184. Cable operators similarly request that cable headends be protected from interference from unlicensed devices, even where the headends are located outside the protected contours of the stations being received for transmission over a cable system, in order to ensure that cable systems will continue to be able to deliver broadcast TV signals to their subscribers.²⁵⁰

²⁴⁶ In specifying the distances in Table 3, we assume that the TVBD antenna is located in an area where it is not situated significantly above the average terrain elevation. While there could be some increased potential for interference from a device that is located on high terrain, we believe that such installations will be infrequent. In addition, our registration requirement will make it possible to identify and rectify any interference that might arise from locating a device on high terrain.

²⁴⁷ A TV translator receive site is a facility at which a translator receives the full service station signal it retransmits (note that it is not one of the individual viewer locations that receive a translator's signal).

²⁴⁸ See National Translator Association *Notice* comments at 6.

²⁴⁹ See National Translator Association *Further Notice* comments at 4.

²⁵⁰ See NCTA *Further Notice* comments at 15.

185. *Discussion.* We find that it is important to avoid disruption of TV service to viewers who are located beyond TV station service areas and able to receive those signals through retransmission on TV translators (as well as low power TV and Class A TV stations; collectively we will refer to these as TV translators herein) and cable systems. While those viewers are in fact located beyond the areas where we normally protect TV services, in these cases TV services have *de facto* been extended and valuable service is being provided to a significant number of households. If a TV band device were to be located between the TV translator/cable headend and station and then operate on one or more of the channels being received by those facilities in a manner that results in interference, TV reception to the households the cable system services could be disrupted. We therefore will protect TV translator receive sites and cable headends.

186. We will protect TV translator receive sites and cable headends using the criteria recommended by the NTA.²⁵¹ Specifically, to prevent interference within the main reception beam of the TV translator station or cable headend receive antenna, operation of TV band devices will be prohibited co-channel and adjacent channel to the channel(s) being received by these facilities over an arc of +/- 30 degrees from a line between the receive site and the TV station(s) being received. The protected zone will extend to the edge of the TV station protected contour, and will be limited in distance to 80 kilometers from the protected contour for co-channel operation and to 20 kilometers from the protected contour for adjacent channel operation. We believe that there are very few cases where a translator receive site or cable headend could be farther outside a TV station protected contour than 80 kilometers and still receive a usable signal.

187. In addition, to prevent interference to TV translators and cable headends from unlicensed TV band devices outside the main beam of the cable TV or translator receive antenna, we will prohibit TVBDs from operating co-channel to the channel(s) being received by these facilities within 8 kilometers and from operating adjacent channel within 2 kilometers in all directions off the +/- 30 degree arc. Again this protection will be afforded only to TV translators and cable headends located within 80 kilometers of a TV station's service area. These protections will be afforded to TV translators and cable headends that register their location and the channel(s) they receive with the unlicensed TVBD database. Parties that operate such facilities and that want to take advantage of these protection criteria will be responsible for requesting the database administrator to register their receive site locations and received TV station channels in the database; facilities not registered will not be protected. To prevent unnecessary entries into the database, we will only permit translator receive sites and cable headends to be registered if they are outside the protected contour of the TV station being received.

188. *Protection of fixed Broadcast Auxiliary Services (BAS) links.* TV studio transmitter links (STLs), TV relay stations and TV translator relay stations may be authorized to operate fixed point-to-point service on UHF TV channels 14-69 on a secondary basis.²⁵² The maximum EIRP for these services is 35 dBW (3,162 watts), although the Commission can authorize higher power if the license application is accompanied by an engineering analysis demonstrating why this limit needs to be exceeded.²⁵³

²⁵¹ The record does not address specific protection standards for cable headends. However, given that the receive circumstances for TV translators and cable headends located outside TV services are essentially the same, we believe that the same protection measures are appropriate for both.

²⁵² See 47 C.F.R. §74.602(h). A TV STL station is a fixed station used for the transmission of TV program material and related communications from the studio to the transmitter of a TV broadcast, Class A TV or low power TV station. A TV relay station is a fixed station used for transmission of TV program material and related communications for use by TV broadcast, Class A TV and low power TV stations. A TV translator relay station is a fixed station used for relaying programs and signals of TV broadcast or Class A TV stations to Class A TV, low power TV and TV translator stations. See 47 C.F.R. § 74.601.

²⁵³ See 47 C.F.R. §74.602(h)(1).

Transmissions are one-way from a transmitter to a receiver, and a system can have more than one link. Except for the temporary links addressed by SBE in its comments, the Commission's Universal Licensing System (ULS) contains information on BAS fixed links, including the frequency and the geographic coordinates of both the transmitter and receiver.²⁵⁴ The ULS shows approximately 220 authorized fixed broadcast auxiliary links in channels 14-51 that are in active status. These links typically range in distance from a few kilometers to tens of kilometers, although the Commission has authorized links to operate over distances in excess of 100 kilometers. The Commission did not propose specific protection criteria for these BAS links in either the *Notice* or *First R&O/Further Notice*, and no parties suggested criteria in their comments. However, because it is a licensed service it must receive protection from unlicensed TV band devices.

189. We find that the most appropriate way to protect fixed BAS links is to specify an exclusion zone near the receive sites similar to the zone we are allowing for translator receive sites and for cable headends located outside the protected service contour of a TV station. Specifically, we will not allow TV band devices to operate co-channel or adjacent channel to a fixed BAS link receiver within +/- 30 degrees of the line extending from the BAS transmitter to the receiver. The protection zone for BAS links will similarly extend to a maximum distance of 80 kilometers from the receiver toward the transmitter for co-channel operations and to 20 kilometers from the receiver toward the transmitter for adjacent channel operation. In addition, to prevent interference from TV band signals outside the main beam of the BAS receive antenna, we will prohibit co-channel operation of TV band devices within 8 kilometers and adjacent channel operation within 2 kilometers of BAS receive sites in all directions off the +/- 30 degree arc. These restrictions will be applied via the TV bands database; that is, the database will be required to include records for BAS links and their technical information and to calculate the exclusion areas where unlicensed TV band devices are not allowed to operate. Permanent fixed BAS receiver sites are already recorded in the Commission's database, so the licensees of those sites will not need to take any action because the designated database administrator(s) will be responsible for obtaining and entering that information from our database. However, we note SBE's concern that temporary fixed BAS links and those operating under STAs are not in the database. We will therefore allow parties operating such links the option of registering those facilities with the database if they so desire to obtain the same protection as permanent fixed BAS links.

190. *Protection of PLMRS/CMRS services.* As discussed above, the PLMRS/CMRS operates on one or two channels in the range of 14-20 in 13 metropolitan areas and the communications systems on these channels are principally used in support of public safety operations. In addition, a number of PLMRS/CMRS operations have been authorized under waivers at locations beyond the 130 kilometer protection zones around the 13 metropolitan areas where they are permitted to operate.²⁵⁵ In the *Notice*, the Commission proposed to require TV band devices to protect PLMRS/CMRS operations using the same criteria in Part 74 of the rules that are applied to TV translator, low power TV and Class A TV stations.²⁵⁶ That is, it proposed to require TVBDs to protect PLMRS/CMRS operations within a 130 kilometer radius of the designated geographic coordinates for each of the 13 metropolitan areas. The field strength from a TV band device on a co- or adjacent channel would not be permitted to exceed 52 dB μ V or 76 dB μ V, respectively, at the 130 km protected radius of the PLMRS/CMRS metropolitan area. Based on these field strength criteria, the Commission proposed to specify that a co-channel TV band device

²⁵⁴ See SBE *Notice* comments at 3-4.

²⁵⁵ See *Notice* at ¶¶ 35-36. The areas where PLMRS/CMRS operations are permitted on a waiver basis are identified on the Commission's Universal Licensing System Database at <http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp>

²⁵⁶ See *Notice* at ¶¶; see also 47 C.F.R. § 74.709.

would have to be 4 kilometers or farther outside this protected radius and an adjacent channel TV band device would have to be 1 kilometer or farther outside this protected radius.²⁵⁷

191. Microsoft states that, given the low duty cycle nature and comparatively low power levels likely for unlicensed services in the TV bands compared to the often 100% duty cycle of low power TV stations, the Commission's proposals for protecting the PLMRS/CMRS seem unduly conservative and constraining.²⁵⁸ Microsoft does not, however, recommend any alternative protection criteria. Motorola argues that TV band devices should operate no closer than 15 kilometers outside the 130 kilometer protected radius, rather than 4 kilometers as proposed by the Commission.²⁵⁹ Motorola derives this separation distance from an analysis in which it believes that the Commission should 1) define a power spectral density limit of 8 dBm/3 kHz consistent with Part 15 rules, 2) consider antenna height and terrain variation, and 3) define an interference level to PLMRS/CMRS of 21 dBμV/25 kHz.

192. We are adopting the proposed protection criteria and therefore will require that co-channel TV band devices be located at least 4 kilometers outside the PLMRS/CMRS protection radius of the 13 metropolitan markets and that adjacent channel TV band devices be located at least 1 kilometer outside this protection radius. These values were derived using the same criteria used to protect PLMRS/CMRS operations from low power TV stations, and no party has demonstrated that they would provide inadequate protection.²⁶⁰ Therefore, we decline to adopt a different definition of interference to the PLMRS/CMRS or adopt additional protection requirements (*i.e.*, a power spectral density limit) for TV band devices as requested by Motorola. We note that the criteria in Part 74 of the rules were developed for protecting PLMRS/CMRS operations against interference from analog TV signals, which have a very non-uniform power spectral density due to the high percentage of power concentrated near the video carrier. Because the current rules adequately protect the PLMRS/CMRS with no power spectral density limit, there is no need to specify a power spectral density limit for TV band devices, which we expect will generally have a much more uniform power spectral density than analog TV.

193. In the case of PLMRS/CMRS operations that have been authorized under waivers at locations beyond the 130 kilometer protection zones around the 13 metropolitan areas, we note that the boundaries of those areas are based on a geographic area (generally that of a county government area) rather than being defined by a point radius. In those cases, mobile units do not operate beyond the geographic boundary of the waiver area. However, the Commission's Universal Licensing System (ULS) contains the coordinates of the licensed PLMRS/CMRS base stations rather than the geographic boundaries of the area covered by the waiver. Therefore, the most practical way to provide protection to PLMRS/CMRS operations pursuant to waivers is to provide a protected zone around each base station licensed under the waiver. The rules specify that the maximum distance a PLMRS/CMRS base station may operate from the geographic center coordinates in the 13 metro areas is 80 kilometers, and then provide an additional 50 kilometer zone of protection for those stations from low power TV operations.²⁶¹

²⁵⁷ *See Id.*

²⁵⁸ *See Microsoft Notice* comments at 21.

²⁵⁹ *See Motorola Further Notice* comments at 12.

²⁶⁰ Specifically, these values are the distances to the 52 dBu and 76 dBu contours, which were calculated by our staff using the FCC F(50,10) curves in Section 73.699 of the rules with an effective radiated power of 4 watts EIRP and an antenna height of 30.5 meters.

²⁶¹ The transmitter sites of PLRMS/CMRS base stations must be located not more than 80 kilometers from the geographic center coordinates of the 13 metropolitan areas, and mobile units must be operated within 48 kilometers of their associated base station. *See* 47 C.F.R. § 90.305. Low power TV stations must protect PLMRS/CMRS operations to 130 kilometers from the geographic center coordinates of the 13 metro areas. Thus, low power TV (continued....)

Thus, new/relocated low power TV stations must not be located within 130 km of a co-channel PLMRS/CMRS base station. We will protect PLMRS/CMRS operations under waivers at the same 50 kilometer distance from base stations as in the 13 metro areas. As discussed above, to prevent interference within a PLMRS/CMRS protected zone, co-channel and adjacent channel TVBDs must be located at least 4 kilometers and 1 kilometer outside the protected zone, respectively. Thus, we will specify that co-channel unlicensed TVBD devices may operate no closer than 54 kilometers from a base station operating under a waiver, and that adjacent channel unlicensed TVBDs may operate no closer than 51 kilometers from a base station operating under a waiver.

194. *Offshore Radiotelephone Service.* The Offshore Radiotelephone Service is a primary radio service that operates on TV channels 15-17 in designated areas along and within the Gulf of Mexico.²⁶² This service is intended to provide public message service between offshore subscribers and central stations. It is used principally for communications between workers at offshore oil facilities and stations on the coast. Operation of low power TV stations is prohibited within designated geographic areas along the Gulf coast on channels 15-18 to prevent interference to the Offshore Radiotelephone Service.²⁶³ The Commission did not specifically propose protection criteria for the Offshore Radiotelephone Service in either the *Notice* or *First R&O/Further Notice*, and no parties addressed this issue in comments. However, it is a licensed service and therefore must be protected from interference from unlicensed TV band devices. We believe it is reasonable to protect Offshore Radiotelephone Service from unlicensed TVBDs in the same manner as we protect those operations from low power TV stations. Accordingly, are prohibiting unlicensed devices, both fixed and personal/portable from operating on channels 15-18 within the designated geographic areas that low power TV stations must avoid to protect the Offshore Radiotelephone Service. This will be accomplished through the use of the geo-location and database capabilities.

195. *Protection of wireless microphones and other Part 74 devices.* Low power auxiliary stations, which include wireless microphones, cue and control communications systems and camera synchronization devices, are allowed to operate on vacant TV channels with power levels of 50 mW in the VHF bands and 250 mW in the UHF bands on a secondary basis under Part 74 of the rules.²⁶⁴ Wireless assist video devices (WAVDs) are similarly allowed to operate under Part 74 on channels 8-12 and 14-51, excluding channel 37, with a power level of 250 mW.²⁶⁵ Operations in these services are licensed, so unlicensed TV band devices are required to provide interference protection to them. The licenses for low power auxiliary and WAVD devices can specify multiple operating channels, but do not specify the exact geographic coordinates where the devices can operate. Further, these devices operate intermittently, rather than continuously like TV stations

196. As indicated above, wireless microphone manufacturers and users request that we protect these devices through several measures, including: 1) limiting new low power devices to fixed operation, 2) prohibiting new low power devices from operating on channels adjacent to occupied TV channels and/or reserving six vacant TV channels in each market to ensure that there is spectrum available for wireless microphones, 3) requiring new low power devices to incorporate spectrum sensing to detect

(Continued from previous page) _____
stations must protect PLMRS/CMRS operations to 50 kilometers from the nearest base station. See 47 C.F.R. §74.709(b).

²⁶² See 47 C.F.R. § 22.1001, *et seq.*

²⁶³ See 47 C.F.R. § 74.709.

²⁶⁴ See 47 C.F.R. § 74.861(e).

²⁶⁵ See 47 C.F.R. § 74.870.

wireless microphones, and 4) requiring new low power devices to sense for the presence of a “smart beacon” that would operate when wireless microphones are in use in an area.

197. We recognize that protection of low power auxiliary devices and WAVDs involves somewhat different considerations than fixed services that continuously, or nearly continuously, occupy the same channels/frequencies or area wide mobile services. The nature of these devices and their use is such they operate for relatively short periods of time at various times (albeit sometimes on a frequent and scheduled) basis and the specific frequencies they use for operation often change from time to time, even at locations such as major event venues. As a result, there are no existing databases that can identify which TV channels are in use by wireless microphones and WAVDs at a given location and a spectrum sensing feature that would be able to reliably detect active microphone operation would not be effective at times when the microphones are not operating.

198. We believe that wireless microphones can be adequately protected under an approach that provides for registration of sites and times where microphones are operated and also includes spectrum sensing as a back-up to the registration system. Under the plan we are adopting, wireless microphone licensees will be allowed to register the sites where they operate along with the days and times when they operate. The database system will then prohibit operation of unlicensed TVBDs from operating near that site on the channels and at the times used for wireless microphones. Wireless microphone licensees will be allowed to register sites and times on a permanent or temporary basis. In addition, as indicated above, TVBDs will be required to look for and detect wireless microphones at signal levels as low as -114 dBm/6 MHz. This will provide protection for microphones that operate on channels on which unlicensed TVBDs are also allowed to operate.²⁶⁶ We are not requiring that unlicensed TVBDs be able to receive and respond to a smart beacon signal identifying the presence of wireless microphone signals for the reasons discussed above.

199. The protection of wireless microphone registered sites will be limited to facilities with wireless microphone use at well defined times and locations.²⁶⁷ Unlicensed TV band devices will be required to include the channels used by wireless microphones and other low power auxiliary devices at such venues in their determinations of available channels for operation. Event site registrations will indicate the type of event, the TV channels used, the geographic coordinates of the event site, whether use of channels at the site is on an on-going permanent basis, the days and times when the site operates, or if site operates on an occasional basis, the dates of such operation. Registration of temporary sites will also be permitted. Unlicensed TVBDs will not be allowed to operate within one kilometer of the recorded geographic coordinates of registered event venues on the channels specified as in use by the registrant during the designated times when low power auxiliary devices are used. This separation distance recognizes the fact that wireless microphones and other devices used at an event site will be at relatively strong signal levels compared to unlicensed TVBD signals at that distance and also allows for wireless microphone use around the area occupied by large event venues such as stadiums, fairgrounds etc. In the case of very large venues such as race tracks and other event sites that may occupy more than a significant portion of the area within a one kilometer geographic square, the operator/coordinator/licensee will be allowed to submit multiple registrations to specify the coordinates of more than one point in the facility. As discussed further in the section on the TV bands database, the Commission reserves the right to request that the database administrator remove voluntarily submitted data that is inaccurate or not justifiable, *e.g.*, is filed for the purpose of limiting other parties’ legitimate use of the white spaces rather than protecting authorized services. In addition to these protections, the TVBD channel usage plan and

²⁶⁶ The technical standards for this sensing requirement are discussed in the technical requirements section below.

²⁶⁷ Significant wireless microphone use includes instances where one or more microphones are in operation for a period of time not less than one hour and can include single events at a site.

our decision to reserve two UHF channels in the range 21-36 and 38-51 will ensure that channels are available for itinerant microphone operations.

200. We do not find it desirable to reserve channels for wireless microphone use in all markets. Such an approach would restrict the availability of spectrum for TVBDs and we see no reason to restrict TVBD operations on frequencies at locations and times where there are no microphone operations.²⁶⁸ In addition, wireless microphones will have access to those channels where TVBDs are not allowed to operate. While the channels where TVBDs are not allowed to operate may not be open in all markets, in many markets there will be channels on which wireless microphones may operate without the need for special measures to receive protection from TVBDs.

E. TV Bands Database System Requirements

201. As indicated above, all unlicensed fixed TV band devices and all personal/portable devices, except for those that operate in Mode I under control of a fixed or Mode II personal/portable device, will be required to access a TV bands database to obtain information on the available channels at their location and all unlicensed fixed TVBDs will be required to register their operations. In the *Notice* and the *First R&O/Further Notice*, the Commission made proposals and asked for comment on a number of specific provisions relating to this database system.²⁶⁹ In particular, the Commission requested comment on the information about authorized stations that should be in a database, such as geographic coordinates, type and class of station, transmit power level, antenna height and other antenna characteristics, the means by which an unlicensed device would access the database, and how often the database would need to be updated. In this section we address the specific plan for operation of the database system, including the information to be stored in the database, the requirements that apply to unlicensed TVBDs for accessing the database system, the responsibilities of a database administrator, and database administrator selection.

202. In comments responding to the *Notice*, Entravision Holdings, LLC (Entravision) and NTA state that a device that automatically checks a database should do so continuously, and that a maintenance routine that allows a frequent check of the accurate functioning of the automatic facilities should be approved with the equipment certification.²⁷⁰ Itron suggests that we require unlicensed TVBDs to automatically check the database daily or weekly.²⁷¹ However, Josephson Engineering, Inc. states that monthly or bimonthly database checks should be sufficient because there is a significant delay between the issuance of a TV station construction permit and actual occupancy of a frequency.²⁷²

203. Motorola submits that the database system could be managed by a third party. It further states that channel availability information should be in a standard format and updated regularly through authorized database registration and that third party providers of database information *e.g.*, a frequency coordinator, industry association, or local broadcast group, should be responsible for its accuracy.²⁷³ Harris similarly believes that the database should be updated at least weekly and states that a device

²⁶⁸ As discussed above, we are, however, reserving two channels in the UHF range for low power auxiliary/wireless microphones in those markets where one or more channels in the range 14-20 are used for PLMRS/CMRS operations.

²⁶⁹ See *Notice* at ¶¶ 26-28 and *First R&O/Further Notice* at ¶¶ 50-51.

²⁷⁰ See *Entravision Notice* comments at 5, *NCTA Notice* comments at 3.

