

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

In the Matter of	)	
	)	
Amendment of Part 15 of the Commission’s Rules for Unlicensed White Space Devices	)	ET Docket No. 16-56 RM-11745
	)	
Amendment of Part 15 of the Commission’s Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37	)	ET Docket No. 14-165
	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268
	)	

**REPORT AND ORDER  
 AND  
 ORDER ON RECONSIDERATION**

**Adopted: March 19, 2019**

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By the Commission:

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**I. INTRODUCTION**

1. Unlicensed white space devices can provide a vital link to provide broadband services to the American public, especially those in rural and underserved areas due to the better propagation characteristics of lower band frequencies that the devices utilize. These devices, which rely on a database to determine what spectrum is available for use at their location, operate in the television bands and parts of the 600 MHz Band that are not in use by licensed services. Since white space device operation relies on a database to determine what spectrum is available for use at the device’s location, white space devices must report precise location information to the database to ensure that the database, in turn, provides them with accurate spectrum availability information.

2. In the Report and Order, we take steps to improve the accuracy and reliability of the fixed white space device data recorded in the white space databases and assure that the potential for these devices to cause interference to protected services is minimized. In the Order on Reconsideration, we modify the white space device antenna height rules to allow improved broadband coverage in rural areas, and we resolve certain outstanding white space reconsideration issues.

**II. BACKGROUND**

3. White space devices can be used to provide a variety of wireless services, including broadband data. Fixed white space devices are being deployed today and are typically used to provide backhaul services for Internet connectivity offered by Wireless Internet Service Providers (WISPs), schools and libraries. The Commission’s Part 15 rules allow unlicensed white space devices to operate at locations where frequencies are not in use by licensed services.<sup>1</sup> The Commission has authorized the operation of unlicensed devices in unused channels of broadcast television spectrum, in the guard band between television spectrum and 600 MHz downlink services, in the guard band between the 600 MHz service band uplinks and downlinks (the 600 MHz duplex gap), and on television channel 37.<sup>2</sup> White space devices may be either fixed or portable.

4. To prevent harmful interference to broadcast television stations and other protected users of these bands, white space devices obtain a list of available channels and operating power levels that may be used at their particular location from databases administered by private entities selected by the Commission.<sup>3</sup> Fixed white space devices must register with a database, incorporate a geo-location capability or have their coordinates determined and programmed by a professional installer, and include a means to access a database that provides a list of available channels that may be used at their location.<sup>4</sup> Portable white space devices can either acquire lists of available channels via another device (Mode I), or

<sup>1</sup> See generally 47 CFR Part 15 subpart H.

<sup>2</sup> *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auction R&O*).

<sup>3</sup> 47 CFR §§ 15.711(c)(2), (d)(2) and 15.715.

<sup>4</sup> 47 C.F.R. § 15.711(c)(1). Fixed devices must re-check the database for available channels at least once daily. 47 C.F.R. § 15.711(c)(2).

include geo-location and database access capabilities (Mode II) that provides a list of available channels that may be used at their location.<sup>5</sup>

5. In 2015, the Commission established technical rules in the *TV White Spaces Order* for white space devices that will operate in the 600 MHz guard band(s) and 600 MHz duplex gap and in channel 37.<sup>6</sup> The Commission also modified the rules to provide greater flexibility for white space devices that will operate in the television bands spectrum that is not repurposed for wireless services after the incentive auction and in the 600 MHz service band at locations where a wireless licensee has not yet commenced operations. In addition, the Commission adopted rules to allow wireless microphones to operate in the 600 MHz guard band(s) and 600 MHz duplex gap, and codified Part 15 rules for unlicensed wireless microphones. Ten parties filed petitions for reconsideration of certain Commission decisions in the *TV White Spaces Order*, while nine parties filed oppositions and 12 parties filed replies.<sup>7</sup>

