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.

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[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 dBμV/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

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[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 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 this 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 dBμV or 76 dBμV, 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]

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[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

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[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 device[279]

[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 14through channel 20 are set aside for use by PLMRS and CMRS operations. These regions are specified in the Commissions 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 stations' 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.