²⁷¹ See *Itron Further Notice* comments at 5-6.

²⁷² See *Josephson Notice* comments at 2.

²⁷³ See *Motorola Notice* comments at 10.

should shut down if it does not receive database updates.²⁷⁴ Motorola submits that the database should contain the Commission's officially established service contour levels to make sure that consistent calculations are performed by various manufacturers' equipment.²⁷⁵ It states that the information in the database should include the TV transmitter location, ERP, antenna height above average terrain (HAAT), radiation center above ground level (RCAGL), FCC service code, license status, and call sign. In addition, Motorola believes that the database should be flexible enough to include different protection levels depending on the transmit power of the TV band device since the interference potential of TV band devices will vary with transmitted power. Motorola supports the Commission's suggestion that a private party be selected to develop and maintain the database.²⁷⁶ CBA suggests that the funding of the database could come from a one-time fee assessed at the purchase of white space devices.²⁷⁷

204. *Database system plan and operation:* We are adopting a database plan that will provide for efficient and effective management of licensee and TVBD records and the identification of available channels for TVBDs. As an initial matter, we will consider authorizing more than one entity to operate a TV bands database. Thus, depending on expressed interest to a solicitation for database managers, the Commission could select multiple database administrators that could offer services on a competitive basis. In this regard, we are mindful that sufficient safeguards must be put in place to ensure that TVBD users would receive the same set of available channels regardless of which database it queries such that entities compete solely on the basis of cost and speed and efficiency of service. The database(s) will be a privately owned and operated service that unlicensed TV band devices must contact to obtain information on channel availability at the locations where they are operated and, in the case of fixed devices, to register their operation at those locations. We will permit database administrators to charge fees for registration of fixed devices and the provision of lists of available channels to fixed devices and personal/portable devices. We believe that third parties will be in the best position to develop and manage a database in a fair and equitable manner and to address the day-to-day operational demands. Any TV bands database will be required to contain information on: 1) all of the authorized services that operate in the TV bands using fixed transmitters with designated service areas, including full service and low power TV stations, 2) the service paths of broadcast auxiliary point-to-point facilities, 3) the geographic regions served by PLMRS/CMRS operations on channels 14-20, 4) regions served by the Offshore Radiotelephone Service, and 5) the locations of cable headends and low power TV receive sites that are outside the protected contours of the TV stations whose signals they receive. In addition, a TV bands database will be required to contain the locations of registered sites where wireless microphones and other low power auxiliary devices are used on a regular or scheduled basis. A TV bands database will be required to register unlicensed TV band devices in accordance with the rules and to provide such devices with a list of the available channels at the specific locations where they are operating.

205. Unlicensed TV band devices, except for those operating as a client to a either a fixed device or a personal/portable device operating in Mode II, will be required to contact a TV bands database through the Internet to obtain a list of available channels at their location in accordance with the rules set forth herein. Database administrator(s) will define protocols so that TV band devices can access a database automatically without human intervention. A TV bands database will calculate the television channels that are available for use by unlicensed TV band devices at their individual locations based on the information in the database and consistent with the separation distances set forth in the rules and then

²⁷⁴ See Harris Notice comments at 8.

²⁷⁵ See Motorola Further Notice comments at 20.

²⁷⁶ *Id.*

²⁷⁷ See CBA Further Notice comments at 4.

return a list of those channels to the TV band device on an approximately real-time basis. A device may then transmit only on those channels which the database indicates are available for its use.²⁷⁸ The database system will also record registration information from each fixed TV band device. The registration information will include the device's location (geographic coordinates) and contact information for its user/operator. This registration information will assist TV band device users in coordinating efficient use of the available television channels at a particular location. In addition, should any interference to licensed services occur, the registration information will assist in the identification of the source of any such interference. Finally, a TV bands database will include provisions for sharing registration data with any other Commission authorized TV bands database.

206. In considering a minimum interval for re-contacting the database system, it is important to note that protection is afforded not only to TV and other fixed facilities that do not change often, but also to mobile/portable facilities such as wireless microphones. As already described, we will allow venues where wireless microphones and other low power auxiliary devices are used on a regular or scheduled basis to register such usage in the TV bands database. Because such usage could change on a daily basis, we will require fixed and mode II TVBDs to recheck the database, at a minimum, on a daily basis. Rechecking in this manner will also provide for timely protection of new or modified licensed facilities. This approach accounts for the continual changes that will occur over time as new licenses are issued or inaccuracies are corrected. We believe that because database access will be done automatically over the internet, rechecking the available channels will not be burdensome. If a device fails to contact a TV bands database on any given day, it will be required to cease transmitting after a one-day grace period. That is, it must cease operating at 11:59 PM on the day following a day when it does not contact a TV bands database. This grace period will allow for situations where there has been a sustained power loss, an internet outage, or other circumstances that disrupt a device's ability to contact a TV bands database. In accessing a TV bands database to update its list of available channels, a device will only need to provide its identification information, current location and, for fixed devices, any changes in its registration information.

207. In addition to the daily database update requirement, personal/portable devices operating in Mode II will be required to re-establish their location coordinates and to access a TV bands database for a list of available channels each time they are activated, *i.e.*, powered on, or move. If such a device maintains a powered on state for one-day or more, the device will then be required to re-check a TV bands database as described above. We find that these measures will ensure that both fixed and personal/portable devices properly maintain a current list of available channels.

208. *Database information.* To ensure that a TV bands database contains sufficient elements to both determine available TV channels for a given location and to register fixed TVBDs, we must define the set of data elements for the database. The elements for the various types of systems that will be in the database is described below. Additionally, we note that for all coordinates we will require that they be referenced to the North American Datum of 1983 (NAD 83) and as described above, we will require accuracy to within 50 meters.

209. The information collected from fixed unlicensed TV band devices will include:

- (1) FCC Identifier (FCC ID) of the device²⁷⁹

²⁷⁸ We will require that fixed TV band devices be designed such that consumers and installers cannot override the functionality of the device to access a database to obtain a list of available television channels and transmit only on those channels contained in the list.

²⁷⁹ See 47 C.F.R. § 2.926.

- (2) manufacturer's serial number of the device
- (3) device's coordinates (latitude and longitude)
- (4) name of the individual or business that owns the device
- (5) name of a contact person responsible for the device's operation
- (6) address of the contact person
- (7) email address of the contact person
- (8) phone number of the contact person.

210. The information collected from personal/portable unlicensed TV band devices, which will not be registered and only access the database for available channels, will include:

- (1) FCC Identifier (FCC ID) of the device
- (2) manufacturer's serial number of the device
- (3) device's coordinates (latitude and longitude)

211. The FCC ID and serial number of the TV band device will uniquely identify individual fixed unlicensed TV band devices. This information will assist the Commission if compliance issues concerning devices arise. A fixed TV band device will be required to update any information that has changed when it makes its daily check with a TV bands database to determine if the list of available channels at its location has changed. If a fixed device does not check the database for three months, its registration will be removed from the database.

212. A database administrator will not be responsible for resolving claims of interference from TVBDs. If there is a claim of interference, a database administrator, upon request from the Commission, must provide TVBD identifying information. If a device is found to be causing interference, the Commission may then require that the party responsible for the unlicensed device take corrective actions or cease operating the device until the interference is resolved. In addition, if a representative of the Commission attempts and is unable to contact the person responsible for a device that is determined to be causing interference, the Commission may require the TV bands database to return a message of "no channels available" to the device at its next scheduled re-check. This will effectively shut down the device until contact is made with the responsible party so that the interference can be resolved. The database administrator will rescind a "no channels available" status for that device only upon authorization by the Commission.

213. Now, regarding services that will be protected a TV bands database will contain the following information on full-power television stations, digital and analog Class A stations, low-power television stations (LPTV), television translator stations, and television booster stations:

- (1) transmitter coordinates (latitude and longitude)
- (2) effective radiated power (ERP)
- (3) height above average terrain of the transmitter (HAAT)
- (4) horizontal transmit antenna pattern (if the antenna is directional)
- (5) channel number
- (6) station call sign

A TV bands database will also be required to include data on the distributed transmission system (DTS) facilities of stations using that technology and to use that data in determining the protected service areas

of such stations.²⁸⁰ The information for full service TV stations is available on the Media Bureau's Consolidated Data Base System (CDBS).²⁸¹

214. A TV bands database will also include information on Broadcast Auxiliary Service (BAS) facilities, which use vacant television channels for fixed point-to-point links. For permanent links, this information is available from the Commission's Universal Licensing System (ULS).²⁸² For temporary BAS links, the party authorized to operate the link may voluntarily submit this information to a TV bands database. For each BAS link the TV bands database will contain:

- (1) transmitter coordinates (latitude and longitude)
- (2) receiver coordinates (latitude and longitude)
- (3) channel number
- (4) call sign

215. In some geographic regions, certain television channels from channel 14 through channel 20 are set aside for use by PLMRS and CMRS operations. These regions are specified in the Commission's rules.²⁸³ A TV bands database will contain the center coordinates (latitude and longitude) for each of these regions and the television channels used in each region. For each of these regions, a TV bands database will include the following data elements:

- (1) region name
- (2) channel(s) reserved for use in the region
- (3) geographic center of the region (latitude and longitude)
- (4) call sign

216. In addition, numerous PLMRS and CMRS licenses have been granted in these channels outside of the identified geographic regions under waivers to the Commission's rules.²⁸⁴ These "waiver" licenses are specified in various ways such as, for example, by allowing a particular transmitted power and antenna height for a base station at a specified location or by specifying a geographic area of coverage, such as the boundaries of a local county administrative area. The database can be populated by information pertaining to facilities authorized by the Commission via an extract from the Wireless Telecommunication Bureau's ULS database. This database contains information on license holders,

²⁸⁰ See Digital Television Distributed Transmission System Technologies, *Report and Order*, MB Docket No. 05-312, adopted November 3, 2008, FCC 08-256, released November 7, 2008. DTS involves the operation of multiple transmitters on the same channel to provide coverage of viewers within a TV station's authorized service area.

²⁸¹ The CDBS is available at <http://www.fcc.gov/mb/cdbs.html>.

²⁸² The ULS database is available at <http://wireless.fcc.gov/uls/index.htm?job=home>.

²⁸³ The 13 regions where channels are set aside for PLMRS/CMRS operations are identified in Section 90.303 of the rules, 47 C.F.R. § 90.303. Base stations may be located within 80 km. (50 mi.) of the center of the geographic region and mobile stations may be located within 48 km. (30 mi.) of the base stations. 47 C.F.R. § 90.305. Consequently, mobile stations may be located within 128 km. (80 mi.) of the center coordinates of the geographic region.

²⁸⁴ Some of these licenses have been issued under explicit waivers to our rules. Others have been issued without a formal waiver request and grant (in effect an informal waiver). For simplicity, we shall refer to all of these PLMRS/CMRS licenses outside of the geographic regions specified in 47 C.F.R. 90.303(b) as having been granted under a waiver to our rules since they do not technically comply with our rules.

facility operation parameters (frequency, location, etc.), and any special conditions that apply. For each of these waiver licenses the following information will be placed into a TV bands database:

- (1) transmitter location (latitude and longitude) or geographic area of operations
- (2) effective radiated power
- (3) transmitter height above average terrain (if specified)
- (4) antenna height above ground level (if specified)
- (5) call sign

In cases where the operator of a PLMRS/CMRS system licensed under a waiver operates multiple transmitters (not including systems that are licensed to operate in a coverage area), information on each transmitter will be required to be maintained in a TV bands database.

217. The Offshore Radiotelephone Service uses channels 15-18 along the coast of the Gulf of Mexico.²⁸⁵ The Commission's rules designate four regions to protect this service.²⁸⁶ For each of the four regions a TV bands database will contain the following information:

- (1) geographic boundaries of the region (latitude and longitude for each point defining the boundary of the region)
- (2) channel(s) used by the service in that region

218. As noted above, cable television systems often use antennas at their headends to receive broadcast television signals and then retransmit those signals to subscriber households throughout the cable system. In many cases, cable systems are able to receive broadcast TV signals at locations outside a station's protected service contour by using high gain antennas mounted on top of buildings or tall towers. Records identifying cable systems that receive TV stations outside of their service areas are not currently maintained in the Commission's databases. As indicated above, we are extending protection to the reception of TV signals by such cable headends. We are therefore allowing cable operators to register, with a TV bands database, their headends that receive TV signals outside of a station's protected contour and requiring that a TV bands database afford protection to those facilities in accordance with the provisions indicated above. A TV bands database will collect the following information to register a cable headend:

- (1) name and address of cable company
- (2) location of the headend receiver (latitude and longitude)
- (3) channel number of each television channel received, subject to the following condition: channels for which the cable headend is located within the protected contour of that channel's transmitting station are not eligible for registration in the database
- (4) call sign of each television channel received and eligible for registration.
- (5) location (latitude and longitude) of the transmitter of each television channel received

219. Television translator and low power stations, including Class A TV stations, rebroadcast the signal of a full service station or another low power station. Like many cable headends, TV translators/low power stations often receive the signal of the station they retransmit outside the

²⁸⁵ See 47 C.F.R. § 22.1007.

²⁸⁶ See 47 C.F.R. § 74.709(e). This rule defines four regions in which low-power television stations cannot operate. TV band devices will be excluded from these same four areas to protect the Offshore Radiotelephone Service.

retransmitted station's protected contour.²⁸⁷ The TV translators and low power stations that currently receive the signal they retransmit off-the-air at locations beyond the originating station's protected service contour are not currently recorded in the Commission's databases. To protect the reception of signals at the receive sites of these stations, we will allow the licensees of such translators and low power stations to register their receive sites with a TV bands database and require the database to afford those sites protection in the same manner as similarly situated cable headends. A TV bands database will collect the following information to register a translator/low power receive site:

- (1) call sign of the TV translator or low power TV station
- (2) location of the TV translator or low power station receive site (latitude and longitude)
- (3) channel number of the retransmitted television station, subject to the following condition: a channel for which the television translator receive site is located within the protected contour of that channel's transmitting station is not eligible for registration in the database
- (4) call sign of the retransmitted television station
- (5) location (latitude and longitude) of the transmitter of the retransmitted television station

220. As discussed above, low power auxiliary stations such as wireless microphones and wireless assist video devices operate in the television bands on a secondary basis under Part 74 of the Commission's rules.²⁸⁸ These devices are usually licensed to operate over a broad geographic area and a wide range of television channels. The use of these devices is sometimes sporadic and nomadic and registration of the locations of such operations' locations in a TV bands database would not be practical. However, in many cases wireless microphones and wireless assist video devices are used regularly and predictably, such as at major sporting events facilities, movie studio lots, and television studios. For these situations, the low power auxiliary device users will be allowed to register in a TV bands database, the location where the devices are used to aid in avoiding interference from TV band devices. In the case of large event facilities such as race tracks and golf courses, we will allow multiple registrations with different geographic coordinates to enable protection of the entire site. We will require that requests for registration of low power auxiliary devices that operate on a seasonal basis, only on certain days within a week or only at specific times include such information; TVBDs will be restricted from operation in the channels used at registered sites only on days and at times when low power auxiliary devices at the sites are in operation. Low power auxiliary registrations will be valid for no longer than a year, after which they may be renewed. The database will collect the following information on registered sites that use low power auxiliary devices :

- (1) name of the individual or business that owns the low power auxiliary device(s)
- (2) the name of a contact person
- (3) an address for the contact person
- (4) an email address for the contact person (optional)
- (5) a phone number for the contact person (optional)
- (6) coordinates where the device(s) are used (latitude and longitude)

²⁸⁷ Many TV translators receive the signal they retransmit without needing to receive the retransmitted station's signal over-the-air. For example, they may obtain the signal of the station they retransmit through use a fixed point-to-point microwave link or wireline connection. Other translators may receive the signal they retransmit via a receiver located within the retransmitted stations protected contour. In those cases, the translator receive sites need not be listed in a TV bands database.

²⁸⁸ 47 C.F.R. § 74.801-82.

- (7) channels used by the low power auxiliary devices operated at the site
- (8) specific months, days and times when the device(s) are used.

221. *Database Administration.* The Commission does not maintain a database of all TV and other stations and operations in the TV bands that could be accessed regularly in real-time by a large number of TVBDs dispersed throughout the country. We will designate one or more database administrators from the private sector to create and operate a TV bands database or databases. We recognize the interests of Google and other TVBD proponents in ensuring that database services be made available on a fair and low cost (or no cost) basis and believe that providing for authorization of more than one party to operate a TV bands database will serve that purpose. The Commission will issue a Public Notice requesting proposals from entities desiring to administer a TV bands database. Any entity that ultimately administrators such a database must make its services available to all TV band device users on a non-discriminatory basis. In addition, to ensure stability for these new devices, we will require each database administrator to provide services for a five-year term, which, at the Commission's discretion, may be renewed. In the event that there is only a single a database administrator and that entity does not wish to continue at the end of its term, it will be required to transfer its database along with the IP address(es) and URL(s) used to access the database to another designated entity and would be allowed to charge a reasonable price for conveyance of that resource.

222. If the Commission chooses multiple entities to administer TV bands databases, we must ensure that each database contains consistent information so that regardless of which database a TVBD queries, it receives the same list of available channels in an area. Because a TVBD will only be required to contact a single TV bands database, there is a need for the TV bands databases to share accurate and timely registration information so that each database has a timely view of the radio environment and can make the best channel recommendations possible. Therefore, we will require that each TV bands database, at a minimum on a daily basis, provide to each other TV bands database, all registration information it receives during the previous day. This data sharing requirement extends only to registrations of fixed devices and protected facilities that are not otherwise captured in Commission databases, including wireless microphone and wireless assist video device locations, cable headends, and TV translator/low power receive sites. The databases can obtain information on other services, such as full service TV, land mobile licenses, etc. directly from Commission databases. We believe that this sharing requirement is extremely important to the success of TVBDs as it decreases the burden on any one database and also foster cooperation between the various database administrators. Although we are requiring the TV bands databases to share information daily, we will leave the actual implementation details up to the database administrators. Once the specific entities are selected, they will need to agree on a specific protocol and data format requirement so that manufacturers can build standard devices that can work with any of the databases and each database can easily transmit and receive data from each other database. In addition, the database administrators may agree whether to share on a more frequent timeframe than daily.

223. A TV bands database will obtain much of the information on licensed use of the television bands for populating the database from the existing Commission databases. The TV bands database will be required to synchronize itself with the existing Commission databases at least once a week so that the information in the TV bands database remains current. Entities operating facilities that are entitled to protection but that are not licensed by the Commission, *e.g.*, cable headends and TV translator/low power TV station receivers, will register their facilities through a process established by the database administrators. We will allow the TV bands databases to charge fees necessary to support the creation and operation of the database. These fees may be imposed on the operators of the TV band devices in order to access the database and/or on the manufacturers of TV band devices, but not on users of the television bands who are not currently in the Commission's database and desire to be included in the database. We do not believe it is appropriate to charge operators of licensed service for protection of their operations from

unlicensed devices. We believe that competition among databases will serve to keep fees low and reasonable. However, if parties believe that the fees charged by a TV bands database are excessive, they may petition the Commission for relief.

224. We recognize that there is potential for inaccurate information to be entered into the database, for omissions to occur, and for records to be present for licensed facilities that are no longer operating. Such inaccuracies could be introduced in several ways. For example, any errors that might inadvertently be present in a Commission database could be transferred to a TV bands database.²⁸⁹ In addition, the fact that we are permitting information on certain services in the TV bands to be voluntarily provided introduces another potential for error. Parties submitting such information could inadvertently provide inaccurate coordinates, channel or other information, and there is also the potential that a party could knowingly provide false information on channel use at a location. The database administrators will be expected to respond quickly to verify and/or correct data in the event that a party brings claims of inaccuracies in the database to its attention, including advising the Commission of any errors that may appear in the Commission's records. Further, the Commission reserves the right to request the removal of voluntarily submitted information from a TV bands database in the event that such information is determined to be inaccurate or not in compliance with the rules.

F. Technical Requirements

225. In this section, we describe the technical requirements that are applicable to unlicensed TV band devices, *i.e.*, both fixed and personal/portable. There are two general categories of requirements. The first consists of transmission system characteristics that are similar to those required for most types of transmitters, including the transmitter power, antenna characteristics and out-of-band emission limits. The second category consists of specific standards and requirements for the procedures to be used to enable unlicensed TV band devices to use the TV white space without causing interference to TV and other authorized services.