6. In 2016, in response to a petition submitted by the National Association of Broadcasters (NAB),<sup>8</sup> the Commission issued the *Geo-location NPRM* to address NAB's concerns about information in the white space databases.<sup>9</sup> The Commission proposed to amend Part 15 of the rules to improve the quality of the geographic location and other data submitted for fixed white space devices operating on unused frequencies in the television bands and the 600 MHz Band for wireless services. The proposals were designed to improve the integrity of the white space database system and, as white space device deployments grow, to increase the confidence of all spectrum users of these frequency bands that the white space geo-location/database spectrum management scheme fully protects licensees and other protected users. The Commission proposed to eliminate the professional installation option for fixed white space devices and require instead that each fixed white space device incorporate a geo-location capability to determine its location.<sup>10</sup> The Commission also proposed options to accommodate fixed white space device installations in locations where an internal geo-location capability is not able to provide this information. Further, the Commission proposed to modify other rules regarding fixed white space device registration to ensure the integrity of the information provided by white space device users. A total of 11 parties filed comments on the *Geo-location NPRM*, and five parties filed reply comments.<sup>11</sup>

7. On October 2, 2018, Microsoft filed an *ex parte* presentation suggesting various changes to the rules.<sup>12</sup> We do not intend to prejudge those requests in this item and may consider them in a future notice of proposed rulemaking.

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<sup>5</sup> 47 CFR §§ 15.703(i) and 15.711(d-e). A Mode I device is not required to incorporate geo-location and database access capabilities.

<sup>6</sup> *Incentive Auction R&O and Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37*, Report and Order, 30 FCC Rcd 9551 (2015) (*TV White Spaces Order*).

<sup>7</sup> A list of petitioners is provided in Appendix C.

<sup>8</sup> National Association of Broadcasters, Emergency Motion for Suspension of Operations and Petition for Rulemaking, RM-11745, March 19, 2015 (NAB Petition). NAB alleges that there are data errors in the registration records for fixed devices in the white space databases, argues that the accuracy of this data is critical for avoiding interference to licensed users of the spectrum, and requests that the Commission undertake rulemaking and other actions to correct and avoid such errors. The Commission sought comment on this petition. *Consumer & Governmental Affairs Bureau Reference Information Center Petition for Rulemaking Filed*, Public Notice, Report No. 3016, (CGB April 1, 2015).

<sup>9</sup> *Amendment of Part 15 of the Commission's Rules for Unlicensed White Space Devices*, Notice of Proposed Rulemaking and Order, 31 FCC Rcd 1657 (2016) (*Geo-location NPRM*).

<sup>10</sup> 47 CFR § 15.711(c).

<sup>11</sup> A list of parties filing comments and reply comments is provided in Appendix B.

<sup>12</sup> Letter from Paula Boyd, Senior Director Government and Regulatory Affairs, Microsoft Corporation, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-165 et al., at 3-14 (filed Oct. 2, 2018).

### III. REPORT AND ORDER

8. In this Report and Order, we adopt certain changes to the rules for fixed white space devices. Specifically, we require all fixed white space devices to incorporate a geo-location capability such as GPS and eliminate the option that permitted the geographic coordinates of a fixed device to be determined by a professional installer. We also adopt rules that allow the use of external geo-location sources by a fixed white space device when the device is used at a location where its internal geo-location capability does not function, such as deep inside a building. In addition, we require fixed white space devices to periodically re-check their geographic coordinates at least once a day and report the coordinates to the white space database.

#### A. Fixed device location data

##### 1. Professional installation vs. incorporated geo-location capability

9. *Background.* Under the current rules, the geographic coordinates and antenna height above ground of a fixed white space device must be determined at the time of installation and first activation from a power-off condition by either an incorporated geo-location capability or a professional installer.<sup>13</sup> Most fixed white space devices that have been certified by the Commission do not incorporate a geo-location capability, and thus the geographic coordinates for most fixed white space devices now in the market are determined by a professional installer.<sup>14</sup> The rules also state that the geographic coordinates and antenna height above ground may be stored internally in the white space device, either by means of the device's incorporated geo-location capability or through the services of a professional installer.<sup>15</sup> The rules do not address how this information is to be provided to the database administrators when the fixed device is registered, whether directly from the device to the database, or manually entered into the database by the party responsible for providing the registration information.