1. Transmit Antenna Height Limits

226. As the transmit antenna height of a fixed unlicensed TV band device is increased, both the device's signal coverage and the distance at which it could cause interference to other RF operations in the TV bands services also increase. In the *First R&O/Further Notice*, the Commission sought comment on whether any requirements are necessary with respect to transmitter height, such as a limit on maximum antenna height or a requirement for reduced power when a higher antenna is used.²⁹⁰ We did not receive any comments specifically addressing this issue with respect to fixed devices. However, the White Space Coalition submits that height restrictions should not be imposed on personal/portable devices, arguing that such restrictions would be impossible to administer and are unnecessary given the low power of the devices.²⁹¹

227. Our analysis indicates that the height of a TV band device's transmit antenna can significantly affect the distance at which interference could occur to licensed services in the TV bands. For example, as indicated above, a transmit antenna at 10 meters with 4 watts EIRP could cause interference to a TV receiver with a 9 meter antenna at a distance of 9 kilometers, while that same transmit antenna at 30 meters could cause interference to that TV receiver at a distance of 18 kilometers

²⁸⁹ While we make every effort to ensure that our databases are complete and accurate, sometimes errors do occur; we correct any such errors as we become aware of them and will continue to do so.

²⁹⁰ See *Further Notice* at ¶ 44.

²⁹¹ See White Space Coalition *Further Notice* comments at 16.

and at 100 meters could cause interference at 30.5 kilometers. We therefore conclude that in order to further limit the potential interference range of fixed unlicensed TVBDs it is necessary to limit the height of antennas used with those relatively higher powered devices. We are not imposing height restrictions on the lower powered personal/portable devices.

228. In considering this issue, we observe that the distance that fixed unlicensed TVBDs must be separated from protected service areas is directly related to the maximum allowed antenna height, that is, the minimum required separation distance must increase as the maximum allowed antenna height increases. We believe that an antenna height limit of 30 meters will appropriately balance the needs of unlicensed fixed TVBDs for range to reach receivers while minimizing the range at which those operations could impact licensed services.

229. We agree with the White Space Coalition that it is not practical to administer an antenna height limit for personal/portable devices. However, those devices will not be used in the same manner as fixed devices with gain antennas mounted outdoors that maximize the propagation range of their signals. Rather, personal/portable devices will be used indoors, so that their signals will be attenuated by exterior walls, and will have a maximum of 0 dBi net antenna gain. These factors will significantly reduce the range at which signals from a personal/portable device will be of sufficient field strength to cause interference. We believe that these considerations, coupled with the fact that operation of a personal/portable device on an upper floor of a building would increase the likelihood of sensing the signals of any licensed services in the area, will adequately ensure that unlicensed personal/portable TV band devices do not cause interference when used above ground level.

2. Transmit Power Control

230. In the *First R&O/Further Notice*, the Commission proposed to require unlicensed TV band devices to incorporate transmit power control (TPC) that would automatically limit emissions to a level 6 dB below the maximum permitted transmit power if that level is sufficient to accomplish the desired communications.²⁹² It also proposed not to apply the TPC requirement to devices whose maximum transmit power capability is at least 3 dB below the maximum permissible transmit power. The Commission sought comment on whether it should require a greater range for transmit power control, such as the ability to operate 9 or 12 dB below the limits if that is sufficient to achieve the desired communications. The Commission has previously applied the proposed TPC provisions to Unlicensed-National Information Infrastructure (U-NII) devices that operate in spectrum at 5 GHz.²⁹³ The Commission also sought comment on whether it should require all devices to use transmit power control and to operate with the minimum power necessary to achieve reliable communication,.

231. The Consumer Electronics Association agrees with the proposed requirements for transmit power control and believes that it is not necessary for the Commission to require a greater dynamic range because manufacturers will likely go beyond 6 dB as a matter of good design practice.²⁹⁴ Other parties also support requiring TPC in TV band devices to reduce the potential for interference to services in the TV bands, but believe that the Commission should require a dynamic range greater than 6 dB. Shure supports requiring TV band devices to incorporate TPC and to operate at the minimum power needed to conduct desired communication, rather than at the proposed 6 dB reduction, to reduce interference to incumbent users and also improve co-existence among unlicensed devices.²⁹⁵ The White

²⁹² See *Further Notice* at ¶ 45.

²⁹³ See 47 C.F.R. § 15.407(h)(1).

²⁹⁴ See Consumer Electronics Association *Further Notice* comments at 3.

²⁹⁵ See Shure *Further Notice* comments at 16.

Space Coalition recommends a TPC range of 25 dB, with devices using the minimum power necessary for reliable communications, while IEEE 802.18 recommends a 30 dB range with one dB steps between power levels.²⁹⁶ The White Space Coalition states that transmit power control can reduce the output power of a TV band device to as low as one-third of a milliwatt as appropriate.²⁹⁷

232. *Discussion.* The use of transmit power control to avoid using more power than necessary for a given communication is a sound spectrum management practice that promotes efficient use of this resource. This technique enables communications while minimizing the potential for interference and is now a practicable feature for transceivers. We will therefore require all fixed and personal/portable TV band devices to incorporate transmit power control to limit their operating power to the minimum necessary for successful communication. We are not, however, adopting our proposal to apply the U-NII transmit power control requirements to unlicensed TVBDs or to specify alternative operating parameters for transmit power control as recommended by some parties. After examining the record and the range of power control options recommended by manufacturers, we now conclude that it would be more appropriate to simply require that TVBDs limit their operating power to the minimum necessary for successful communications and let manufacturers determine the range of power control that is appropriate for their individual products. We acknowledge the Consumer Electronics Association statement that manufacturers will likely incorporate transmit power control as a matter of good design practice and note that the developing IEEE 802.22 standard has provisions for transmit power control with a wide dynamic range. We also note that the White Space Coalition states that it intends to incorporate transmit power control into its devices. While we are not specifying the technical parameters for transmit power control, we will require applicants for certification to describe a device's transmit power control feature mechanism in the application.

3. Out-Of-Band Emissions Limits

233. In the *First R&O/Further Notice*, the Commission proposed to require that emissions from an unlicensed device outside that device's channel of operation comply with the limits in Section 15.209 of the rules.²⁹⁸ These are the same out-of-band limits that apply to most intentional radiators operating under Part 15 of the rules, and at frequencies above 30 MHz are also the same as the limits that apply to most unintentional radiators, including computers and radio and TV receivers. However, the Commission recognized the concerns of some parties that these emission levels may be too high for devices that operate in the TV bands and sought comment on whether other emission limits would be more appropriate.

234. The White Space Coalition initially argued that the current Section 15.209 out-of-band emission limits are adequate to protect against interference, except on adjacent channels.²⁹⁹ However, in a subsequent filing, the White Space Coalition recommended that we adopt an out-of-band emissions mask that requires emissions from a device to be 55 dB below the highest average power in the band, as measured in 500 kHz segments, at the edges of the 6 MHz channel in which the device is operating. Tropos Networks believes that the Section 15.247 out-of-band emission limits for spread spectrum and

²⁹⁶ See White Space Coalition *Further Notice* reply comments at 6 and IEEE 802.18 *Notice* comments at 17.

²⁹⁷ See White Space Coalition *Further Notice* reply comments at 4.

²⁹⁸ See *Further Notice* at ¶¶ 59 and 47 C.F.R. § 15.209.

²⁹⁹ See White Space Coalition *Further Notice* comments at 29. The White Space Coalition also suggested that adjacent channel interference protection can be accomplished using a combination of spectrum sensing and transmit power control to meet the adjacent channel D/U ratios. See White Space Coalition *Further Notice* comments at 15.

digitally modulated devices should apply to TV band devices, except in restricted bands.³⁰⁰ However, other parties, including IEEE 802.18, Shure and NAB/MSTV claim that these limits, which resolve to the 15.209 limits at low signal levels, are too high and should be substantially reduced for devices operating in the TV bands.³⁰¹ NAB/MSTV argue that the Section 15.209 limits were not problematic previously because unlicensed devices were prohibited from operating in the TV band, so that emissions in the TV band were far separated in frequency from the channels to which TV receivers tune and therefore well below the Section 15.209 limits. They further submit that until recently most unlicensed devices operated with narrow bandwidths, so out-of-band emissions were generally narrowband spikes that presented low interference risks. MSTV/NAB state that broadband unlicensed TVBDs will have wide out-of-band emissions that may be right at the limit. They observe that the Section 15.209 limits are 5 dB higher than the 41 dB μ V/m field strength of a UHF DTV station at the edge of its protected contour, and in fact need to be 23 dB lower than that level to avoid causing interference.³⁰² GE Healthcare believes that the Section 15.209 limits are not strict enough to protect the WMTS on channel 37 and requests that we adopt a more stringent mask for protection of WMTS devices on that channel.³⁰³ In an *ex parte* letter of May 8, 2008, Dell, Inc. and Google support GE Healthcare's proposal for an emissions mask in channels 36 and 38 to protect WMTS devices. CTIA asks the Commission to ensure that operation of unlicensed TV band devices do not cause interference to 700 MHz band commercial wireless operations.³⁰⁴

235. We find that the emissions mask suggested by the Coalition will adequately protect against interference from out-of-band emissions from signals at the maximum 40 mW (16 dBm) power level that adjacent channels will be allowed to use. At the 10 meter distance we are using for the range at which a user can be expected to exercise control of interference, a 40 mW signal propagating over a free-space path would produce a signal level of -32 dBm at an indoor receiver using an antenna with 0 dBi gain or, in the worst case, -24 dBm radiating directly into an outdoor antenna with 10 dBd (dB reference to a dipole) gain and 4 dB cable loss.³⁰⁵ However, we also believe that in the great majority of instances a personal/portable device will not transmit directly into a TV gain antenna but rather will be off to the side and/or below the rooftop level of the TV antenna so that the received TVBD signal will be picked up at less than maximum gain and could in fact be negative. Thus, we will ignore the gain factor of outdoor antennas in this analysis and use only the -32 dBm signal level at the edge of a TVBD users premises. We also believe that it is appropriate to consider that a TV set or a receiver in some other TV band service that might receive interference from a personal/portable TVBD would be located in the premises of someone else would be on the other side of some structural elemental such as a wall and therefore, as detailed above, assume 10 dB of wall attenuation, 3 dB of polarization mismatch, and an additional 5 dB to account for indoor propagation which is generally greater than free space resulting in 18 dB of

³⁰⁰ See Tropos Networks comments at 13-14. Section 15.247 of the rules which addresses spread spectrum transmitters requires out-of-band emissions to be attenuated at least 20 dB below the level of the fundamental signal, but in no case less than the Section 15.209 limits. Emissions in restricted bands may not exceed the Section 15.209 limits. See 47 C.F.R. § 15.247. The requirement to attenuate out-of-band emissions 20 dB below the level of the fundamental emission may be significantly less stringent than the Section 15.209 limit, depending on the transmitter power used.

³⁰¹ See IEEE 802.18 Notice comments at 27, Shure Notice comments at 20-21, and NAB/MSTV Notice comments at 21-24.

³⁰² See NAB/MSTV Notice reply comments at 22-23.

³⁰³ See GE Healthcare Further Notice comments at 7-8.

³⁰⁴ See CTIA Further Notice comments at 3.

³⁰⁵ Free space attenuation of a 600 MHz signal 10 meters from a non-directional antenna is approximately 48 dB. The attenuation varies slightly over the TV band depending on the specific frequency of operation.

attenuation of the TVBD signal, so that the signal would be no higher than -50 dBm in the adjoining premise.

236. The mask suggested by the Coalition would reduce emissions at the edges of the channel to -55 dB below the average power level in 500 kHz. Using that mask would reduce the out-of-band emissions appearing at a TV receiver to -110 dBm or to 23 dB μ V/m at the receiver's antenna, which is well below the service threshold for DTV reception and the Section 15.209 limit and in fact below the noise floor for 6 MHz. This mask is also more restrictive than the DTV emissions mask in the first adjacent channel for signals of the same power level. We also see no reason to extend the -23 db "weak signal" signal to noise ratio provision of Section 73.622(c)(3) to protection against adjacent channel interference but instead will use the standard 15 db signal-to-noise ratio in that rule section. Given that -110 dBm is more than the standard 15 dB signal-to-noise ratio below the -84 dBm DTV reception threshold (and is in fact below the -107 dBm thermal noise floor in a 6 MHz channel), we conclude that TVBD signals complying with the -55 dB mask will adequately avoid the interference concerns expressed by MSTV/NAB. We also observe that the performance of the Adaptrum transmitter demonstrates that meeting this mask is feasible. While we believe that the emissions mask is less critical for fixed devices that will not operate on adjacent channels, we will require those devices to comply with the same mask as personal/portable devices. This will ensure that out-of-band emissions from all TVBDs pose the minimum potential for interference. Accordingly, we will require that emissions from unlicensed TVBDs be at least 55 dB below the highest average power in the 6 MHz channels adjacent to the 6 MHz channel in which the device is operating.³⁰⁶ Beyond 6 MHz from the edge of the operating channel, radiated emissions from TVBD devices shall meet the requirements of Section 15.209. In addition, we are adopting GE Healthcare's proposal for a mask in channels 36 and 38 to protect WMTS devices in channel 37. All TVBDs will be required to comply with this more stringent requirement for suppression of out-of-band emissions into channel 37.

4. Spectrum Sensing

237. As discussed above, we are requiring TVBDs to be capable of detecting DTV stations, analog (NTSC) TV stations (because low power analog stations may continue to operate after the DTV transition), and wireless microphones at a minimum signal level of -114 dBm. In this section, we discuss and specify the technical requirements for spectrum sensing by unlicensed TV band devices.

238. *Detection Bandwidth and Sensing Antenna.* In the *First R&O/Further Notice*, the Commission sought comment on the appropriate detection threshold for TV band devices that incorporate spectrum sensing. The Commission noted that IEEE 802.22 was considering detection threshold values as low as -114 dBm, referenced to an omnidirectional receive antenna with a gain of 0 dBi, and sought comment on this value or alternative values for the detection threshold.³⁰⁷ The Commission noted that there is a relationship between the sensing receiver bandwidth and ability of a device to detect weak signals. A receiver with a wide bandwidth is not able to detect as weak a signal as a receiver using a narrow bandwidth because the thermal noise in a receiver is proportional to the bandwidth. The Commission sought comment on whether there is a need to specify a sensing bandwidth in addition to a

³⁰⁶ To determine compliance with the OOB, the average power, in 500 kHz segments, in the first adjacent 6 MHz channel is compared to the highest average power in the 6 MHz channel in which the device is operating. Since the resolution bandwidth generally used for making measurements in the 30 MHz to 1000 MHz band is 100 kHz, this measurement may be performed using a minimum resolution bandwidth of 100 kHz as long as the same RBW is used in both channels. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over the RBW used to make the in-band measurement.

³⁰⁷ See *Further Notice* at ¶¶ 37-39.

detection threshold, or whether it is necessary to specify only the characteristics of the signals to be detected as discussed below and leave the sensing bandwidth to the manufacturer's discretion.³⁰⁸ Shure recommends a detection bandwidth of 200 kHz for wireless microphones.³⁰⁹

239. IEEE 802.18 believes that the sensing antenna should have a minimum gain of 0 dBi, assuming the antenna is omnidirectional, but believes that the Commission's rules should allow alternative approaches, such as an electronically rotated high gain antenna that scans 360 degrees.³¹⁰ IEEE 802.18 recommends a requirement that the sensing antenna be located outdoors at a minimum height of 10 meters above the ground to ensure that it is not shadowed by either terrain or man made structures.³¹¹ The White Space Coalition is not opposed to a requirement that the receive antenna have a gain of 0 dBi, but argues that a minimum sensing height requirement is not practical for personal/portable devices.³¹²

240. We are specifying detection bandwidths for TVBDs to ensure uniformity of detection capabilities between devices. We find that a detection bandwidth of 6 MHz is appropriate for digital TV because that is the nominal occupied bandwidth of an ATSC signal, a detection bandwidth for analog TV is 100 kHz, which is representative of the visual carrier bandwidth of an NTSC signal, and a detection bandwidth for wireless microphones is 200 kHz, recommended by Shure and IEEE as being representative of the bandwidth in which they typically operate.

241. As proposed, we will require that the -114 dBm detection threshold be referenced to a 0 dBi gain receive antenna for both fixed and personal/portable devices. That antenna design will maximize the likelihood of sensing signal on an omnidirectional basis. We will also require that the receive antenna used with fixed devices be located at least 10 meters above the ground to maximize the likelihood that it's reception is not blocked from receiving signals originating from any direction. We will allow alternative approaches for the sensing antenna, *e.g.*, electronically rotate-able antennas, provided the applicant for equipment authorization can demonstrate that its sensing antenna provides at least the same performance as an omnidirectional antenna with 0 dBi gain.³¹³ We agree with the White Space Coalition that sensing antenna receive height requirements are impractical for personal/portable devices and decline to impose such requirements.

242. *Channel Availability Check Time, Move Time, and Non-Occupancy Period.* In the *First R&O/Further Notice*, the Commission proposed to require that unlicensed TV band devices that use sensing to determine the availability of unused TV band frequencies perform sensing for a certain period of time before accessing a channel and periodically thereafter to ensure that the channel is still available, *i.e.*, unoccupied.³¹⁴ The Commission sought comment on whether sensing for 30 seconds would be a necessary or sufficient period of time for the initial channel availability check when a device is placed in operation, *i.e.*, turned-on. It also proposed to require that devices re-check the channel at least every 10 seconds to ensure that they are not on the air for extended periods of time causing harmful interference to

³⁰⁸ See *Further Notice* at ¶ 43.

³⁰⁹ See *Shure Notice* comments at 14.

³¹⁰ See *IEEE 802.18 Further Notice* comments at 16.

³¹¹ See *IEEE 802.18 Further Notice* comments at 12.

³¹² See *White Space Coalition Further Notice* comments at 16.

³¹³ Minimum directional gain is defined as the antenna gain in the direction and at the frequency that exhibits the least gain.

³¹⁴ See *Further Notice* at ¶¶ 40-41.

authorized services in the TV bands that are not present during an initial sensing check. The Commission did not propose to require unlicensed devices to remain off-the-air for any prescribed period of time after a channel is first determined to be occupied because it believed that the requirement to perform sensing before operating would ensure that devices will not cause harmful interference to authorized services that are already on the air.

243. The White Space Coalition argues that it is not necessary for the Commission to specify a channel availability minimum sensing period because the optimum check time will be dictated by the algorithms implemented by each manufacturer to meet the minimum detection threshold. It also submits that because of the “always on” nature of services in the TV bands, a re-check interval of one minute is more appropriate than 10 seconds, because the shorter 10 second interval would reduce the throughput of TV band devices.³¹⁵ The White Space Coalition states that a period of 10 seconds after detecting a station is sufficient and appropriate for a device to vacate a channel, and that it is unnecessary to specify a non-occupancy period because devices would be required to confirm that a channel is unoccupied before commencing operation.³¹⁶ IEEE 802.18 recommends that we require that TV band devices check for the presence of wireless microphones every two seconds, but states that a recheck interval of 10 seconds or longer is adequate for DTV signals.³¹⁷

244. Shure advocates that a TV band device be required to monitor a channel for 30 seconds before transmitting to detect wireless microphones that operate intermittently. It believes that an unlicensed device should vacate a channel within two seconds after detecting that it is occupied. Shure further submits that if the Commission does not adopt a requirement that unlicensed devices to avoid for a period of time channels detected as occupied (non-occupancy period), then it should require TV band devices to engage in periodic re-sensing every 10 seconds.³¹⁸ Tropos Networks agrees that the proposed 30 second channel check and 10 second re-check intervals are reasonable.³¹⁹

245. We will require that an unlicensed TV band device perform a channel availability check for at least 30 seconds before first accessing a channel each time the device is activated, *i.e.*, powered-up after being off. This will allow sufficient time for the TVBDs to ensure that the channel is unoccupied, and in particular, to verify that there are no wireless microphones operating intermittently on that channel. We will also require that an unlicensed TVBD perform periodic monitoring of channels being used at intervals not to exceed one minute. This will ensure that the TVBD can detect the signal of an authorized TV band service, particularly wireless microphones, which may commence operation after the device begins using a channel. While we did not propose to set a specific time limit within which a TVBD must vacate a channel after detecting an authorized user, we conclude that such a requirement is needed to ensure that a TVBD device vacates a channel quickly to prevent interference to other users. We therefore are requiring that TVBDs vacate a channel found to be occupied subsequent to a devices’ initial sensing operation within a two second interval, as suggested by Shure. This will provide a reasonable time

³¹⁵ We note that while wireless microphones tend to operate on an intermittent basis over periods of time, *i.e.*, an evening, an afternoon, a one or two hour program, etc., the predominant method of modulation used by those devices is frequency modulation (FM) in which the carrier is always on. However, we are also aware that some digital wireless microphones are now available that use digital modulation schemes that may or may not be on for the full period of an event.

³¹⁶ See White Space Coalition *Further Notice* comments at 14.

³¹⁷ See IEEE 802.18 *Further Notice* comments at 12-14.

³¹⁸ See Shure *Further Notice* comments at 15.

³¹⁹ See Tropos Networks *Further Notice* comments at 10.

interval for the TVBDs to terminate its use of the channel while minimizing interference to the service that has commenced operation on that channel.

246. We decline to adopt a non-occupancy period during which a TVBD must remain off a channel after determining that it is occupied. The requirements to monitor a channel for 30 seconds before commencing operation, combined with the requirement to periodically monitor a channel being used and quickly vacate when an authorized user begins operation, will adequately protect against operation on occupied channels. We recognize the White Space Coalition's concerns that a channel re-check interval of ten seconds could affect throughput capacity, and agree that under most circumstances the users of the spectrum will not change rapidly and a channel re-check time of one minute should be sufficient.

247. *Distributive Sensing and Display of Available Channels.* In the *First R&O/Further Notice*, the Commission recognized that distributive sensing, whereby multiple receivers/antennas at different locations share sensing information, offers an approach for mitigating the hidden node problem. It requested comment on how a distributed sensing approach could be employed on an unlicensed basis. The Commission also indicated that it intended to consider other measures that would promote sharing and further protection of licensed services by devices using spectrum sensing.³²⁰

248. Shure, the White Space Coalition, and WISPA support requiring unlicensed TV band devices to use distributed sensing, although the White Space Coalition believes that a sensing threshold of -114 dBm is sufficient to detect TV band signals in any case.³²¹ Shure recommends that we require distributed sensing by at least two TV band devices, stating this approach would immensely improve the ability of devices to detect wireless microphones and overcome the hidden node problem. WISPA states that a distributed sensing approach would improve the ability to detect the signals, and that the performance of such capability would improve over time as the number of sensors in an area increases.

249. We agree with these parties that distributive sensing will improve the ability of unlicensed TVBDs to detect the signals of licensed services. Use of this approach will better enable these devices to avoid using occupied channels when they are located in hidden nodes or areas where there are signal nulls. We are therefore requiring that unlicensed TVBDs communicating in a local area group or network, either directly with one another or linked through a common base station, share information on channel occupancy determined by sensing. If any device in a local area group or network determines that a channel is occupied, all other linked devices will also be required to treat a sensed signal as if they detected it themselves. However, we also recognize that the service range of wireless microphones is limited to very short distances and that the coverage of a network of TVBDs could extend to areas beyond which some TVBDs on the network would not pose a threat to the operation of a detected microphone system. We therefore will limit the application of the distributive sensing provision with respect to wireless microphones to only require that all TVBDs that are in direct communication with one another treat a wireless microphone signal detected by one as if they detected it themselves.

250. In order to aid users in responding to any complaints of interference that may arise, we are also requiring that an unlicensed TVBD be able to provide its user with a list of available channels as determined by the TV bands database and sensing. This information could be provided through the devices set-up menu or other feature that is readily accessible by the user. While the commenting parties did not specifically address this measure, we find that including this capability in unlicensed TVBDs will greatly simplify answering questions about the channels they are using and provide a means to readily

³²⁰ See *Further Notice* at ¶¶ 42 and 47.

³²¹ See Shure *Further Notice* comments at 14 and *Notice* reply comments at 7, White Space Coalition *Further Notice* comments at 17, and WISPA *Further Notice* reply comments at 3.

examine whether a device is sensing a licensed TV band service. We also do not believe that inclusion of this feature in devices will have a significant cost impact as the current channel availability information must be resident in a device at all times in order for it to function in compliance with the rules adopted herein. In addition, we are requiring that the user manual for the TVBD include information advising consumers of the potential for harmful interference and steps that they can take to identify and remediate the interference, such as increasing the separation of the device from other communications equipment and contacting the manufacturer for technical assistance.

5. Measurement Procedures

251. In the *First R&O/Further Notice*, the Commission stated that it intended to develop interim measurement procedures that will be provided when final rules are adopted. It indicated that these procedures would draw on the measurement procedures for 5 GHz U-NII devices, to the extent those procedures are relevant to unlicensed devices in the TV bands and the rules it adopts for their operation, and its general measurement procedures for unlicensed devices as specified in Section 15.31 of the rules.³²² The Commission also presented proposals on certain specific measurement issues. With regard to testing the sensing detection threshold, it proposed to subject the sensing capabilities of unlicensed devices to an ATSC DTV signal, an NTSC signal and a 200 kHz FM signal with peak levels adjusted to the threshold level. It also observed that the test procedure for 5 GHz U-NII devices calls for performing the detection tests a number of times and specifies pass/fail ratios. The Commission stated that it does not believe such an approach is appropriate for detection of TV band signals because it should be simpler to detect signals from the types of transmitters operating in the TV spectrum than for radars, but invited comment in this regard.

252. A new measurement procedure is needed for evaluating compliance by unlicensed TVBDs with the spectrum sensing and other technical requirements that we are adopting herein. While the spectrum sensing requirements for TVBDs are somewhat similar to the U-NII dynamic frequency selection (DFS) requirements, as we observed in the *First R&O/Further Notice*, there are important differences between TV band and U-NII devices. For example, TV band devices must be capable of detecting signals at a significantly lower threshold than U-NII devices. Also, the types of signals that must be detected (TV, wireless microphone, PLMRS/CMRS, and certain other signals) have different spectral characteristics than radar signals. Further, there are other new requirements for TVBDs, including geo-location accuracy, that are not addressed in any current measurement procedures. Due to the complexity of the requirements necessary to protect authorized services in the TV bands, we expect that it will take some time to develop the appropriate procedures. We plan to develop these measurement procedures as expeditiously as possible. Consistent with the Commission's actions in the U-NII proceeding, our Office of Engineering and Technology will release the procedure for unlicensed TV band devices when it is completed and the Commission will accept data that has been measured in accordance with that procedure pursuant to Section 2.947(a) of the rules.³²³

6. Spectrum Sharing

253. In the *First R&O/Further Notice*, the Commission stated that it anticipates that industry will develop protocol standards that facilitate shared use of the TV white space spectrum.³²⁴ It expressed concern, however, that in the absence of some minimal mandatory requirements, a single device or network of devices could conceivably monopolize use of a channel at a given location or area. The

³²² As indicated above, the U-NII compliance measurement procedure is set forth in the appendix to the *Memorandum Opinion and Order* in ET Docket No. 03-122. See also 47 C.F.R. § 15.31.

³²³ See 47 C.F.R. § 2.947(a)(1).

³²⁴ See *Further Notice* at ¶ 47.

Commission therefore invited comment as to whether it may be necessary or appropriate for the Commission to establish minimal technical requirements to facilitate sharing by TV band devices. It cited examples of such requirements that might include limitations on the duration of transmissions and a requirement to repeat spectrum sensing at intervals more frequently than ten seconds.

254. The White Space Coalition states that it is not opposed to a minimal regulatory requirement to ensure spectrum sharing among devices. It proposes a maximum channel occupancy time of 400 milliseconds, followed by a minimum 100 millisecond interval during which a device may not transmit.³²⁵ However, IEEE 802.18 opposes restrictions on the duration or duty cycle of unlicensed transmissions, arguing that the sharing protocols it is developing will render regulatory restrictions unnecessary.³²⁶ Tropos believes that Commission requirements to facilitate spectrum sharing would ill serve innovation and may undermine the Commission's objective to promote competition.³²⁷ CEA believes that the Commission should leave any spectrum sharing initiatives in the hands of industry, which it claims has proven more facile in adopting self-regulatory standards that improve spectrum efficiency than government regulation.³²⁸

255. We see no demonstrated need at this time for mandatory spectrum sharing provisions for TVBDs and therefore are not adopting such rules. We also note that the IEEE industry group is already developing standards for spectrum sharing between TVBDs. In addition, we are concerned that any spectrum sharing requirements we might adopt now could conflict with the developing industry standards or otherwise limit manufacturers' flexibility in designing TVBDs. We further observe that the requirements we are adopting for TVBDs to periodically re-check a channel for availability will prevent a device from transmitting continuously. We also advise the involved industries and other interested parties that we may revisit this decision in the future if it appears that regulatory requirements for spectrum sharing between TVBDs are needed.

G. Equipment Certification Required

256. We are requiring TVBDs to be certificated under our equipment authorization program. The applicant for an equipment authorization of a device based on geo-location and database access and sensing must meet all of the usual requirements for an application for equipment certification as specified in Parts 2 and 15 of the FCC rules.³²⁹ In addition, we will require an applicant to submit a sample of the device for testing at the FCC Laboratory to determine compliance with all of the pertinent requirements for a TVBD. The device will only be certified once it has been found through testing to meet all of the FCC requirements. This is the process that the Commission has generally followed for new technologies that must meet complex standards and raise significant interference concerns. For example, we have taken a similar approach relative to certification of ultrawideband devices and to new 5 GHz unlicensed devices that include spectrum sensing to avoid causing interference to Department of Defense radars. As noted below, we are not allowing certification of TVBDs by Telecommunications Certification Bodies at this time. The FCC laboratory will act on such applications under delegated authority pursuant to section 0.241(b) of the Commission's rules.

³²⁵ See White Space Coalition *Further Notice* comments at 17.

³²⁶ See IEEE 802.18 *Further Notice* comments at 18.

³²⁷ See Tropos Networks *Further Notice* comments at 11.

³²⁸ See CEA *Further Notice* comments at 5.

³²⁹ See 47 C.F.R. Parts 2 and 15.

H. Equipment Certification Under A “Proof Of Performance” Standard

257. As indicated above, we are providing a special equipment certification procedure for approval of sensing only devices that demonstrate the ability to detect protected services with a high level of accuracy. In providing this procedure, we recognize that cognitive radio technology, including sensing, is in its nascent stage of development for commercial applications. Cognitive radio technology holds great promise for increasing access spectrum access to the benefit of consumers and businesses and we find it in the public interest to continue to encourage the development of this technology. We also recognize that the TV band prototype devices that were submitted to the Commission for evaluation were designed primarily to demonstrate the capability of using spectrum sensing for interference avoidance. While the devices were able to detect the signals of incumbent services under certain conditions, they were not able to do so under others. For example, it does not appear that the devices were designed to cope with certain real-world conditions such as strong adjacent channel signals or the challenges of operating in noisy environments. This made it particularly difficult to fully validate the performance of the technology and develop standards that would ensure a high degree of confidence that devices relying on sensing alone would not interfere. Nevertheless, we believe that these problems can be solved. As an incentive to continue to develop this technology, we will provide for certification of devices under the conditions and process described below.

258. We therefore are adopting rules that will allow for certification of personal/portable devices that rely solely on a spectrum sensing capability and do not include geo-location and database access capabilities. These sensing only devices will be required to meet a “proof of performance” standard where they must demonstrate with an extremely high degree of confidence that they will not cause harmful interference to incumbent radio services. Devices authorized under this procedure will be subject to all rules for personal/portable devices, except that out-of-an abundance of caution with regard to their interference potential, such devices will be limited to 50 mW EIRP rather than the 100 mW permitted for personal/portable devices that use the geolocation and database method.

259. Manufacturers must submit an application for certification in accordance with Part 2, Subpart J of the Commission’s rules. The application must include a full explanation of how the device will protect the incumbent radio services against harmful interference. In addition to the procedures of Part 2, Subpart J of the Commission’s rules, the applicant must submit a pre-production sample for laboratory and field testing. The pre-production sample device must be identical to the device expected to be marketed.

260. The Commission will process this application in the following manner. Applications will be placed on Public Notice for a minimum of 30 days for comments and 15 days for reply comments. Applicants may request that portions of their application remain confidential in accordance with section 0.459 of this chapter. This Public Notice will include proposed test procedures and methodologies. After the comment period, the Commission will test the devices to evaluate proof of performance, including characterization of its sensing capability and its interference potential. The testing will be open to the public. Subsequent to the completion of testing, the Commission will issue by Public Notice, a test report including recommendations. The Public Notice will specify a minimum of 30 days for comments and, if any objections are received, an additional 15 days for reply comments. The ultimate decision on whether to certify a device that relies solely on sensing will be made by the full Commission.

261. The determination of whether to certify the device will be based on a demonstrated ability to avoid causing harmful interference with an extremely high degree of reliability. As noted above, there has been much discussion in this proceeding as to the effectiveness of sensing at particular levels. We note that we are adopting a detection threshold of -114 dBm for devices that rely on geolocation and database access. However, this particular level may or may not be the appropriate sensing threshold for these sensing only devices. The decision by the Commission whether to certify the equipment will rest on its performance in avoiding interference, not any particular sensing level. If the

device is certificated, we will permit routine certification of other devices that have identical characteristics (*i.e.*, have the identical electrical characteristics and antenna system). We will endeavor to complete the certification process within 180 days of submittal of the device for testing, barring any unforeseen circumstances.

I. Other Matters

1. Certification By Telecommunications Certification Bodies

262. In the *First R&O/Further Notice*, the Commission proposed that Telecommunications Certification Bodies (TCBs) initially not be permitted to certify TV band devices because these devices would contain new technologies and many questions about the application of the rules may arise.³³⁰ Specifically, the Commission proposed to place TV band devices on the list of types of devices that TCBs are excluded from certifying until it has more experience with them and can advise TCBs on the application of the rules.³³¹ Both the Consumer Electronics Association and Shure support this proposal and no parties opposed it.³³² We continue to believe that we should exclude TCBs from granting applications for certification of unlicensed TV band devices at this time for the reasons indicated above. We will therefore limit the processing of those applications to our Laboratory Division until such time as we gain experience with unlicensed TVBDs and the technology used in those products becomes mature such that the application review process becomes routine. Accordingly, we will not allow TCBs to certify TV band devices until further notice.

2. Operation In Border Areas

263. The allotment and assignment of TV channels in the border areas with Canada and Mexico are subject to agreements with each of those countries. Low power TV assignments within 32 kilometers (20 miles) of the Canadian border must be referred to the Canadian authorities for approval.³³³ In addition, low power UHF TV stations that are located less than 40 kilometers (25 miles) from the Mexican border, and low power VHF TV stations that are less than 60 kilometers (37 miles) from the Mexican border, must be referred to the Mexican government for approval.³³⁴ In the *Notice*, the

³³⁰ See *Further Notice* at ¶ 64. All unlicensed transmitters and most licensed transmitters are required to be certified by the Commission or a designated Telecommunication Certification Body (TCB) before they may be legally marketed within the United States. In establishing the requirements for TCBs, the Commission stated that while it intended to allow TCBs to certify a broad range of equipment, certain functions should continue to be performed by the Commission. These functions include certifying new or unique equipment for which the rules or requirements do not exist or for which the application of the rules is not clear.

³³¹ The Commission's Laboratory maintains a list of types of devices that TCBs are excluded from certifying. Once it determines that TCBs have the necessary expertise to certify an excluded device, the Laboratory will remove it from the list.

³³² See Consumer Electronics Association comments at 7 and Shure comments at 21.

³³³ See *Working Arrangement for Allotment and Assignment of VHF and UHF Television Broadcasting Channels under the Agreement between the Government of the United States of America and the Government of Canada Relating to the TV Broadcasting Service*, dated March 1, 1989. This agreement is available on the Commission's web site at <http://www.fcc.gov/ib/sand/agree/files/can-bc/can-tv.pdf>.

³³⁴ See *Agreement Amending the Agreement Relating to Assignments and Usage of Television Broadcasting Channels in the Frequency Range 470-806 MHz (Channels 14-69) along the United States-Mexico Border*, dated November 21, 1988. This agreement is available on the Commission's web site at <http://www.fcc.gov/ib/sand/agree/files/mex-bc/lpuhfbc.pdf>. See also, the untitled amendment to the United States-Mexican agreement on VHF stations dated September 14-26, 1988, available on the Commission's web site at <http://www.fcc.gov/ib/sand/agree/files/mex-bc/lpvhfbc.pdf>. The agreements may require coordination at greater distances from the border depending on the ERP and HAAT of the LPTV station.

Commission proposed to prohibit unlicensed TV band devices from operating at less than these distances from the Canadian and Mexican borders until agreements are reached with those countries.³³⁵ The Commission also sought comment on how to ensure that unlicensed devices using vacant TV channels do not operate within the border areas and whether the methods used to ensure that these devices operate only on vacant TV channels could be adapted to preclude operation in the border areas. In the *First R&O/Further Notice*, the Commission sought comment on whether the agreements with Canada and Mexico would need to be modified before unlicensed TV band devices could operate in the border areas.³³⁶

264. The White Space Coalition argues that the agreements with Canada and Mexico do not need to be modified because they relate to restrictions on TV station operations and not on devices that operate in the TV bands using significantly less power than TV stations. It further argues that the use of unlicensed TV band devices is not inconsistent with those agreements, assuming the devices use spectrum sensing to avoid Canadian and Mexican TV signals.³³⁷ NAF, et al., believe that given the low power and sensing capabilities proposed in this proceeding, there is no risk to either Canadian or Mexican television operations. They also believe that geo-location is another reliable option. The NAF, et al., also submit that the Commission should interpret the legal requirement for coordination as existing only where a device can potentially interfere.³³⁸ IEEE 802.18 states that operation of fixed devices can easily be controlled using geo-location to ensure that they do not violate the necessary separation from the border.³³⁹

265. We find that fixed TV band devices should not be permitted to operate within the border areas specified in our Canadian and Mexican agreements until we have an opportunity to negotiate any necessary changes to those agreements with Canada and Mexico. The fixed TV band devices that operate with outdoor antennas at an EIRP of up to 4 watts will be somewhat similar in operation to low power TV stations. Therefore, in keeping with the low power broadcasting agreements with Canada and Mexico, we will not permit fixed TV band devices to operate on any channels within 32 kilometers of the Canadian border, within 40 kilometers of the Mexican border on UHF channels, or within 60 kilometers of the Mexican border on VHF channels.³⁴⁰ These distance restrictions will be enforced through the use of a device's geo-location and database access capabilities, which all fixed devices must incorporate.

266. We will apply these same restrictions on the use of unlicensed personal/portable TV band devices within the border areas. While personal/portable devices will operate with significantly lower power, in order to avoid any uncertainty in administering our agreements with our neighboring administrations, we believe it is also necessary to restrict operation of those devices in the border areas. Personal/portable devices that operate in Mode II using a geo-location/database access capability will be required to use that capability to determine whether they are located in a border area. Devices operating in Mode I on a client basis without a geo-location/database access capability will be prevented from operating in the border areas in that they will operate relatively close to an associated base station (fixed or personal/portable) that uses a geo-location/database access capability that will keep it from operating in

³³⁵ See Notice at ¶ 46.

³³⁶ See *First R&O/Further Notice* at ¶ 65.

³³⁷ See White Space Coalition *Further Notice* comments at 30-31.

³³⁸ See NAF, et al. *Further Notice* comments at 87-88.

³³⁹ See IEEE 802.18 *Further Notice* comments at 24.

³⁴⁰ The distances we specify are the minimums specified in the agreements because those distances would apply to a station with the proposed maximum unlicensed device power of 1 watt into a 6 dBi gain antenna (2.43 watts ERP).

the border areas. The requirement that all personal/portable devices incorporate sensing to a level of -114 dBm will further minimize the risk of interference to TV stations in Canada and Mexico.

3. Reconsideration Of Marketing Date For Unlicensed TV Band Devices

267. In their Petition for Reconsideration, NAF/CUWN request that we reverse our decision to prohibit the marketing of TV white space devices until the DTV transition ends on February 17, 2009, and instead authorize marketing of such devices as soon as we develop rules and certify that devices comply with them. NAF/CUWN argue that there is no technical reason why devices using any of the mechanisms the Commission will approve cannot operate prior to the analog switch off date. They also contend that if the transition is to go smoothly, the vast majority of stations must be converted to digital operation and the public must be ready to receive digital signals well before February 17, 2009. They further argue that delays will impose considerable and needless costs on the public. NAF/CUWN state that because TVBDs will represent new devices operating under new rules, developers will need to start from scratch when innovating with the new equipment rather than simply building on past experience and existing software. They contend that the sooner the Commission allows properly certified devices on the market, the sooner the learning and experimentation can begin.