10. To improve the accuracy of the geo-location data provided to the databases and ensure the integrity of and confidence in the system, the Commission proposed to modify Section 15.711(c) to eliminate the option of allowing professional installation of fixed white space devices, thereby eliminating the possibility that manual data entry could cause incorrect location data to be stored in the white space device or provided to a database.<sup>16</sup> The Commission proposed to instead require fixed white space devices to include a geo-location capability that can automatically determine its geographic coordinates.<sup>17</sup> It also proposed that the geographic coordinates be stored automatically in the fixed white space device and transmitted electronically directly from the device to the database, rather than entered manually in the database, thereby further reducing the possibility of introducing data errors.<sup>18</sup>

11. *Discussion.* We will require all fixed white space devices to include an internal geo-location capability to determine their geographic coordinates and require that fixed white space devices automatically provide their coordinates to the database when the device is registered. We agree with NAB and Carlson et al. that these actions will help ensure the accuracy of information provided to the white space database, thus reducing the likelihood of imprecise registered coordinates for fixed white

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<sup>13</sup> 47 CFR § 15.711(c)(1).

<sup>14</sup> The Commission granted a waiver to Koos Technical Services, Inc. and Deere & Company to permit the certification and operation of fixed white space devices that obtain their geographic coordinates from a separate geo-location device. *Deere & Company Request for Limited Waiver of Part 15 Rules for Fixed White Spaces Device*, Order, 31 FCC Rcd 2131 (2016).

<sup>15</sup> *Id.*

<sup>16</sup> *Geo-location NPRM*, 31 FCC Rcd at 1663, para. 20.

<sup>17</sup> *Id.*

<sup>18</sup> *Id.*

space devices.<sup>19</sup> These actions will also enable simpler “do-it-yourself” installations of certain fixed devices, e.g., those where a professional installer is not needed to mount an antenna on a tall structure. Additionally, these actions will provide a means for a fixed white space device to automatically re-establish its coordinates if they are lost or altered due to a power outage or equipment reboot. We do not believe that these requirements are overly burdensome because manufacturers can incorporate a variety of location technologies into their devices; many of these, such as GPS<sup>20</sup> and Wi-Fi, are widely available at low cost.<sup>21</sup> As suggested by WISPA and Google, we will not require the use of GPS, and note that the rules already allow manufacturers to use other geo-location technologies.<sup>22</sup> We recognize certain geo-location technologies such as GPS generally do not work deep inside a building or at certain other locations, so as discussed below we are making provisions for operation of fixed devices in locations where incorporated geo-location may not work, including low power fixed devices used indoors.<sup>23</sup>

12. We disagree with Microsoft and WISPA that additional requirements for professional installers (e.g., a certification program for professional installers) would eliminate the need to require fixed devices to include an automatic internal geo-location capability.<sup>24</sup> We note Microsoft’s concerns that for some devices, the user would be paying for both the cost of professional installation and the internal geo-location capability because many fixed white space devices may need to be professionally installed if the device is to be mounted on a tall tower.<sup>25</sup> However, we find that requiring all devices to include an internal geo-location capability will reduce the likelihood of inadvertent errors when an installer manually enters geographic coordinates. Further, although some white space devices may need to be professionally installed in certain situations, other users would be able to forgo the expense of professional installation. For example, the same device could be installed with its antenna on high structures where a professional installer may be needed, but also on much lower structures (e.g., private homes) where a professional installer may not be needed.

13. Although Microsoft and Runcom express concern that a geo-location receiver in a fixed white space device transmitter may not be co-located with the transmit antenna (i.e., located at some horizontal distance away), thus resulting in some inaccuracy in the coordinates that the receiver determines,<sup>26</sup> we do not believe that this is problematic. We note that the rules allow a location

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<sup>19</sup> NAB Comments at 3-4, Carlson et al. Reply at 4. We are making no change to the geo-location requirements for Mode II personal/portable white space devices, which are already required to incorporate a geo-location capability. 47 CFR § 15.711(d).