268. We are maintaining our decision to prohibit the marketing of unlicensed TV band devices until the DTV transition ends on February 18, 2009. In this regard, we remain concerned that allowing operation of unlicensed devices during the transition period could cause uncertainty for the broadcast television about possible interference. For example, in the transition period stations will be changing channels and otherwise operating in manners that are temporary. This changing pattern of TV channel usage will affect the availability of channels that could be used by unlicensed devices. We believe that it is quite reasonable for broadcasters to be uncertain about whether their services are adequately protected from interference from unlicensed devices in such an environment. We further note that, as reflected in the issues raised in the third DTV period review, all stations will not be fully converted well before the end of the transition.³⁴¹ We also are not persuaded by NAF/CUWN's argument that the proscription on marketing of unlicensed TVBDs until the transition ends will impede the development of unlicensed TVBDs. That development process, including completion of the certification requirement, can take place prior to the actual marketing of devices. Given that there are only a few months remaining before the end of the transition, the period of time between when devices are certified and otherwise ready for marketing and the end of the transition will be long in any case.

4. Emergency Request For Additional Comment Period

269. On October 17, 2008, several broadcast interests filed an "Emergency Request" asking the Commission to issue a public notice seeking comment on the Phase II Test Report.³⁴² The requesters contend that the report expresses conclusions that are not supported by the data in the report and that the public has not had opportunity to review and comment meaningfully on the results of the report. This request is denied. The testing process has been open and members of the public, including persons representing the requesters and their interests, have observed the testing and have been privy to the data as it was collected. All have had opportunity on a continuing basis to comment and they have done so, as has been demonstrated in numerous *ex parte* submissions related to, referring to, or based on the testing.

³⁴¹ See *Notice of Proposed Rulemaking* in MB Docket No. 07-91, *supra*.

³⁴² See Emergency Request filed by The Association For Maximum Service Television, Inc., The National Association of Broadcasters, The ABC, NBC, CBS, and FOX Television Networks, and The Open Mobile Video Coalition, filed Oct. 17, 2008.

V. PROCEDURAL MATTERS

A. Final Regulatory Flexibility Analysis

270. The Final Regulatory Flexibility Analysis, required by the Regulatory Flexibility Act, *see* 5 U.S.C. § 604, is contained in Appendix B.

B. Final Paperwork Reduction Act of 1995 Analysis

271. This Second Report and Order contains new or modified information collections subject to the Paperwork Reduction Act of 1995 (PRA) and will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA, Public Law 104-13. A modification is required to the Form 731 (OMB 3060-0057).

C. Contact Persons

272. For additional information concerning this Second Report and Order and Memorandum Opinion and Order, please contact Mr. Hugh L. Van Tuyl at (202) 418-7506, Mr. Nicholas Oros at (202) 418-0636, or Mr. Alan Stillwell at (202) 418-2925, or via the Internet at Hugh.VanTuyl@fcc.gov, Nicholas.Oros@fcc.gov, and Alan.Stillwell@fcc.gov, respectively.

VI. ORDERING CLAUSES

273. Accordingly, **IT IS ORDERED** that, pursuant to the authority contained in Sections 4(i), 302, 303(e), 303(f), and 307 of the Communications Act of 1934, as amended, 47 USC Sections 154(i), 302, 303(c), 303(f), and 307 this Second Report and Order **IS HEREBY ADOPTED**.

274. **IT IS FURTHER ORDERED** that Part 15 of the Commission's rules **IS AMENDED** as specified in Appendix B, and such rule amendments shall be effective 30 days after publication of the text thereof in the Federal Register. This Second Report and Order contains information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13, that are not effective until approved by the Office of Management and Budget. The Federal Communications Commission will publish a document in the Federal Register following approval of the information collection by the Office of Management and Budget ("OMB") announcing the effective date of those rules.

275. **IT IS FURTHER ORDERED** that, pursuant to Sections 4(i), 302, 303(e) 303(f), 303(g), 303(r) and 405 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 302, 303(e), 303(f), 303(g), 303(r) and 405, the petition for reconsideration filed by the New America Foundation and the Champaign Urbana Wireless Network **IS DENIED**.

276. **IT IS FURTHER ORDERED** that, pursuant to Sections 4(i), 302, 303(e) 303(f), 303(g), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 302, 303(e), 303(f), 303(g) and 303(r), the Emergency Request filed by The Association For Maximum Service Television, Inc., The National Association of Broadcasters, The ABC, NBC, CBS, and FOX Television Networks, and The Open Mobile Video Coalition **IS DENIED**.

277. **IT IS FURTHER ORDERED** that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, **SHALL SEND** a copy of the Second Report and Order, including the Final Regulatory Flexibility Analysis, to the Government accountability Office pursuant to the Congressional Review Act, see 5 U.S.C. 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Parties Filing Comments

Comments on NPRM

1. Adaptrum, Inc.
2. Alan Greagor
3. Association of Public Safety Communications Officials
4. Association of Public Television Stations
5. ATK Audiotek
6. Attron Networks, LLC
7. Audio-Technica U.S., Inc.
8. Chip Brown
9. Chuck Profito
10. Cohen, Dippell and Everist, P.C.
11. Commercial Broadcasting Corporation
12. Community Broadcasters Association
13. Consumer Electronics Association
14. County of Los Angeles
15. Cox Broadcasting, Inc.
16. CWLab
17. Dan Lubar
18. Dustin Goodwin
19. Entravision Holdings, LLC
20. Harris Corporation
21. IEEE 802
22. Industrial Telecommunications Association, Inc.
23. Intel Corporation
24. International Communications Industries Association, Inc.
25. Itron, Inc.
26. James M. McKinion
27. James Stoffo
28. John Laprise
29. John Notor
30. John Terrill
31. Jon M. Peha
32. Josephson Engineering, Inc.
33. Karl Winkler
34. Kenneth DiPietro
35. Kenneth Youngquist
36. KHEM Television
37. Lee Good, RTS
38. Mark Koskenmaki
39. Marlon K. Schafer
40. Metropolitan Area Networks, Inc.
41. Michael Falaschi
42. Michael J. Marcus
43. Michael Mason
44. Michiana Wireless
45. Microsoft Corporation
46. Motorola, Inc.
47. NAB and MSTV
48. NAMM, the International Music Products Association
49. National Academy of Sciences
50. National Cable & Telecommunications Association
51. National Radio Astronomy Observatory
52. National Systems Contractors Association
53. National Translator Association
54. New America Foundation, et al.
55. Noah Miller
56. NPG of Oregon, Inc.
57. NYCwireless.net
58. Old Colorado City Communications
59. OnlyInternet Broadband & Wireless, Inc.
60. Pappas Telecasting Companies
61. Paul Burkholder
62. Pikes Peak Broadcasting Company
63. Professional Audio Manufacturers' Alliance
64. PVT Networks, Inc.
65. QUALCOMM Incorporated
66. R. Kent Parsons
67. Raymond D. Meredith, Jr.
68. Rebekah Morris
69. Red River Broadcasting Co., LLC
70. Region 1 Translator Association
71. Ron Wallace
72. Ronald E. Wallace
73. Sascha D. Meinrath
74. Sennheiser Electronic Corporation
75. Shared Spectrum Company
76. Shure Incorporated
77. Society of Broadcast Engineers, Inc.
78. Southwest Colorado TV Translator Association
79. Stelios Valavanis
80. Symmetrical Networks, Inc.
81. Syncom Media Group, Inc.
82. Telecommunications Industry Association
83. Telex Communications, Inc.
84. Tim Foster
85. Tony Ray
86. Total RF Marketing, Inc.

87. Tropos Networks
88. Vaxeo.com
89. WDLP Broadcasting Co., LLC
90. White Pine Television District No. 1
91. Wi-Fi Alliance
92. Wireless Broadband Operators Coalition
93. Wireless Internet Service Providers Association
94. Wireless Unleashed
95. Yochai Benkler
96. Zachary C. Miller

Reply Comments on NPRM

1. 700 MHz Advancement Coalition
2. Alan B. Greager
3. Allcom Communications, Inc.
4. BPS Networks
5. Brendan Geaney
6. Cameron Communications Corporation
7. Cohen, Dippell and Everist, P.C.
8. Community Broadcasters Association
9. Consumer Electronics Association
10. EarthLink, Inc.
11. Information Technology Industry Council
12. Intel Corporation
13. KBDI, Channel 12
14. Kennebec Telephone Company
15. Land Mobile Communications Council
16. Lanham Rattan
17. Motorola, Inc.
18. NAB and MSTV
19. NARTE
20. National Translator Association
21. New America Foundation, et al.
22. North Dakota Network Company
23. OnTarget Technologies, LLC
24. Pitkin County FM-TV Department
25. Ponderosa Telephone Company
26. PVT Networks, Inc.
27. QUALCOMM Incorporated
28. Red River Rural Telephone Association
29. Shared Spectrum Company
30. Shure Incorporated
31. Society of Broadcast Engineers, Inc.
32. Timothy X Brown
33. Webster Calhoun Cooperative Telephone Association

Comments on Further NPRM

1. Advanced Broadband Solutions, Inc.
2. American Society for Healthcare Engineering – ASHE
3. American Federation of Television and Radio Artists
4. Comm Enterprises, LLC
5. Communications Research Centre Canada
6. Community Broadcasters Association
7. CompTIA
8. Consumer Electronics Association
9. County of Los Angeles
10. Cox Broadcasting, Inc.
11. CTIA – The Wireless Association
12. Dell, Google, HP, Intel, Microsoft and Philips (“The Coalition”)
13. Entravision Holdings, LLC
14. GE Healthcare
15. Guitar Center, Inc.
16. IEEE 802.18 Radio Regulatory Technical Advisory Group
17. ION Media Networks
18. Itron, Inc.
19. James R. McDonald
20. Joint Comments of Broadcasters
21. Kenneth E. Lewetag
22. KJLA, LLC
23. Land Mobile Communications Council
24. Martin J. Jackson
25. McGraw-Hill Broadcasting Company, Inc.
26. Media General, Inc.
27. Motorola, Inc.
28. MSTV & NAB
29. National Cable and Telecommunications Association
30. National Translator Association
31. National Radio Astronomy Observatory
32. Qualcomm Incorporated
33. R. Kent Parsons
34. Radio-Television News Directors Association
35. Recording Artists’ Coalition
36. Region 1 Translator Association
37. Shure, Inc.
38. The Brattle Group
39. The Professional Audio Manufacturers Alliance
40. The National Academy of Recording Arts and Sciences
41. Tropos Networks
42. TV Transmission Antenna Group, Inc.

43. Wi-Fi Alliance
44. Microphone Interests Coalition
45. NAF, et al.
46. Thomas C. Smith

17. Shure, Inc.
18. The Brattle Group
19. Tropos Networks
20. Wireless Internet Service Providers' Association

Reply comments on Further NPRM

1. Audio-Technica U.S., Inc.
2. Capitol Broadcasting Company, Inc.
3. DC Access, LLC
4. Dell, Google, HP, Intel, Microsoft and Philips ("The Coalition")
5. EchoStar Satellite LLC
6. Grand Ole Opry and Microphone Interests Coalition
7. Hubbard Broadcasting Company, Inc.
8. Motorola, Inc.
9. MSTV and NAB
10. NAMM, The International Music Products Association
11. National Translator Association
12. National Cable and Telecommunications Association
13. NAF, et al
14. NextWave Broadband, Inc.
15. Professional Audio Manufacturers Alliance
16. Roadstar Internet

Comments on Technical Reports

1. Cohen, Dippell and Everist, P.C.
2. Community Broadcasters Association
3. DTV Manufacturers
4. LG Electronics, Panasonic and TTE
5. Microphone Interests Coalition
6. Microtune, Inc.
7. Motorola, Inc.
8. MSTV and NAB
9. NAF, et al.
10. National Cable & Telecommunications Association
11. Philips Electronics North America Corporation
12. Samsung Electronics
13. Shure, Inc.
14. Sony Electronics, Inc.
15. Sprint Nextel Corporation
16. White Space Coalition

In addition to the above-listed comments, over 30,000 parties submitted filings outside of the Commission's designated comment and reply comment periods.

APPENDIX B**Final Rules**

Part 15 of Title 47 of the Code of Federal Regulations is amended as follows:

1. The authority citation of Part 15 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302a, 303, 304, 307, 336, and 544a

2. Section 15.37 is amended by adding a new paragraph (n) to read as follows:

Section 15.37 Transition provisions for compliance with the rules.

* * * * *

(n) Marketing of TV band devices operating under Subpart H of this section is not permitted prior to February 18, 2009.

3. A new Subpart H is added to read as follows:

Subpart H – Television Band Devices

Section 15.701 Scope.

This subpart sets out the regulations for Television Band Devices (TVBDs) which are unlicensed intentional radiators operating on available channels in the broadcast television frequency bands at 54-60 MHz, 76 - 88 MHz, 174 - 216 MHz, 470 - 608 MHz and 614 - 698 MHz bands.

Section 15.703 Definitions.

(a) Available Channel. A television channel which is not being used by an authorized user at or near the same geographic location as the TVBD and is acceptable for use by an unlicensed device under the provisions of Section 15.709 of this chapter. A TVBD determines television channel availability either from the *TV bands database* or *Spectrum Sensing*.

(b) Client Device. A TVBD operating in *Client Mode*.

(c) Client Mode. An operating mode in which the transmissions of the TVBD, including frequencies of operation, are under control of the *Master Device*. A device in client mode is not able to initiate a network.

(d) Fixed Device. A TVBD that transmits and/or receives radiocommunication signals at a specified fixed location. Fixed TVBDs may operate as part of a system, transmitting to one or more fixed TVBDs or to personal/portable TVBDs.

(e) Geo-location. The capability of a TVBD to determine its geographic coordinates within a specified level of accuracy.

(f) Master Device. A TVBD operating in *Master Mode*.

(g) Master Mode. An operating mode in which the TVBD has the capability to transmit without receiving an enabling signal. The TVBD is able to select a channel itself and initiate a network by sending enabling signals to other devices. A network always has at least one device operating in master mode.

- (h) Mode I Operation. Operation of a personal/portable TVBD operating only on the *Available Channel* identified by either the fixed TVBD or Mode II TVBD that enables its operation. Mode I operation does not require use of a *Geo-location* capability or access to the *TV bands database* and requires operation in *Client Mode*.
- (i) Mode II Operation. Operation of a personal/portable TVBD whereby the device determines the *Available Channels* at its location using its own *Geo-location* and *TV bands database* access capabilities. Devices operating in Mode II may function as *Master Devices*.
- (j) Network Initiation. The process by which a fixed or Mode II TVBD sends control signals to another similar device or to a *Client Devices(s)* and allows them to begin transmissions.
- (k) Operating Channel. An *Available Channel* used by a TVBD for transmission and/or reception.
- (l) Personal/portable Device. A TVBD that transmits and/or receives radiocommunication signals while in motion or at unspecified locations.
- (m) Receive site. The location where the signal of a full service station is received for rebroadcast by a television translator or low power TV, including Class A TV, station.
- (n) Spectrum Sensing. A process whereby a TVBD listens to a television channel to detect whether the channel is occupied by a radio signal.
- (o) Television band device (TVBD). Intentional radiators operating on *Available Channels* in the broadcast television frequency bands at 54-60 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-698 MHz.
- (p) TV bands database. A database of authorized services in the TV frequency bands that is used to determine the *Available Channels* at a given location for use by TVBDs.

Section 15.705 Cross reference.

- (a) The provisions of Subparts A, B, and C of this part apply to TVBDs, except where specific provisions are contained in subpart H.
- (b) The requirements of subpart H apply only to the radio transmitter contained in the TVBD. Other aspects of the operation of a TVBD may be subject to requirements contained elsewhere in this chapter. In particular, a TVBD device that includes a receiver that tunes within the frequency range specified in Section 15.101(b) or contains digital circuitry not directly associated with the radio transmitter is also subject to the requirements for unintentional radiators in subpart B.

Section 15.706 Information to the user.

- (a) For TV band device, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

NOTE: This equipment has been tested and found to comply with the rules for TV band devices, pursuant to Part 15 of the FCC Rules. These rules are designed to provide reasonable protection against harmful interference. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the

instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the manufacturer, dealer or an experienced radio/TV technician for help.

(b) In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

Section 15.707 Permissible Channels of operation.

(a) All TVBDs are permitted to operate in the frequency bands 512-608 MHz and 614-698 MHz, except that in the 13 metropolitan areas listed Section 90.303(a) of this chapter and nearby areas where private land mobile services and commercial land mobile services are authorized by waiver, operation of TVBDs is prohibited on the first available channel on each side of TV channel 37 (608-614 MHz). These channels will be listed in the TV bands database.

(b) Operation in the bands 54-60 MHz, 76-88 MHz, 174-216 MHz, 470-512 MHz is permitted only for fixed TVBDs that communicate only with other fixed TVBDs.

(c) Fixed and Mode II TVBDs shall only operate on available channels as determined by the TV bands database and in accordance with the interference avoidance mechanisms of section 15.711 of this part.

(d) Mode I TVBDs shall only operate on available channels provided to it from a Fixed or Mode II TVBD.

Section 15.709 General technical requirements.

(a) Power limits for TVBDs are as follows:

(1) For fixed TVBDs, the maximum conducted output power over the TV channel of operation shall not exceed one watt. Transmitter power will be measured at the antenna input to account for any cable losses between the transmitter and the antenna. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(2) For personal/portable TVBDs, the maximum conducted output power over the TV channel of operation shall not exceed 100 milliwatts; except that for personal/portable TVBDs that do not meet the adjacent channel separation requirements in Section 15.712(a), the maximum conducted output power shall not exceed 40 milliwatts. If transmitting antennas of directional gain greater than 0 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 0 dBi.

(3) TVBDs shall incorporate transmit power control to limit their operating power to the minimum necessary for successful communication. Applicants for certification shall include a description of a device's transmit power control feature mechanism.

(4) Maximum conducted output power is the total transmit power in the entire emission bandwidth delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (*e.g.*, alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(b) Antenna requirements.

(1) For personal/portable TVBDs, the antenna shall be permanently attached.

(2) The receive antenna used with fixed devices shall be located outdoors at least 10 meters above the ground. The antenna system shall be capable of receiving signals of protected services equally in all directions. The transmit antenna used with fixed devices may not be more than 30 meters above the ground.

(3) For both Fixed and personal/portable TVBDs, the provisions of Section 15.204(c)(4) do not apply to the receive antenna used for spectrum sensing.

(c) Undesirable emission limits for TVBDs are as follows:

(1) In the 6 MHz channels adjacent to the operating channel, emissions from TVBD devices shall be at least 55 dB below the highest average power in the band.

(2) The above emission measurements shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

(3) At frequencies beyond 6 MHz from the edge of the operating channel, radiated emissions from TVBD devices shall meet the requirements of Section 15.209 of this part.

(4) Emissions in the band 602 – 620 MHz must also comply with the following field strength limits at a distance of one meter.

Frequency (MHz)	Field Strength dB μ V/meter/120 kHz
602 - 607	$120 - 5[F(\text{MHz}) - 620]$
607 - 608	95
608 - 614	30
614 - 615	95
615 - 620	$120 - 5[620 - F(\text{MHz})]$

(5) TVBDs connected to the AC power line are required to comply with the conducted limits set forth in Section 15.207 of this part.

(d) Compliance with radio frequency exposure requirements. To ensure compliance with the Commission's radio frequency exposure requirements in §§ 1.1307(b), 2.1091 and 2.1093 of this chapter, fixed TVBDs shall be accompanied by instructions on measures to take to ensure that persons maintain a distance of at least 40 cm from the device, as well as any necessary hardware that may be needed to implement that protection. These instructions shall be submitted with the application for certification. Personal/portable TVBDs that meet the definition of portable devices under Section 2.1093 of this chapter and that operate with a source-based time-averaged output of less than 20 mW will not be subject to routine evaluation for compliance with the radio frequency exposure guidelines, while devices that operate with a source-based time-average output power greater than 20 mW will be subject to the routine evaluation requirements.

Section 15.711 Interference avoidance mechanisms.

(a) Except as provided in Section 15.717, television channel availability for a TVBD is determined based on either the geo-location and database access mechanism described in paragraph (b) of this section or spectrum sensing described in paragraph (c) of this section.

(1) A TVBD shall rely on the geo-location and database access mechanism to identify available television channels consistent with the interference protection requirements of Section 15.712. Such protection will be provided for the following authorized services: digital television stations, and digital and analog Class A, low power, translator and booster stations; translator receive; fixed broadcast auxiliary service links; private land mobile service/ commercial radio service (PLMRS/CMRS) operations; offshore radiotelephone service; and cable system head-ends. In addition, protection shall be provided in border areas near Canada and Mexico in accordance with Section 15.712(g) of this part.

(2) For low power auxiliary services authorized pursuant to Section 74.801-74.882 of this chapter, including wireless microphones, a TVBD shall rely on the geo-location and database access mechanism to identify available television channels to provide interference protection to registered locations of such operations, consistent with the requirements of Section 15.722, and shall rely on spectrum sensing to identify available television channels to provide interference protection to all other operations.

(b) Geo-location and database access.

(1) The geographic coordinates of a fixed TVBD shall be determined to an accuracy of +/- 50 meters by either an incorporated geo-location capability or a professional installer. In the case of professional installation, the party who registers the fixed TVBD in the database will be responsible for assuring the accuracy of the entered coordinates. The geographic coordinates of a fixed TVBD shall be determined at the time of installation and first activation from a power-off condition, and this information may be stored internally in the TVBD. If the fixed TVBD is moved to another location or if the stored coordinates become altered, the operator shall re-establish its geographic location and store this information in the TVBD either by means of the device's incorporated geo-location capability or through the services of a professional installer.

(2) A Mode II personal/portable device shall incorporate a geo-location capability to determine its geographic coordinates to an accuracy of +/- 50 meters. The device must re-establish its position each time it is activated from a power-off condition.

(3) (i) Fixed devices must access a TV bands database over the Internet to determine the TV channels that are available at their geographic coordinates prior to their initial service transmission at a given location. Operation is permitted only on channels that are indicated in the

database as being available for TVBDs. Fixed TVBDS shall access the database at least once a day to verify that the operating channels continue to remain available. Operation must cease immediately if the channel is no longer available.

(ii) Mode II personal/portable devices must access a TV bands database over the Internet to determine the TV channels that are available at their geographic coordinates prior to their initial service transmission at a given location. Operation is permitted only on channels that are indicated in the database as being available for TVBDs. A Mode II personal/portable device must access the database for a list of available channels each time it is activated from a power-off condition and re-check its location and the database for available channels if it changes location during operation. A Mode II personal/portable device that has been in a powered state shall re-check its location and access the database daily to verify that the operating channel(s) continue to be available.

(iii) If a fixed or mode II TVBD fails to contact the TV bands database during any given day, it may continue to operate until 11:59 PM of the following day at which time it must cease operations unless it has contacted the TV bands database during the intervening period.

(iv) Personal/portable devices operating in Mode I shall obtain a list of channels on which they may operate from a master device.

(4) All geographic coordinates shall be referenced to the North American Datum of 1983 (NAD 83).

(c) Spectrum sensing.

(1) Detection threshold.

(i) All fixed and personal/portable TVBDs must be capable of detecting ATSC digital TV, NTSC analog TV and wireless microphone signals using analog or digital modulation methods. The required detection thresholds are.

- (A) ATSC signals: -114 dBm, averaged over a 6 MHz bandwidth;
- (B) NTSC signals: -114 dBm, averaged over a 100 kHz bandwidth;
- (C) Wireless microphone signals: -114 dBm, averaged over a 200 kHz bandwidth.

(ii) The detection thresholds are referenced to an omnidirectional receive antenna with a gain of 0 dBi. If a receive antenna with a minimum directional gain of less than 0 dBi is used, the detection threshold shall be reduced by the amount in dB that the minimum directional gain of the antenna is less than 0 dBi. Minimum directional gain shall be defined as the antenna gain in the direction and at the frequency that exhibits the least gain. Alternative approaches for the sensing antenna are permitted, *e.g.*, electronically rotateable antennas, provided the applicant for equipment authorization can demonstrate that its sensing antenna provides at least the same performance as an omnidirectional antenna with 0 dBi gain.

(2) Low power auxiliary device channel availability check time. A TVBD may start operating on a TV channel if no wireless microphone or other low power auxiliary device signals above the detection threshold are detected within a minimum time interval of 30 seconds.

(3) TV channel availability check time. A TVBD is required to check for TV signals for a minimum time interval of 30 seconds. If a TV signal is detected on a channel indicated as

available for use by the database system, the device will provide a notice of that detection to the operator of the device and a means for the operator to optionally remove the channel from the device's list of available channels.

(4) In-service monitoring. A TVBD must perform in-service monitoring of an operating channel a minimum of once every 60 seconds. There is no minimum channel availability check time for in-service monitoring.

(5) Channel move time. After a wireless microphone or other low power auxiliary device signal is detected on a TVBD operating channel, all transmissions by the TVBD must cease within two seconds.

(6) Personal/portable devices operating in the client mode shall identify to the fixed or Mode II personal/portable device those television channels on which it senses any signals above the detection threshold. The fixed or Mode II device shall respond in accordance with the provisions of this paragraph as if it had detected the signal itself.

(7) TVBDs communicating either directly with one another or linked through a base station must share information on channel occupancy determined by sensing. If any device in a local area group or network determines that a channel is occupied, all other linked devices will also be required to respond in accordance with the provisions of this paragraph as if it had detected the signal itself.

(d) A TVBD must incorporate the capability to display a list of identified available channels and its operating channels.

(e) Fixed TVBDs shall transmit identifying information. The identification signal must conform to a standard established by a recognized industry standards setting organization. The identification signal shall carry sufficient information to identify the device and its geographic coordinates.

(f) If a fixed TVBD device does not have a direct connection to the Internet and has not yet been initialized and registered with the TV bands database, consistent with Section 15.713, but can receive the transmissions of another fixed TVBD, the device needing initialization may transmit on either a channel that the other TVBD has transmitted on or on a channel which the other TVBD indicates is available for use to access the database to register its location and receive a list of channels that are available for it to use. Subsequently, the newly registered TVBD must only use the television channels that the database indicates are available for it to use. Such client fixed devices must re-contact their master device to review their list of available channels at least once every 60 seconds. A fixed device may not operate as a client to another fixed device.

(g) A personal/portable TVBD operating in Mode I may only transmit upon receiving the transmissions of fixed or Mode II TVBD. A personal/portable device operating in Mode I may transmit on either an operating channel of the fixed or Mode II TVBD or on a channel the fixed or Mode II TVBD indicates is available for use.

Section 15.712 Interference protection requirements.

(a) *Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations:*

(1) Protected contour. TVBDs must protect digital and analog TV services within the contours shown in the following table. These contours are based on the R-6602 curves contained in Section 73.699 of this chapter.

Type of station	Protected contour		
	Channel	Contour (dBu)	Propagation curve
Analog: Class A TV, LPTV, translator and booster	Low VHF (2-6)	47	F(50,50)
	High VHF (7-13)	56	F(50,50)
	UHF (14-69)	64	F(50,50)
Digital: Full service TV, Class A TV, LPTV, translator and booster	Low VHF (2-6)	28	F(50,90)
	High VHF (7-13)	36	F(50,90)
	UHF (14-51)	41	F(50,90)

(2) Required separation distance. Fixed TVBDs and personal/portable TVBDs operating in Mode II must be located outside the contours indicated in paragraph (1) of this section of co-channel and adjacent channel stations by at least the minimum distances specified in the following table. Alternatively, Mode II personal/portable TVBDs may operate at closer separation distances, including inside the contour of adjacent channel stations, provided the power level is reduced as specified in Section 15.709(a)(2).

Antenna Height of Unlicensed Device	Required Separation (km) From Digital or Analog TV (Full Service or Low Power) Protected Contour	
	Co-channel	Adjacent Channel
Less than 3 meters	6.0 km	0.1 km
3 – Less than 10 meters	8.0 km	0.1 km
10 – 30 meters	14.4 km	0.74 km

(b) *Translator receive sites and cable headends*: For translator receive sites and cable headends registered in the TV bands database, TVBDs may not operate within an arc of +/-30 degrees from a line between the registered translator or cable headend receive site and the TV station being received within a distance of 80 km from the receive site for co-channel operation and 20 km for adjacent channel operation. Outside of this +/-30 degree arc, TVBDs may not operate within 8 km from the receive site for co-channel operation and 2 km from the receive site for adjacent channel operation.

(c) *Fixed Broadcast Auxiliary Service (BAS) Links*: For permanent BAS receive sites appearing in the Commission's Universal Licensing System or temporary BAS receive sites registered in the TV bands database, TVBDs may not operate within an arc of +/-30 degrees from a line between the BAS receive site and its associated permanent transmitter within a distance of 80 km from the receive site for co-channel operation and 20 km for adjacent channel operation. Outside this +/-30 degree arc, TVBDs may not operate within 8 km from the receive site for co-channel operation and 2 km from the receive site for adjacent channel operation.

(d) *PLMRS/CMRS operations*: TVBDs may not operate at distances less than 134 km for co-channel operations and 131 km for adjacent channel operations from the coordinates of the metropolitan areas and on the channels listed in Section 90.303(a) of this chapter. For PLMRS/CMRS operations outside of the metropolitan areas listed in Section 90.303(a) of this chapter, co-channel and adjacent channel TVBDs may not operate closer than 54 km and 51 km, respectively from a base station.

(e) *Offshore Radiotelephone Service*: TVBDs may not operate on channels used by the Offshore Radio Service within the geographic areas specified in Section 74.709(e) of this chapter.

(f) *Low power auxiliary services, including wireless microphones*:

(1) TVBDs will not be permitted to operate within 1 km of the coordinates of registered wireless microphone sites during designated times when wireless microphones are used.

(2) (A) TVBDs will not be permitted to operate within 134 km of the 13 metropolitan areas listed in Section 90.303(a) of this chapter. ,

(B) TVBDs will not be permitted to operate on the first available channel on each side of TV channel 37 (608-614 MHz) within 134 km of the 13 metropolitan areas listed in Section 90.303(a) of this chapter. If one or both of those channels are occupied by a licensed service in one or more of these metropolitan areas, operation of TVBDs is prohibited on the first channel adjacent to the occupied channel(s).

(g) *Border areas near Canada and Mexico*:

(1) Fixed and personal/portable TVBDs shall not operate within 32 kilometers of the Canadian Border.

(2) Fixed and personal/portable TVBDs shall not operate within 40 kilometers of the Mexican border on UHF channels, or within 60 kilometers on VHF channels.

(h) *Radio astronomy services*: Operation of fixed and personal/portable TVBDs is prohibited on all channels within 2.4 kilometers at the following locations.

(1) The Naval Radio Research Observatory in Sugar Grove, West Virginia.

(2) The Table Mountain Radio Receiving Zone (TMRZ) at 40°07'50" N and 105°15'40" W.

(3) The following facilities.

Observatory	Longitude (Deg/Min/Sec)	Latitude (Deg/Min/Sec)
Allen Telescope Array	121 28 24 W	40 49 04 N
Arecibo Observatory	066 45 11 W	18 20 46 N
Green Bank Telescope (GBT)	079 50 24 W	38 25 59 N
Very Large Array (VLA)	107 37 04 W	34 04 44 N
Very Long Baseline Array (VLBA) Stations		
Pie Town, AZ	108 07 07 W	34 18 04 N
Kitt Peak, AZ	111 36 42 W	31 57 22 N
Los Alamos, NM	106 14 42 W	35 46 30 N
Ft. Davis, TX	103 56 39 W	30 38 06 N
N. Liberty, IA	091 34 26 W	41 46 17 N
Brewster, WA	119 40 55 W	48 07 53 N
Owens Valley, CA	118 16 34 W	37 13 54 N
St. Croix, VI	064 35 03 W	17 45 31 N
Hancock, NH	071 59 12 W	42 56 01 N

Mauna Kea, HI	155 27 29 W	19 48 16 N
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Section 15.713 TV bands database.

One or more entities will be designated to serve as database administrator.

(a) Purpose. The TV bands database serves the following functions:

- (1) To determine and provide to a TVBD, upon request, the available TV channels at the TVBD's location. Available channels are determined based on the interference protection requirements in Section 15.712 of this part.
- (2) To register the identification information and location of fixed TVBDs.
- (3) To register protected locations and channels as specified in paragraph (b)(2) of this section, that are not otherwise recorded in Commission licensing databases.

(b) Information in the TV bands database.

(1) Facilities already recorded in Commission databases. Identifying and location information will come from the official Commission database. These services include:

- (A) Digital television stations
- (B) Digital and analog Class A television stations
- (C) Low power television stations
- (D) Television translator and booster stations
- (E) Broadcast Auxiliary Service stations (including receive only sites), except low power auxiliary stations
- (F) Private land mobile radio service stations
- (G) Commercial mobile radio service stations
- (H) Offshore radiotelephone service stations

(2) Facilities that are not recorded in Commission databases. Identifying and location information will be entered into the TV bands database in accordance with the procedures established by the TV bands database administrator(s). These include:

- (A) Cable television headends
- (B) Television translator station receive sites
- (C) Sites where low power auxiliary stations, including wireless microphones and wireless assist video devices, are used and their schedule for operation
- (D) Fixed TVBDs

(c) Restrictions on registration.

- (1) Television translator station receive sites within the protected contour of the station being received are not eligible for registration in the database.
- (2) Cable television headends within the protected contour of a television channel are not eligible to register that channel in the database.

(d) Determination of available channels.

(1) The TV bands database will determine the available channels at a location using the interference protection requirements of section 15.712 of this part, the location information supplied by a TVBD, and the data for protected stations/locations in the database. The TV bands database will also check for proximity of a TVBD to the Canadian and Mexican borders where operation may be prohibited pursuant to Section 15.712(g) of this chapter.

(e) TVBD initialization.

(1) Fixed and Mode II TVBDs must provide their location and required identifying information to the TV bands database in accordance with the provisions of paragraph (b) of this section.

(2) Fixed and Mode II TVBDs shall not transmit unless they receive, from the TV bands database, a list of available channels.

(3) Fixed TVBDs register and receive a list of available channels by either connecting directly to the internet or by receiving information from another fixed TVBD.

(4) Mode II TVBDs register and receive a list of available channels by connecting directly to the internet.

(f) Fixed TVBD registration.

(1) Prior to operating for the first time or after changing location, a fixed TVBD must register with the TV bands database by providing the information listed in (c)(3) of this paragraph.

(2) The party responsible for a Fixed TVBD must ensure that the TVBD registration database has the most current, up-to-date information for that device.

(3) The TVBD registration database shall contain the following information for fixed TVBDs:

- (A) FCC identifier (FCC ID) of the device
- (B) manufacturer's serial number of the device
- (C) device's geographic coordinates (latitude and longitude (NAD 83) accurate to +/- 50 m)
- (D) name of the individual or business that owns for the device
- (E) name of a contact person responsible for the device's operation
- (F) address for the contact person
- (G) email address for the contact person
- (H) phone number for the contact person.

(g) A personal/portable device operating in Mode II shall provide the database its FCC Identifier (as required by Section 2.926 of this chapter), serial number as assigned by the manufacturer, and the device's geographic coordinates (latitude and longitude (NAD 83) accurate to +/- 50 m)

(h) The TV bands database shall contain the listed information for each of the following:

(1) Digital television stations, digital and analog Class A, low power, translator and booster stations:

- (A) transmitter coordinates (latitude and longitude in NAD 83)
- (B) Effective radiated power (ERP)
- (C) height above average terrain of the transmitter (HAAT)

- (D) horizontal transmit antenna pattern (if the antenna is directional)
- (E) channel number
- (F) station call sign

(2) Broadcast Auxiliary Service.

- (A) transmitter coordinates (latitude and longitude in NAD 83)
- (B) receiver coordinates (latitude and longitude in NAD 83)
- (C) channel number
- (D) call sign

(3) Metropolitan areas listed in section 90.303(a) of this chapter.

- (A) region name
- (B) channel(s) reserved for use in the region
- (C) geographic center of the region (latitude and longitude in NAD 83)
- (D) call sign

(4) PLMRS/CMRS base station operations located more than 80 km from the geographic centers of the 13 metropolitan areas defined in section 90.303(a) of this chapter (*e.g.*, in accordance with a waiver).

- (A) transmitter location (latitude and longitude in NAD 83) or geographic area of operations
- (B) Effective radiated power
- (C) transmitter height above average terrain (if specified)
- (D) antenna height above ground level (if specified)
- (E) call sign

(5) Offshore Radiotelephone Service. For each of the four regions where the Offshore Radiotelephone Service operates.

- (A) geographic boundaries of the region (latitude and longitude in NAD 83 for each point defining the boundary of the region)
- (B) channel(s) used by the service in that region

(6) Cable Television headends.

- (A) name and address of cable company
- (B) location of the headend receiver (latitude and longitude in NAD 83, accurate to +/- 50 m)
- (C) channel number of each television channel received, subject to the following condition: channels for which the cable headend is located within the protected contour of that channel's transmitting station are not eligible for registration in the database
- (D) call sign of each television channel received and eligible for registration
- (E) location (latitude and longitude) of the transmitter of each television channel received

(7) Television translator and low power TV, including Class A TV stations, receive sites.

- (A) call sign of the TV translator station
- (B) location of the TV translator receive site (latitude and longitude in NAD 83, accurate to +/- 50 m)

(C) channel number of the retransmitted television station, subject to the following condition: a channel for which the television translator receive site is located within the protected contour of that channel's transmitting station is not eligible for registration in the database

(D) call sign of the retransmitted television station

(E) location (latitude and longitude) of the transmitter of the retransmitted television station

(8) Low power auxiliary stations, including wireless microphones and wireless assist video devices. Sites with significant wireless microphone use at well defined times and locations may be registered in the database. Multiple registrations that specify more than one point in the facility may be entered for very large sites. Registrations will be valid for no more than one year, after which they may be renewed.

(A) name of the individual or business that owns the low power auxiliary device(s)

(B) an address for the contact person

(C) an email address for the contact person (optional)

(D) a phone number for the contact person

(E) coordinates where the device(s) are used (latitude and longitude in NAD 83, accurate to +/- 50 m)

(F) channels used by the low power auxiliary devices operated at the site

(G) specific months, days and times when the device(s) are used.

(h) Commission requests for data.

(1) A TV bands database administrator must supply upon request by the Commission, any information contained in the database.

(2) A TV bands database administrator must remove information from the database, upon direction, in writing, by the Commission

Section 15.714 TV bands database administration fees.

(a) A TV bands database administrator may charge a fee for provision of lists of available channels and for registering Fixed TVBDs and temporary BAS links.

(b) The Commission, upon request, will review the fees and can require changes in those fees if they are found to be excessive.

Section 15.715 TV bands database administrator.

The Commission will designate one or more entities to administer a TV bands database. Each database administrator shall:

(a) Maintain a database that contains the information described in Section 15.713 of this part.

(b) Establish a process for downloading and storing in the database necessary and appropriate information from the Commission's databases and synchronizing the TV bands database with the current Commission databases at least once a week to include newly licensed facilities or any changes to licensed facilities.

- (c) Establish a process for registering Fixed TVBDs and registering and including in the database facilities entitled to protection but not contained in a Commission database, including cable headends and TV translator receiver sites.
- (d) Establish a process for registering facilities where Part 74 low power auxiliary devices are used on a regular basis.
- (e) Provide lists of available channels to Fixed and personal/portable TVBDs that submit to it the information required under Section 15.713(f) based on their geographic location.
- (f) Make its services available to all unlicensed TV band device users on a non-discriminatory basis.
- (g) Provide service for a five-year term. This term can be renewed at the Commission's discretion.
- (h) Respond in a timely manner to verify, correct and/or remove, as appropriate, data in the event that the Commission or a party brings claim of inaccuracies in the database to its attention.
- (i) Transfer its database along with the IP addresses and URLs used to access the database and list of registered Fixed TVBDs, to another designated entity in the event it does not continue as the database administrator at the end of its term. It may charge a reasonable price for such conveyance.
- (j) The database must have functionality such that upon request from the Commission it can indicate that no channels are available when queried by a specific TVBD or model of TVBDs.
- (k) If more than one database is developed, the database administrators must cooperate to develop a standardized process for providing on a daily basis or more often, the data collected for the facilities listed in section 15.713(b)(2) of this part to all other TV bands databases.

Section 15.717 TVBDs that rely on spectrum sensing.

- (a) Parties may submit applications for certification of TVBDs that rely solely on spectrum sensing to identify available channels. Devices authorized under this section must demonstrate with an extremely high degree of confidence that they will not cause harmful interference to incumbent radio services.
 - (1) In addition to the procedures in Subpart J of Part 2 of this chapter, applicants shall comply with the following.
 - (i) The application must include a full explanation of how the device will protect incumbent authorized services against interference.
 - (ii) Applicants must submit a pre-production device, identical to the device expected to be marketed.
 - (2) The Commission will follow the procedures below for processing applications pursuant to this section.
 - (i) Applications will be placed on Public Notice for a minimum of 30 days for comments and 15 days for reply comments. Applicants may request that portions of their application remain confidential in accordance with section 0.459 of this chapter. This Public Notice will include proposed test procedures and methodologies.