<sup>20</sup> Carlson Wireless estimates that the cost of adding GPS to a fixed white space device is less than \$10 per unit. Carlson et al. Reply at 8.

<sup>21</sup> No particular technology is specified for meeting the geo-location requirement. We note that other technologies than can be used to determine location include beacons and RFID.

<sup>22</sup> WISPA Reply at 5, Google Comments at 2. The minimum required protection distances in the rules are based on a geo-location accuracy of  $\pm 50$  meters. Devices with a lower accuracy are permitted, in which case the database increases the protection distances by the amount the reported location uncertainty exceeds  $\pm 50$  meters. 47 CFR §§ 15.711(b)(1) and 15.712.

<sup>23</sup> Microsoft and Wi-Fi Alliance argue that a geo-location requirement should not apply to low-power, indoor, fixed devices. Microsoft Comments at 3, Wi-Fi Alliance Comments at 5.

<sup>24</sup> Microsoft and WISPA argue that the Commission could require professional installers to register for an FCC Registration Number (FRN) and require inclusion of this FRN in a fixed white space device registration to make it easier to correct erroneous entries and discipline installers’ performance. Microsoft Comments at 3, 11, WISPA Comments at 6-7, WISPA Reply at 5. Microsoft states that the certification program for professional installers that WISPA is developing could further increase geo-location reliability without increasing the burdens on consumers. Microsoft Reply at 4-5.

<sup>25</sup> Microsoft Reply at 3-4, 7.

<sup>26</sup> Microsoft Reply at 3, Runcom Comments at 1. Runcom states that a white space device may be 100 feet or more from the transmit antenna.

uncertainty of  $\pm 50$  meters (164 feet), and we do not expect that the location uncertainty of a geo-location receiver such as GPS, plus the horizontal distance from the transmit antenna to the transmitter, would commonly exceed 50 meters.<sup>27</sup> Further, in the event a manufacturer markets a white space device that is routinely located at a greater horizontal distance from the transmit antenna, the device will report a larger location uncertainty to the white space database, which will require greater separation distances from protected services.<sup>28</sup>

## 2. External geo-location capability

14. *Background.* The Commission recognized in the *Geo-location NPRM* that there will be applications for fixed white space devices in which a device is installed at a location where an internal geo-location capability may not function, such as inside a building.<sup>29</sup> To allow devices to operate in such situations, the Commission proposed to permit fixed white space devices to obtain their geographic coordinates from an external source that is connected to the fixed white space device when the internal geo-location capability does not function.<sup>30</sup> The Commission also proposed, in cases where the geo-location capability is provided by an external source connected to the fixed white space device, the fixed device and external geo-location source would be required to communicate using a secure method that ensures that the fixed device obtains information only from a source that has been approved for that function by the Commission's equipment certification program.<sup>31</sup> It further proposed that if the fixed white space device is unable to verify that the external source from which it is receiving geo-location data is an approved source, the fixed device would not be allowed to use that received data when reporting its location to the database.<sup>32</sup> The Commission sought comment on whether each fixed white space device should be associated with specific external geo-location sources or whether manufacturers should have the flexibility to design fixed white space devices to operate with a variety of geo-location sources as long as such sources are approved for use with the fixed white space device.<sup>33</sup>

15. The Commission sought comment on how to ensure, if an external geo-location source is used, each fixed white space device's geographic coordinates are accurate and options for how such an external source could be "connected" to the fixed white space device.<sup>34</sup> It sought comment on two approaches suggested by NAB and the Carlson et al. One approach would require the external geo-location source to be connected by an Ethernet, USB, serial port or other wired connection at all times to the fixed white space device located within 100 meters of the geo-location source, and the fixed white space device would cease transmitting if the connection to the external geo-location source is disconnected or ceased to function.<sup>35</sup> The other approach would be applicable to low power, i.e., 40 milliwatts or less equivalent isotropically radiated power (EIRP), fixed white space devices that contain an internal geo-location capability and that operate indoors where their geo-location capability does not

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<sup>27</sup> GPS enabled smartphones are typically accurate to within approximately 5 meters with a clear view to the sky. <http://www.gps.gov/systems/gps/performance/accuracy/>. If a white space device has a similar degree of accuracy, it could be up to 45 meters (159 feet) horizontally from the transmit antenna and still comply with the  $\pm 50$  meter accuracy requirement.