(ii) The Commission will conduct laboratory and field tests of the pre-production device. This testing will be conducted to evaluate proof of performance of the device, including characterization of its sensing capability and its interference potential. The testing will be open to the public.

(iii) Subsequent to the completion of testing, the Commission will issue by Public Notice, a test report including recommendations. The Public Notice will specify a minimum of 30 days for comments and, if any objections are received, an additional 15 days for reply comments.

(b) The device shall meet the requirements for personal/portable devices in this subpart except that it will be limited to a maximum EIRP of 50 mw and it does not have to comply with the requirements for geo-location and database access in Section 15.711(b). Compliance with the detection threshold for spectrum sensing in Section 15.711(c), although required, is not necessarily sufficient for demonstrating reliable interference avoidance. Once a device is certified, additional devices that are identical in electrical characteristics and antenna systems may be certified under the procedures of Part 2, Subpart J of this chapter.

APPENDIX C

Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act (RFA),³⁴³ an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rule Making (NPRM)* in ET Docket No. 04-186³⁴⁴ and an additional IRFA was incorporated in the *First Report and Order and Further Notice of Proposed Rule Making (Further Notice)* in ET Docket No. 04-186.³⁴⁵ The Commission sought written public comment on the proposals in the *NPRM* and in the *Further Notice*, including comment on the IRFAs. No comments were received in response to either IRFA. This Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.³⁴⁶

A. Need for, and Objectives of, the Second Report and Order

This Second Report and Order allows low power unlicensed transmitters to operate in the TV broadcast bands at locations where spectrum is not being used by authorized services. The new rules provide for operation of two types of unlicensed devices that may provide broadband data and other types of communications services: 1) fixed devices, which will operate from a fixed location with relatively higher power and could be used to provide a variety of services including wireless broadband access in urban and rural areas, and 2) personal/portable devices, which will use lower power and could, for example, take the form of devices such as Wi-Fi-like cards in laptop computers or wireless in-home local area networks (LANs). In order to operate without causing interference to licensed services, both types of devices will be required to be able to reliably determine which channels are occupied by licensed operations at their location at any given time and to avoid interfering with services on those channels. The specific compliance requirements are described in Section D below.

The actions in this Second Report and Order will open for use a significant amount of spectrum with very desirable propagation characteristics that has heretofore lain fallow. These new rules will allow the development of new and innovative types of unlicensed devices that provide broadband data and other services for businesses and consumers without disrupting the incumbent television and other authorized services that operate in the TV bands. In addition, because transmissions on frequencies in the TV bands are less subject to propagation losses than transmissions in the spectrum bands where existing low power broadband unlicensed operations are permitted, *i.e.*, the 2.4 GHz and 5 GHz bands, the Commission anticipates that allowing unlicensed operation in the TV bands will benefit wireless internet service providers (WISPs) by extending the service range of their operations. This will allow wireless broadband providers that use unlicensed devices to reach new customers and to extend and improve their services in rural areas. The Commission anticipates that allowing use of the TV white spaces by unlicensed devices will have significant benefits for both businesses and consumers and thereby promote more efficient and effective use of the TV spectrum.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

No comments were received in response to either the IRFA in the *NPRM* or the IRFA in the *Further Notice*.

³⁴³ See 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

³⁴⁴ *NPRM*, 19 FCC Rcd at 10018.

³⁴⁵ *Further Notice*, 21 FCC Rcd at 12299.

³⁴⁶ *See* 5 U.S.C. 603, Title II, 110 Stat 857 (1996).

C. Description and Estimate of the Number of Small Entities To Which Rules Will Apply

The RFA directs agencies to provide a description of, and, where feasible, an estimate of, the number of small entities that may be affected by the rules adopted herein.³⁴⁷ The RFA generally defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and “small governmental jurisdiction.”³⁴⁸ In addition, the term “small business” has the same meaning as the term “small business concern” under the Small Business Act.³⁴⁹ A “small business concern” is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).³⁵⁰

Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing. The Census Bureau defines this category as follows: “This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.”³⁵¹ The SBA has developed a small business size standard for Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing, which is: all such firms having 750 or fewer employees.³⁵² According to Census Bureau data for 2002, there were a total of 1,041 establishments in this category that operated for the entire year.³⁵³ Of this total, 1,010 had employment of under 500, and an additional 13 had employment of 500 to 999.³⁵⁴ Thus, under this size standard, the majority of firms can be considered small.

Wireless Service Providers. The SBA has developed a small business size standard for wireless firms within the two broad economic census categories of “Paging”³⁵⁵ and “Cellular and Other Wireless Telecommunications.”³⁵⁶ Under both categories, the SBA deems a wireless business to be small if it has

³⁴⁷ 5 U.S.C. § 604(a)(3).

³⁴⁸ 5 U.S.C. § 601(6).

³⁴⁹ 5 U.S.C. § 601(3) (incorporating by reference the definition of “small-business concern” in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies “unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register.”

³⁵⁰ 15 U.S.C. § 632.

³⁵¹ U.S. Census Bureau, 2002 NAICS Definitions, “334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing”; <http://www.census.gov/epcd/naics02/def/NDEF334.HTM#N3342>.

³⁵² 13 C.F.R. § 121.201, NAICS code 334220.

³⁵³ U.S. Census Bureau, American FactFinder, 2002 Economic Census, Industry Series, Industry Statistics by Employment Size, NAICS code 334220 (released May 26, 2005); <http://factfinder.census.gov>. The number of “establishments” is a less helpful indicator of small business prevalence in this context than would be the number of “firms” or “companies,” because the latter take into account the concept of common ownership or control. Any single physical location for an entity is an establishment, even though that location may be owned by a different establishment. Thus, the numbers given may reflect inflated numbers of businesses in this category, including the numbers of small businesses. In this category, the Census breaks-out data for firms or companies only to give the total number of such entities for 2002, which was 929.

³⁵⁴ *Id.* An additional 18 establishments had employment of 1,000 or more.

³⁵⁵ 13 C.F.R. § 121.201, NAICS code 517211.

³⁵⁶ 13 C.F.R. § 121.201, NAICS code 517212.

1,500 or fewer employees. For the census category of Paging, Census Bureau data for 2002 show that there were 807 firms in this category that operated for the entire year.³⁵⁷ Of this total, 804 firms had employment of 999 or fewer employees, and three firms had employment of 1,000 employees or more.³⁵⁸ Thus, under this category and associated small business size standard, the majority of firms can be considered small. For the census category of Cellular and Other Wireless Telecommunications, Census Bureau data for 2002 show that there were 1,397 firms in this category that operated for the entire year.³⁵⁹ Of this total, 1,378 firms had employment of 999 or fewer employees, and 19 firms had employment of 1,000 employees or more.³⁶⁰ Thus, under this second category and size standard, the majority of firms can, again, be considered small.

D. Description of Projected Reporting, Record Keeping, and Other Compliance Requirements

Unlicensed transmitters are currently required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation, and TV band devices would be subject to a certification requirement. The existing certification procedure in the Commission's rules will be used for TV band devices, except that TV band devices that rely on spectrum sensing as the sole method of determining whether a channel is available will have additional certification requirements which are described below. The compliance requirements for TV band devices are as follows.

Fixed devices

- may communicate with other fixed devices and with personal/portable devices
- are permitted to operate on TV channels 2-51, excluding channels 3,4 and 37; may not operate on adjacent TV channels; and, must not use any channels used locally by the private land mobile radio service (PLMRS)
- determine their geographic location by means of an incorporated geo-location capability or a professional installer
- access a database system to determine the available channels at a location
- use outdoor antennas
- are allowed up to 1 watt (W) transmitter output power with a gain antenna to achieve up to 4 W effective isotropic radiated power (EIRP)
- Must register identifying information in a database to help investigate any potential interference due to higher powered operations.

Personal/portable devices

- may communicate with fixed devices and with other personal/portable devices

³⁵⁷ U.S. Census Bureau, 2002 Economic Census, Subject Series: Information, "Establishment and Firm Size (Including Legal Form of Organization)," Table 5, NAICS code 517211 (issued Nov. 2005).

³⁵⁸ *Id.* The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with "1000 employees or more."

³⁵⁹ U.S. Census Bureau, 2002 Economic Census, Subject Series: Information, "Establishment and Firm Size (Including Legal Form of Organization)," Table 5, NAICS code 517212 (issued Nov. 2005).

³⁶⁰ *Id.* The census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with "1000 employees or more."

- are permitted to operate on TV channels 21-51, excluding channel 37
- can operate in two different modes:
 - Mode I - client, controlled by a fixed device that has determined the available channels in the area
 - Mode II - independent, in which the device determines the available channels using its own internal geo-location/database access capabilities
- 100 milliwatts (mW) EIRP, but limited to 40 mW EIRP when operating adjacent to occupied channels.

All TV band devices

- must be capable of sensing TV and wireless microphone signals at levels as low as -114 dBm
 - Operation prohibited on channels where wireless microphones are detected
 - Will provide an additional indication as to whether a TV channel is occupied
 - Will encourage the further development of sensing technology

The purpose of the TV bands database system for fixed and Mode II personal/portable devices is to identify all services in the TV bands that are eligible for protection. A TV band device will send its geographic coordinates to the database, which will return a list of channels available at that location. The Commission will issue a Public Notice to solicit interested parties in administering the database. The database will contain information about licensed services operating in the TV bands obtained from the Commission's databases, including full service and low power TV stations, Broadcast Auxiliary Service (BAS) links, and PLMRS operations under waivers. In addition, the database will contain voluntarily submitted information on services in the TV bands that are either not in the Commission's databases or are not licensed by specific coordinates, such as wireless microphones.

The Second Report and Order provides for certification of devices that rely on sensing alone based on a proof of performance standard. The manufacturer may submit an application for certification of a device that meets all of the requirements for a TV band device except for geo-location and database access. The application would be available to the public, except for information that may qualify as a trade secret under our rules. A fully functioning pre-production prototype would need to be submitted to the Commission for laboratory and field testing. The testing will be open to the public. The determination of whether to certify the equipment will depend on whether the device is shown to provide a high level of confidence that it will not interfere with incumbent radio services. It must perform at least as well as a device that uses geo-location and database access for interference avoidance. Once a device is certified under these provisions, the Commission would certify other devices that are electrically identical under the usual certification process.

The Second Report and Order imposes new reporting requirements on parties operating fixed TV band devices. Operators of fixed TV band devices will be required to register their location and information about the operator with a TV bands database. When a fixed TV band device queries the database the first time, the device will be registered in the database system. Operators of fixed TV band devices must supply the following registration information and update this information, as necessary, when performing the daily database queries to verify continued channel availability. The Commission may ask a database administrator for this information in the event that a device is found to be causing interference.

- (1) FCC identifier (FCC ID) of the device
- (2) manufacturer's serial number of the device

- (3) device's coordinates (latitude and longitude accurate to within 50 m)
- (4) name of the entity, whether an individual or business, responsible for the device
- (5) name of a contact person responsible for the device's operation
- (6) address for the contact person
- (7) email address for the contact person
- (8) phone number for the contact person.

As noted above, the Commission's Office of Engineering and Technology will designate a party or parties to administer the database of authorized services in the TV bands. Much of this information will be obtained from the Commission's databases, including information on full service and low power TV stations, Broadcast Auxiliary Service (BAS) links, and PLMRS operations under waivers. However, the database will also contain information submitted voluntarily by parties operating services in the TV bands that are either not listed in the Commission's databases or are not licensed by specific coordinates. These services include BAS links authorized on a temporary basis, receive sites for TV translators and cable TV systems, and sites where wireless microphones are used regularly and predictably, such as major sporting events. The purpose of this voluntarily submitted information is to prevent TV band devices from causing interference to services that do not appear in the Commission's database. The submission of such information is strictly voluntary, but services operated by parties that do not submit this information may not be protected against interference from TV band devices.

E. Steps Taken to Minimize Significant Economic Impact on Small Entities and Significant Alternatives Considered

The RFA requires an agency to describe any significant alternatives that it has considered in developing its approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."³⁶¹

The rules adopted in the Second Report and Order may have a significant economic impact on a substantial number of small entities. For an entity that chooses to manufacture or import equipment for the subject bands, the rules would impose costs for compliance with equipment technical requirements. The costs for fixed and Mode II personal/portable devices include incorporating a geo-location method to determine the geographic coordinates and the ability to access a database of authorized services in the TV bands, for which a fee may be charged by the database administrator. The costs for all TV band devices include incorporating the ability to detect TV and wireless microphone signals. However, the burdens for complying with these rules would be the same for both large and small entities. Therefore, no disproportionate burden of compliance would be sustained by small entities. Further, the rules adopted in the Second Report and Order are ultimately beneficial for both large and small entities because they will provide for more efficient and effective use of the TV spectrum and allow the development of new and innovative types of wireless devices and communication services for businesses and consumers. Also, because transmissions in the TV band are subject to less propagation attenuation than transmissions in other bands where lower power operations are permitted (such as unlicensed operations in the 2.4 GHz band), operations in the TV bands can improve the service range of wireless operations, thereby allowing operators to reach new customers.

³⁶¹ 5 U.S.C. § 603(c)(1) – (c)(4).

F. Report to Congress

The Commission will send a copy of the Second Report and Order, including this FRFA, in a report to be sent to Congress pursuant to the Congressional Review Act.³⁶² In addition, the Commission will send a copy of the second Report and Order, including the FRFA, to Congress and the Government Accountability Office. A copy of the Second Report and Order and FRFA (or summaries thereof) will also be published in the Federal Register.³⁶³

³⁶² See 5 U.S.C. § 801(a)(1)(A).

³⁶³ See 5 U.S.C. § 604(b).

**STATEMENT OF
CHAIRMAN KEVIN J. MARTIN**

Re: Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380

Today's approval of rules authorizing the use of television (TV) "white spaces" spectrum is a significant victory for consumers.

Today's action was advocated by a diverse coalition of consumer groups, technology leaders and Internet pioneers. Opening the white spaces will allow for the creation of a WiFi on steroids. It has the potential to improve wireless broadband connectivity and inspire an ever-widening array of new Internet based products and services for consumers. Consumers across the country will have access to devices and services that they may have only dreamed about before. I fully expect that everything from enhanced home broadband networks, to intelligent peer-to-peer devices, and even small communications networks will come into being in TV "white spaces."

More specifically, the rules adopted by the Commission establish a framework for enhanced wireless communications by building on a proven concept: the safe deployment of new, intelligent devices in the unused spectrum that exists between television channels.

We do so without disrupting TV services, wireless microphones, or other permitted uses of this spectrum. I have always said that opening the white spaces must be conditioned on protecting primary spectrum users from interference.

We have been cautious in our approach. Significantly, the Commission embarked on extraordinary testing. Not only did the Commission consider thousands of comments, ideas and recommendations submitted by the public, we opened up the testing of the prototype white spaces devices that had been submitted to the FCC. For months, both proponents and opponents of opening the white spaces participated in laboratory and field testing conducted by our engineers. OET also released a lengthy and detailed report of its findings to the public.

Normally, the Commission adopts prospective rules about interference and then certifies devices to ensure they are in compliance. Here, we took the extraordinary step of first conducting this extensive interference testing in order to prove the concept that white space devices could be safely deployed. Prior to going to market any white space device will undergo a rigorous certification process. Today's item protects broadcasters' operations. It also protects entertainment, sports and other significant venues, including the unlicensed operation of many wireless microphones and other wireless devices in those areas. Additionally, channels have even been set aside to protect wireless microphones in major markets.

In order to protect broadcasters, all white space devices must initially use geo-location in conjunction with database consultation to ensure they can operate in a particular location without interference. Manufacturers remain free to demonstrate that sensing-only devices can operate safely and efficiently, without causing interference to television viewers. Such devices will only be deployed after they have demonstrated their effectiveness through a vigorous, public, proof of performance process.

Similarly, manufacturers are challenged to show ways that devices using higher power levels that authorized today can be deployed on adjacent channels.

In conjunction with our other actions today regarding Verizon-Alltel and Sprint-Clearwire, opening up the TV white spaces furthers the goal of making wireless a powerful, competitive broadband platform and offers significant benefits to consumers across the country.

STATEMENT OF
COMMISSIONER MICHAEL J. COPPS

Re: *Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380*

One of the great lessons of history I quickly learned here at the FCC is the power of technology to turn scarcity into abundance. Once upon a time, it seemed that certain swaths of the public airwaves could support only a few expensive, bulky “brick” telephones (so named because of their forbidding size and weight). These early phones permitted just 30 minutes of scratchy voice communications on a single battery charge. Today, thanks to the extraordinary work of America’s great engineers and inventors, the same amount of spectrum can support millions of full-featured, relatively inexpensive, multimedia handsets—like the popular iPhone—that perform many of the functions of a desktop computer for days between charges.

Or, to take an example even closer to today’s item, we have learned in the past decade that unlicensed bands—once derided as “junk spectrum” suitable only for garage door openers—can actually support Wi-Fi connectivity for tens and even hundreds of millions of users every day. Something that seemed of marginal value has given us broadband in homes, airports, hotels, coffee shops, and downtown areas—developments that are changing the ways in which we live. Just stop by a Starbucks and look at how many people are typing away on laptops. That, to me, is the most important lesson of the wireless revolution: as technology marches on, the real winners are American consumers. This process is as it should be—the airwaves, after all, are the *people’s* airwaves. And it is the FCC’s job to make sure that the American people continue to extract full value from their property.

So in setting responsible spectrum policy, the FCC must always recognize that technology cannot stand still, and that even as we protect existing users from harmful interference, we also have to promote innovation—because until someone finds a way to make more electromagnetic spectrum, it is only *innovation* that can improve the wireless choices available to consumers.

For four years, the FCC has been considering proposals to authorize unlicensed devices in the TV white spaces. The proponents have argued that we can enable a whole new generation of wireless devices—bringing new broadband connectivity to our rural and urban communities—without harming free, over-the-air TV. Does this seem almost too good to be true? Of course. But so did the modern cellular industry, the explosion of Wi-Fi devices, and so many other innovations at comparable stages in their development. Even the notion of transmitting high quality video through the air to millions of TV sets must have seemed pretty fantastical when it was first demonstrated decades ago. This is the history of wireless innovation in a nutshell—the nearly miraculous becomes commonplace.

My approach throughout this process has been to let the engineering analysis drive our decision-making. The good news is that the process—while far from perfect—has involved a great deal of serious study and public openness. In fact, the last round of testing was conducted with engineers and lawyers from all sides looking over the shoulders of the FCC’s engineers as they performed their bench and field testing. While I do not envy the Commission’s engineers for undergoing this level of scrutiny as they go about their daily tasks, I think it’s fair to say that few other engineering analyses at the FCC have been as lengthy or open as this one.

The results of our testing have shown that there is merit in the initial positions of *both* sides in this debate—and I believe our conclusion today reflects this point. For example, the white spaces proponents initially argued that spectrum-sensing alone would be adequate. Our testing has shown that this approach, right now, is not ready for prime time. That is why our decision does not authorize devices today that rely

exclusively on sensing—though we do create a process for evaluating the next generation of such devices.

Instead, today, we move towards a compromise technology—geo-location—that represents a simpler and more conservative approach to protecting existing licensed users of the television band. We also have built in several forms of belt-and-suspender protections. First, we still will have a chance to “kick the tires” of these devices at the certification stage—to make sure they operate as designed. Second, because we permit these devices to operate under our Part 15 unlicensed rules, they must protect broadcast licensees and shut off if they create harmful interference. Third, because we use geo-location technology, we retain the ability to require particular makes and models of white space devices to turn off if they have a manufacturing flaw. Fourth, to the extent that we consider certifying a next-generation sensing-only device, we have established a process to make sure that all parties have an opportunity to be present during the testing process. So, though there will never be metaphysical certainty when it comes to interference issues, I am comfortable that the FCC and its dedicated engineers have approached this issue with the necessary seriousness and developed an approach that will adequately protect over-the-air viewers.

In this lengthy process, some parties have come forward with arguments for licensed use of the TV white spaces, either in whole or in part. As I have stated before, I think that both licensed and unlicensed regimes benefit consumers. The key is to get the right mix. In the past few years, we have auctioned off almost 150 MHz of new *licensed* spectrum. The time has now come, I believe, to increase the amount of *unlicensed* spectrum—especially the amount of spectrum below 1 GHz. The order we vote on today will do exactly that.

Some have called this new technology “Wi-Fi on steroids”—and I hope they are right. Certainly, this new technology, taking advantage of the enhanced propagation characteristics of TV spectrum, should be of enormous benefit in solving the broadband deficit in many rural areas. Indeed, I agree with the view of several of my colleagues that it should be quite possible, at some point, to authorize higher-power devices in rural areas that will support backhaul and broadband infrastructure. That is why I support our commitment to issue a Notice of Inquiry on this topic—which should give the Commission more than enough time to build a record and act before the first commercially-ready devices enter the market.

Today’s item represents the culmination of a lot of hard work by the Commission’s skilled engineers and staff in our Office of Engineering and Technology and elsewhere. I want to thank them for their dedication to this task and their accomplishment in charting a course that accommodates both existing users and innovators in this spectrum. Ultimately, this careful threading of the needle between the path-breaking and the tried-and-true will reap huge benefits for the American people.

**STATEMENT OF
COMMISSIONER JONATHAN S. ADELSTEIN**

Re: Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380

Today the Commission takes a critically important step towards managing the public's spectrum to promote efficiency, and to encourage the development and availability of innovative devices and services.

White spaces are the blank pages on which we will write our broadband future. I have long called for not only a "third pipe" into the home but a "third channel" directly to consumers, wherever they may roam. Today, we make a key advance toward a third channel for broadband competition and deployment. This Order is a central element of the national broadband strategy that I have advocated for quite some time.

Today's decision is consequential to our nation's future because wireless broadband has the potential to improve our economy and quality of life in even the remotest areas. One of the best options for promoting broadband and competition across the country, particularly in rural areas, is maximizing the potential of spectrum-based services. Because we are a nation of innovators and entrepreneurs, the Commission's decision to open fallow spectrum to new uses will give our country an opportunity to reclaim its place as a world leader in broadband deployment.

Wireless devices have become a central part of many of our lives. As the market continues to expand, so too does our need for spectrum and infrastructure that can meet the rising demands. Our job as a Commission is to pack as much data as possible over the public spectrum without causing harmful interference. Unlicensed spectrum holds by far the most promise for maximizing the use of white spaces. Our balanced approach in this order provides the flexibility and low barriers to entry needed to provide an opportunity for everyone to make the best use of this under-used spectrum. It also implements safeguards to protect those that already make valuable use of the spectrum.

The results of the Office of Engineering and Technology's study show that geo-location technology offers an accurate and dependable means of protecting spectrum incumbents from interference. I am pleased with our decision to require both master-client based and independent based devices to utilize geo-location technology and database access for identifying vacant channels. Because broadcasters have such a vital role in local communities, preservation of consumers' television reception and other services is critical to acceptance of new white spaces devices. Although spectrum-sensing technology has not yet been proven to offer the same level of protection, I applaud our support for its continuing development and look forward to the innovation it may bring.

I am pleased that my colleagues have agreed to provide details regarding the certification process for white space devices. These additional details will provide an avenue for public comment on this process and ensure that the resulting process is fully vetted by interested parties.

Many have raised the concern that broadcasters and users of wireless microphones will suffer harmful interference as a result of this Order. The Office of Engineering and Technology assures us that there are adequate protections here to prevent harmful interference to licensed users, and I accept their assurances.

It is small consolation to those that feel justifiably aggrieved by the process that there was overwhelming support for acting now, and that more time was unlikely to change the outcome. This process is not a model of transparency. When the Commission puts expediency ahead of an open process, it creates unnecessary resentment from parties that believe they were not given a fair hearing. This is not

the process I would have undertaken, but since our independent engineering staff justifies the decision on the basis of their best expert analysis, I approve this item.

An issue of great concern remains, though, that many unwary consumers purchased wireless microphones that may not comport with Commission rules. An investigation is underway, and if we find that Commission rules were violated, we must act to protect the many musicians, performers and others who will need to ensure their equipment continues to work. While I am hopeful the protections we adopt today are sufficient, we will need to closely follow the impact on users of wireless microphones, and devise solutions, considering all spectrum at our disposal, so they can continue to use them with confidence they will function as they have come to expect.

I am pleased that the Chairman and my colleagues have agreed to launch a separate Notice of Inquiry (NOI) into the best use of the white space spectrum for higher powered unlicensed operations in rural areas. In order for the white spaces to achieve maximum utilization in rural areas, rural wireless Internet service providers will need cheap, available and reliable backhaul. We need to explore all ways of achieving this. Variable power limits deserve our consideration as one possible means. I would have preferred that these questions were raised in a Notice of Proposed Rulemaking rather than an NOI, and that they covered all spectrum, but getting this discussion underway is a positive development.

Historians looking at American telecommunications policy may well view today as a day that heralded change not only with the nationwide vote that is taking place at the polls, but also the vote that takes place here to open the white spaces for broadband deployment. Both portend great progress for our future technological development. Just as I enthusiastically voted at the polls earlier this morning, I vote again enthusiastically for this item here today.

**STATEMENT OF
COMMISSIONER ROBERT M. McDOWELL**

Re: Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380

To paraphrase astronaut Neil Armstrong as he became the first person to step on the moon, today the FCC is making both a small step and a giant leap. It will be a giant leap for American consumers to be able to use the untapped television “white spaces.” At the same time, we enter this new frontier with a small step in the form of a prudent and cautious order that sets up safeguards to ensure that new unlicensed devices do not cause harmful interference with licensees and other users of these frequencies.

While new broadband technologies are the most likely uses of these channels, the most exciting part about our action today is that we are creating the opportunity for an explosion of entrepreneurial brilliance. Our de-regulatory order will allow the market place to produce new devices and new applications that we can’t even imagine today. Not only will the lives of millions of Americans be enriched by these new technologies, but I am confident that imaginative use of the TV white spaces could actually improve our safety as well.

We owe this historic moment to several white spaces pioneers including former FCC Chairman Michael Powell who initiated this proceeding four years ago, many Members of Congress, countless entrepreneurs and, of course, my Commission colleagues. I also acknowledge our chief engineer and technologist, Julie Knapp, and his entire OET team. Thank you for your patience, openness, fortitude and counsel.

To those who have expressed concern regarding the results of this proceeding, I would like to offer them comfort in the form of the text of today’s order. As a preliminary matter, I note that the empirical data we have studied suggests a very real potential for deployment of new personal/portable devices, and it would be premature to either wholly endorse or close the door entirely on future developments. Accordingly, it is appropriate that the steps today are limited in scope, define an outline for our future approach toward device certification and allow for any and all changes that may be required by future circumstances.

We have listened carefully to the arguments of broadcasters, cable TV operators, wireless microphone companies and entertainers, and today’s order addresses their concerns. In short, all avenues of modification and improvement remain open. And I thank my colleagues for working collectively to strengthen and clarify these protections. In fact, as technology improves, I expect that one day we will likely look back on this order and think of it as quaint; but today it is state-of-the-art.

Our decision today also obviates the need for artificial government mandates, such as those imposed on the C Block of our 700 MHz auction. Make no mistake, I have long advocated application and device portability as well as free and open networks. Consumers want these features, and the market started working on delivering them years before unnecessary, counterproductive and after-the-fact Commission mandates. Therefore, if such mandates were not necessary then, they are even more unnecessary after our action today. Robust unlicensed use of white spaces will give nimble entrepreneurs the freedom to disrupt the market in positive and constructive ways that will force incumbents to keep pace with this new revolution. As a result, the pressure created by dynamic competition will knock down barriers created by walled gardens and pry open closed networks. This liberation will come about not

through increased regulation, but through increased competition. Our ultimate shareholders, American consumers, will reap the dividends.

I also appreciate my colleagues' support for a notice of inquiry to commence an examination of possible other limited uses of white spaces, such as point-to-point backhaul in rural areas as a substitute for special access. This is an idea that was raised in our original notice, is thoroughly discussed on the record, and is already ripe for decision. I still believe that a further notice of proposed rulemaking would have presented us with a clearer path toward a closer examination. Nonetheless, I hope my colleagues in the next Commission will move forward expeditiously on what I believe to be a win-win solution.

Here is the challenge: all wireless services have to be backhauled to the PSTN and the Internet via a network of some kind. Over the years, some people in the tech industry, as well as some of my colleagues, have complained about a lack of competition in the special access market which, they allege, artificially drives up backhaul costs. Competitive local exchange carriers (CLECs) and competitive wireless carriers presented us with a possible solution to this challenge for rural areas which enjoy more unused spectrum than urban areas and suffer from the least amount of special access competition. Some form of limited white spaces point-to-point licensing may allow entrepreneurs to find more efficient paths for their backhaul needs while leaving the lion's share of white spaces spectrum on the table for unlicensed users.

I am disappointed by some in the tech industry and public interest community who seem to oppose the Commission even discussing this issue while also complaining about the condition of the special access market. All of us should remember that CLECs, wireless companies and their supplier partners are also part of the tech industry and their voices should be heard as well. Hopefully, this notice of inquiry can plant the seeds of progress to find a workable solution that inures to the benefit of all parties, but mainly, American consumers.

Our decision today is revolutionary. It does more than simply foster the development of exciting new wireless services. It also has the potential to sustain the continuing good health of an "old" technology: television broadcasting, by protecting the interests of the millions of consumers who continue to rely on broadcasting for their news, entertainment and public safety information.

Accordingly, I strongly support today's order.

**STATEMENT OF
COMMISSIONER DEBORAH TAYLOR TATE
APPROVING IN PART AND DISSENTING IN PART**

Re: *Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380*

In the midst of the present economic downturn gripping our nation and the world, there is one bright spot on the horizon – American technology and the American entrepreneurial spirit, especially in the communications and technology sector, which hold the promise of future innovation, investment, jobs and economic growth. One of the more promising areas of innovation cannot even be seen – the “white spaces” that represent the unused portions of spectrum in the bands presently allocated to TV broadcast operations. Today’s item advances us on a path to facilitate use of the white spaces for new wireless services, including broadband services, for all Americans.

These are first steps only, ones that hopefully will move us towards modernization and more effective use of the unused portions of this spectrum. Indeed, these are revolutionary times in an evolutionary industry, with the promise of even yet unseen innovative devices on the horizon. Many visions exist for how unlicensed use of the white spaces will evolve, but evolve they certainly will. Hopefully, this item will help facilitate the deployment of unlicensed devices and services that enable consumers to enjoy more television programming and video than ever before, and that will allow families to transfer and network information, photos, and much more across multiple devices, technologies and platforms in their homes. Similarly, communities of users may find they are able to communicate seamlessly through mesh networks rather than traditional phone lines. Finally, as someone who has championed rural America, I hope that this item will facilitate services, including broadband, to rural areas and thus help reduce the digital divide that is far too prevalent in rural communities across our nation.

In considering this order, I have listened to and weighed seriously the concerns of an amazingly broad array of interests. In the end, I have tried to reach a reasonable position that takes into account all interests, including, most especially, the interests of the American consumer. The order is not perfect – it precludes licensed services and lacks needed language regarding a specific and expedited complaint process for broadcasters, cable providers, wireless microphones and individual users in the case of interference. Nonetheless, the order ultimately may help promote the innovation and investment in advanced services that consumers have come to expect from the communications and technology sector. Accordingly, I would like to address several important public policy goals, as well as some of my concerns regarding how this item falls short of our mandate to advance the interests of the American public.

Measures to Address Interference

In crafting public policy, one must weigh the benefits and costs of various options. In this case, the potential costs of enabling unlicensed use of the white spaces are substantial. Specifically, this order enables a vision for entirely new services and devices but ones that also hold a real risk of causing interference with existing services, including broadcasting, cable television, and wireless microphones, among others.

Addressing interference in the use of the spectrum has always been one of the primary roles of the Federal Communications Commission since its creation by Congress in 1934. Our predecessor agency, the Federal Radio Commission, also assumed this important responsibility starting as early as 1927. Clearly, addressing interference is one of the crucial tasks this agency takes most seriously and performs most effectively.

Within the Commission, the Office of Engineering and Technology (OET) is the team responsible for conducting the research, analysis, and evaluation of devices that use the airwaves in this country. This group of talented staff has spent the past four years carefully considering whether and to what extent unlicensed devices may utilize the white spaces in the broadcast spectrum without causing undue harm to incumbent users. I have placed much faith in the Chief of OET, Julie Knapp, and his entire staff of engineers. Their recommendations, while always useful in any rulemaking, played an especially persuasive role in my final decision to support this item.

I have been assured by Chief Knapp and our top engineers that the risks of interference have been appropriately considered. Ultimately, as the Commission's most recent report states, the extensive testing by OET has provided "proof of concept" for some types of unlicensed devices to use the white spaces. Further, as this order makes very clear, all devices that in the future will be used in the U.S. market must first be tested and approved by the Commission, in effect demonstrating not only that there is "proof of concept" but also "proof in practice." While some commenters have criticized our testing process, both our 2007 and 2008 reports on the test results were peer reviewed by other expert staff within the Commission. In addition, these tests were open to the public, and at various points during this long process the work of our OET engineers was observed by members of the press, Congressional staff, broadcasters and other industry representatives, as well as other interested parties. I am proud of this transparent and open process and encourage OET to continue this commitment going forward.

Based on the results of these tests, this order establishes a number of significant technical rules related to unlicensed use of the white spaces in the broadcast bands. Power limits are more restricted – to 40 milliwatts, or a fraction of what wireless microphones are authorized to employ in these frequencies – when operated in a channel immediately adjacent to a broadcast service, while a higher power limit applies in non-adjacent channels.

In addition, and of critical importance to incumbent providers, the item will create a database of existing operations in specific channels and entire geographic areas that will remain unavailable to all unlicensed operations. Incumbent providers may register their locations and unlicensed devices will be required to first verify that channels are available prior to accessing them. This requirement to use this database will ensure that broadcast operations, broadcast auxiliary services (BAS), cable head-ins, public safety operations, and venues such as sports stadiums and theatres may register their locations and receive complete protection.

The Commission, through our Enforcement Bureau and in consultation with the Office of Engineering and Technology, will investigate complaints of interference and take appropriate action, as we do with all cases of interference. I regret that my colleagues were unwilling to set forth in this item a more specific and swift process to deal with complaints of interference. I remain concerned that the item is too vague and does not provide necessary protections after the interference has occurred.

I also would like to acknowledge the legitimate concerns of the many industries that already provide valuable services using the core TV bands. Regarding the concerns of my friends in the broadcasting industry, I want to recognize the important service they provide, especially all they currently are doing to make the DTV transition as smooth as possible. Over 90 percent of Americans are now aware of the DTV transition, thanks in large part to the more than \$1 billion invested by the broadcasters and the cable industry in PSAs and other public education efforts. The DTV transition is an extraordinary opportunity for consumers to receive revolutionary TV picture quality and additional programming, as well as new wireless services that will be available in the 700 MHz band when those channels are vacated. In addition, broadcasters play a key role in providing emergency alerts to the public. It is, therefore, imperative that TV broadcasting continue to be protected from interference. The power limits and other technical rules, proposed by OET and adopted herein, are designed to do just that.

Regarding similar concerns by cable operators, I also recognize the potential for interference, both to cable head ends as well as to cable connections inside the home. The item takes steps to protect cable head ends by restricting use of white spaces devices in the geographic areas in which head ends are located. With regard to cable systems in the home, OET has attempted to establish power limits that will lower the risk of interference between devices in the home, though this risk is not, in my mind, fully mitigated. However, the Commission does not generally focus on interference that users cause to themselves. Just as we have all learned to move devices away from each other in the office and we no longer place our cell phones next to the computer, so might consumers need to reduce interference inside their home by moving devices, at least until the next generation of cable equipment becomes more widely disseminated. I encourage device manufacturers and indeed the Commission to provide information to consumers regarding these devices as they come online, as well as establishing 800 numbers, arming call centers with tech-specific solutions, email alerts, software “fixes” that lower power and other forms of outreach to consumers.

Regarding the concerns of facilities and events managers – including Broadway, sports stadiums, churches, my friends at the Grand Ole Opry, and many others – the geographic database provides a critical line of defense. In addition, the item will make spectrum available in two channels above Channel 20 in those markets that are particularly congested due to public safety operations in Channels 14 – 20. Taken together, these measures should protect the vast majority of wireless microphones.

Remaining Concerns

While the use of white spaces by unlicensed devices holds great promise and I am excited about their potential, I also have several significant concerns that I believe we should have addressed and encourage a future Commission to re-address.

With regard to the possibility of interference, I regret that the Order does not include language that would specifically state the legal responsibilities of those who provide these new unlicensed devices. In particular, I would like providers of these devices to have clear notice of what they must and must not do under the Commission’s rules. Perhaps more important still, I wanted to ensure that our rules specify that, in the event of significant interference caused by an unlicensed device, the party responsible for this device will also be responsible for rectifying the problem and assume the cost. Some companies have assured us that this will be the case; that their business reputation requires it and it is indeed “good business” for them to correct the situation. However, the potential impact of millions of devices in the marketplace calls for a prudent process for recall, provisions for mitigating interference caused by faulty equipment, and a clear exposition of fines and penalties for violations. I felt it was imperative to deal with this on the front end, but today’s item is not sufficiently clear on these matters. I hope the next Commission will address this before, rather than after, any harm occurs.

In addition, I am disappointed that this item does not take more specific steps to address higher-power fixed operations in rural areas, which could have been used to provide much needed backhaul, a key component of broadband service in rural communities. While I understand that the Commission will issue a Notice of Inquiry on this issue, this is too little and too late. Rural consumers need help now, and the record on the various options – including licensed approaches – is sufficiently developed for the Commission to take action today.

More fundamentally, and most troubling about today’s order, the Commission’s decision makes it difficult if not impossible to allow anything other than unlicensed use in the white spaces of the roughly 300 megahertz that comprise the TV broadcast spectrum. Other valuable uses, such as licensed operations, are precluded. I am not convinced that all of the white spaces in Channels 2 – 51 needed to be

made available for unlicensed use. Indeed, many of the companies that have discussed with me their exciting new business models have focused only on the use of Channels 21 – 51.

As with any policy decision, we must be cognizant of the opportunity cost – that is, we must look with a clear head at that which we are giving up. This is extremely valuable spectrum – beachfront property spectrum – with estimates of the value of white spaces under a licensed approach ranging from \$8 billion to over \$24 billion. Even if the low estimates in this range are the most accurate, we must consider this lost value to the U.S. Treasury and, ultimately, to taxpayers. Even more important than the lost auction revenues, the consumer benefits of spectrum use in a licensed regime are many times greater than what service providers pay to the U.S. Treasury. Of course, the benefits to consumers of services in unlicensed bands also may be significant. But if all white spaces spectrum in this band is set aside for unlicensed use – rather than appropriately balancing licensed and unlicensed approaches – we are likely to ignore the huge value of alternative uses. In short, we need to consider the tradeoffs, and the American consumer – in urban as well as rural areas – will suffer if we do not.

Based on my conversations with OET, independent engineers and various members of the White Spaces Coalition, it would appear that allowing unlicensed use of the white spaces only in Channels 31-51 would be sufficient to provide four channels – that is, 24 megahertz – in even the most congested markets and many, many more channels in suburban and rural markets. As an example, 24 megahertz is greater than the amount of spectrum made available in the largest block in the 700 MHz auction held this spring. In that auction, the C block sold for \$3.7 billion, despite significant use restrictions that arguably lowered the final bid. While four channels of white spaces creating 24 megahertz would not represent contiguous spectrum, this nonetheless would be sufficient for broadband services in these highly congested markets. Other urban markets would have somewhat more spectrum available, while rural markets might have as much as 100 megahertz more spectrum available.

Accordingly, I am not convinced that making Channels 21 – 51 available only for unlicensed use is necessary to create the types of exciting new services that have been predicted. I am even less convinced – and the record does not support – that we must make the entire core TV band, Channels 2 – 51, available for such use. This is more spectrum than was requested by most of the parties who argued that they could provide new and innovative services using Channels 21 – 51. Therefore, while I supported moving forward to allow a portion of the white spaces be made available for unlicensed use, I respectfully dissent from including all channels in the band plan in this order.

I thank Chief Julie Knapp, the fine staff at OET, and all those who have worked so hard on this item, including the many hours spent testing and analyzing devices. However, this was only a step on this incredible technology journey. Testing on individual devices will now commence and must be subject to the same stringent, thorough, and transparent procedures and reporting we have seen thus far in this process, consistent with the Commission's procedures for all device certifications. In addition, it is of critical importance that the Commission establishes and ensures a process that will immediately respond to and mitigate any interference experienced by incumbent users and individual consumers alike.