<sup>28</sup> 47 CFR §§ 15.711(b)(1), (c)(2)(ii), (d)(1) and 15.712.

<sup>29</sup> *Geo-location NPRM*, 31 FCC Rcd at 1664-65, para. 23.

<sup>30</sup> *Geo-location NPRM*, 31 FCC Rcd at 1665, para. 23.

<sup>31</sup> *Id.*

<sup>32</sup> *Id.*

<sup>33</sup> *Id.*

<sup>34</sup> *Geo-location NPRM*, 31 FCC Rcd at 1665, para. 24.

<sup>35</sup> *Id.* The plan would also allow a separate geo-location source to be connected to more than one fixed device at the same general location, as long as the white space devices it serves are all located no more than 100 meters from the geo-location source.

function.<sup>36</sup> Under this provision, the rules would allow a low power fixed white space device operator to establish the device's location by taking it to a point immediately outside the area where the geo-location capability does not function, permit the device to register and store the geographic coordinates for that outdoor location, and then register the device with the database after it is installed at its fixed indoor location using the location established at the outdoor point.<sup>37</sup>

16. Additionally, the Commission sought comment on whether it should permit the connection to an external geo-location source via a wireless link, and if permitted, what safeguards would be needed to ensure location data is within the required accuracy guidelines.<sup>38</sup> It also sought comment on whether it should allow other methods of transferring location data into a white space device (e.g., SD cards or USB memory sticks), and the circumstances under which a white space device should be required to re-check its coordinates.<sup>39</sup> In addition, the Commission sought comment on whether a fixed white space device could use a separate antenna connected by a long cable to enable use of its internal geo-location capability instead of using a separate geo-location source, and if this approach were permitted, what requirements would be necessary to ensure that the coordinates and location uncertainty reported to the white space database are accurate.<sup>40</sup>

17. *Discussion.* We will allow fixed white space devices to obtain their geographic coordinates through an external geo-location source when they are used at locations where their internal geo-location capability does not function, such as deep inside a building. Most commenters express support for allowing the use of an external geo-location device.<sup>41</sup> Specifically, we will allow an external geo-location source to be connected to a fixed device through either a wired or a wireless connection and will allow a single geo-location source to provide location information to multiple fixed devices. We will require that an external geo-location source be connected to a fixed device using a secure connection that ensures that only an external geo-location source that has been approved with a particular fixed device can operate with (i.e., provide geographic coordinates to) that device. Additionally, we will allow the use of extender cables to connect a remote receive antenna to a geo-location receiver within a fixed device. For any of these scenarios, we will require the applicant for equipment certification to demonstrate the accuracy of the geo-location method used, and in particular, the location uncertainty with a confidence level of 95%.<sup>42</sup> We will also require applicants to demonstrate that the location uncertainty will be reported correctly to the database.<sup>43</sup> These changes will increase the flexibility that manufacturers have to develop fixed white space devices that can be used in a wide variety of locations while ensuring that devices accurately determine their location and report it to the white space database to prevent harmful interference to protected services.

18. We decline to adopt rules to implement the NAB and Carlson et al. plan to require wired connections between a remote geo-location source and a fixed white space device or the special provision

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<sup>36</sup> *Geo-location NPRM*, 31 FCC Rcd at 1666, para. 26.

<sup>37</sup> The device would then be installed at its fixed location and register with its database within 30 minutes using the coordinates of the outdoor location and the time stamp for when it recorded the coordinates. If the device did not complete its registration within the 30 minute period, it would need to start over and re-establish its coordinates at a location where its geo-location capability functions and initiate a new 30 minute time period.

<sup>38</sup> *Geo-location NPRM*, 31 FCC Rcd at 1665-66, para. 24.

<sup>39</sup> *Geo-location NPRM*, 31 FCC Rcd at 1667, para. 27-29.

<sup>40</sup> *Geo-location NPRM*, 31 FCC Rcd at 1666, para. 25.

<sup>41</sup> NAB Comments at 7 (supporting a wired connection only), Google Comments at 5, Carlson et al Reply at 6-7, WISPA Comments at 5, WISPA Reply at 7. Google, Carlson et al. and WISPA support the use of either a wired or wireless connection.

<sup>42</sup> 47 CFR § 15.711(b).

<sup>43</sup> 47 CFR § 15.711(c)(2)(i).

for low power fixed white space devices located indoors.<sup>44</sup> We agree with those commenters that are concerned that these approaches would be overly complex and burdensome on users, particularly a requirement that users must take a device outdoors on a periodic basis so that it will continue to operate.<sup>45</sup> Instead, we are specifying a number of approaches that can be used to determine the coordinates of white space devices that are used at locations where technologies such as GPS will not function, including indoor locations. Thus, we find that the rules suggested by NAB and Carlson et al. are not necessary.

19. We will not explicitly limit the distance between a remote geo-location source and a fixed white space device, nor prohibit the use of wireless connections as requested by NAB.<sup>46</sup> However, practical considerations such as power constraints or the length of a connecting cable as well as the existing rules on location uncertainty will ensure that the geo-location source is in close proximity to the white space device. We note that the rules already allow configurations where Mode I personal/portable devices can obtain a list of available channels based on the coordinates of a nearby fixed or Mode II personal portable device. To address NAB's concern about the uncertainty of geographic coordinates provided by a separate geo-location source, we will require that a fixed white space device receive its coordinates automatically from a particular remote source. With regard to a wireless connection, the device providing the coordinates must be in close proximity, e.g. a Wi-Fi or Bluetooth connection. Further, as noted above, the rules already require manufacturers of fixed white space devices to demonstrate the location uncertainty with a 95% confidence level at the time of equipment certification.<sup>47</sup> We clarify here that this location uncertainty must consider factors such as the accuracy of the coordinates determined by the geo-location source, the length of a connecting cable (for a wired source), and the maximum range at which a wireless source could communicate with the fixed white space device.

20. We disagree with the Wi-Fi Alliance's contention that there is no need to require the use of a remote geo-location source with low power fixed white space devices used indoors.<sup>48</sup> Even if low power indoor devices have low probability of moving, the spectrum resources available to those devices could change over time (e.g., transient use of a licensed wireless microphone). Therefore, if a device is unable to determine its coordinates, it cannot obtain an updated list of available channels from the white space database on a regular basis and could potentially operate on an occupied channel and cause harmful interference. Many consumers are already familiar with installing computer, video, or audio equipment (e.g., cable modems, routers, printers, television sets, or speakers) using either wired or wireless connections, and we have no reason to believe that installing an external geo-location source or a remote antenna would pose any greater complexity.

### 3. Geo-location accuracy requirement

21. *Background.* In the *Geo-location NPRM*, the Commission noted that NAB and certain white space device manufacturers had recommended changing the required geo-location accuracy for white space devices from  $\pm 50$  meters to  $\pm 100$  meters and increasing the minimum required separation

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<sup>44</sup> NAB Comments at 8, Carlson et al. Reply at 6. NAB supports permitting low power indoor fixed devices to operate with coordinates obtained from a nearby outdoor location for up to 30 days, at which time the user would have to take action to re-establish the coordinates or the device would cease operating.

<sup>45</sup> Wi-Fi Alliance Comments at 6, Microsoft Reply at 5-6.

<sup>46</sup> NAB Comments at 7-8 and Reply at 7. NAB supports a wired connection to an external geo-location source located within 100 meters of the fixed device and opposes wireless connections for external geo-location sources because it believes the locations provided by wireless connections could be erroneous or falsified. Google, Carlson et al. and WISPA support the use of either a wired or wireless connection. Google Comments at 5, Carlson et al Reply at 6-7, WISPA Comments at 5, WISPA Reply at 7.

<sup>47</sup> 47 CFR §15.711(b). See also, ETSI EN 301 598, section 4.2.8.3, page 24(available at: [http://www.etsi.org/deliver/etsi\\_en/301500\\_301599/301598/01.01.01\\_60/en\\_301598v010101p.pdf](http://www.etsi.org/deliver/etsi_en/301500_301599/301598/01.01.01_60/en_301598v010101p.pdf).) which specifies the requirement for a white space device to report its coordinates and its geo-location uncertainty (in meters) with a confidence level of 95%.

<sup>48</sup> Wi-Fi Alliance Comments at 5-6.

distance between white space devices and television contours by 100 meters.<sup>49</sup> The *Geo-location NPRM* also noted that the Commission had subsequently adopted rules to account for geo-location uncertainty greater than  $\pm 50$  meters by requiring the white space database to increase the required separation distances from protected services by the amount the device's reported location uncertainty exceeds  $\pm 50$  meters.<sup>50</sup> The Commission tentatively concluded that it is not necessary to modify the default location accuracy requirement from  $\pm 50$  meters to  $\pm 100$  meters since it had already adopted rules to address the use of less precise geo-location methods, and it sought comment on that tentative conclusion. It also sought comment on any changes in the protection distances that would be necessary if it specified a less precise geo-location requirement.<sup>51</sup>

22. *Discussion.* We are not making any changes to the location accuracy rules in response to the *Geo-location NPRM*. For the reasons discussed below in the Order on Reconsideration, we are affirming the location accuracy rules that the Commission adopted in the *TV White Spaces Order*. Microsoft and WISPA agree with our decision, contending that the existing rules strike the right balance with regard to preventing interference, reducing equipment costs, and encouraging innovation.<sup>52</sup> With respect to Sennheiser's concern about the protection of wireless microphones, these rules include a provision that require an increase in the minimum separation distance from all protected services, including wireless microphones, that is proportional to any increase in location uncertainty.<sup>53</sup>

#### 4. Daily database contact to report geographic coordinates

23. *Background.* The rules require that a fixed white space device contact the database at least once a day to verify that its operating channels continue to be available for its use. The Commission proposed to revise this rule to include safeguards against changes to a device's location.<sup>54</sup> Specifically, it proposed to require a fixed white space device to check its coordinates once each day using its incorporated geo-location capability, except when not in operation, and to report its geographic location to the database when it makes its daily request for a list of available channels.<sup>55</sup> The Commission believed that this requirement would provide multiple observations that could be used to reduce the uncertainty of the device's location.<sup>56</sup> It sought comment on whether the geographic coordinates reported each day should be treated by the white space database as a modification of the registration record, and whether the registration record should be updated only if the difference in location exceeds 50 meters.<sup>57</sup>

24. *Discussion.* We will require that a fixed white space device verify its coordinates at least once per day, except when not in operation (e.g. in a sleep mode), and to report its geographic location to the database when it makes a request for a list of available channels. NAB and Cohen et al. support this approach.<sup>58</sup> Our action serves to improve the accuracy of the coordinates that fixed white space devices

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<sup>49</sup> *Geo-location NPRM*, 31 FCC Rcd at 1667-68, para. 30.

<sup>50</sup> *Id.*

<sup>51</sup> *Geo-location NPRM*, 31 FCC Rcd at 1668, para. 31.

<sup>52</sup> Microsoft Comments at 13, WISPA Comments at 5.

<sup>53</sup> Sennheiser Comments at 2. Section 15.712 of the rules lists the minimum separation distances between white space devices and various protected services. The listed separation distances must be increased by the amount that the location uncertainty of a white space device exceeds  $\pm 50$  meters. If, for example, a white space device reports to the database that it has a location uncertainty of  $\pm 150$  meters, the database will increase all of the protection distances from that device by 100 meters. 47 CFR § 15.712.

<sup>54</sup> *Geo-location NPRM*, 31 FCC Rcd at 1664, para. 22.

<sup>55</sup> *Id.*

<sup>56</sup> *Id.*

<sup>57</sup> *Id.*

<sup>58</sup> NAB Comments at 6-7, Cohen et al. Comments at 2.

report to the database by providing multiple observations that could be used to reduce the uncertainty of the device's location. It will also provide a safeguard that allows the coordinates to be re-established if they are inadvertently or deliberately altered. Because the daily re-check of coordinates and transmission of them to the white space database will be automatic, we disagree with Microsoft, Google, and Carlson et al. that this change would be burdensome on the users of fixed white space devices.<sup>59</sup> As discussed in the next section, we will require registration record updates only when there is a change in coordinates greater than 50 meters from those previously reported.

25. With regard to Sennheiser's concerns on protecting wireless microphones, we do not limit database re-checks to once a day.<sup>60</sup> We will consider the appropriate database re-check interval for protecting wireless microphones when addressing the petitions for reconsideration of the push notification rule.<sup>61</sup>

## 5. Re-registration of devices when moved or coordinates altered

26. *Background.* The Commission proposed that when a fixed white space device is moved to another location or its coordinates become altered, the device's geographic coordinates and antenna height above ground must be re-established and the device re-registered with a database.<sup>62</sup> With regard to the geographic coordinates, the Commission proposed that they be re-established using an incorporated geo-location capability.<sup>63</sup> The Commission sought comment on whether a re-registration requirement should apply to any change in location or only those changes where the coordinates differ by more than the accuracy requirement ( $\pm 50$  meters) from the last registered location.<sup>64</sup>

27. *Discussion.* We require that a fixed white space device's coordinates and antenna height above ground be re-established and the device registered with the database when it is moved or when its coordinates are altered by more than  $\pm 50$  meters (i.e., the fixed white space device location accuracy requirement) from the last registered location. Cohen et al. agree with this approach.<sup>65</sup> By limiting this requirement to location changes greater than 50 meters, we determine that fixed devices will not have to re-register with the database repeatedly for small changes in coordinates that have no effect on channel availability, such as when their geo-location mechanism detects small differences from the previously registered coordinates.<sup>66</sup> This will ensure that when a fixed device is moved or its coordinates are changed by more than 50 meters, the database will have accurate information necessary to determine the channels available for use by the device.

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<sup>59</sup> Microsoft Reply at 5, Google Comments at 4, Carlson et al. Reply at 7. These parties disagree that a fixed white space device should be required to contact the database every day to verify that it has not moved because fixed devices rely on external power sources and cannot be moved without being powered off and on again, which would require a device to reacquire its location and contact the database.

<sup>60</sup> Sennheiser Comments at 1-2. Sennheiser states that if the Commission reconsiders its decision to "push" microphone registrations to white space devices and revert to a "pull" requirement, the proposed rule would not provide for a sufficiently rapid response to protect wireless microphones.

<sup>61</sup> 47 CFR § 15.711(i). The attached Order on Reconsideration does not address the petitions for reconsideration of the push notification rule.

<sup>62</sup> *Geo-location NPRM*, 31 FCC Rcd at 1663, para. 21.

<sup>63</sup> *Id.*

<sup>64</sup> *Id.*

<sup>65</sup> Cohen et al. Comments at 2.

<sup>66</sup> Even when a device is at a fixed location, the geographic coordinates determined by GPS may vary slightly each time they are read due to measurement uncertainties in the system.

28. We decline to exclude low power devices from this rule as requested by the Wi-Fi Alliance.<sup>67</sup> A low power device is capable of causing harmful interference to protected services such as nearby television receivers and registered wireless microphones, and the likelihood of interference would increase if the device were moved beyond  $\pm 50$  meters and did not notify the database of its new location.

## 6. Determining antenna height above ground

29. *Background.* In the *Geo-location NPRM*, the Commission sought comment on whether it should require that the antenna height above ground be determined automatically using the fixed device's incorporated geo-location capability (e.g., GPS).<sup>68</sup> Because the vertical height accuracy of GPS is typically less than the horizontal location accuracy,<sup>69</sup> the Commission also sought comment on whether it should allow users (including professional installers and operators) to override an automatically determined height that proves to be inaccurate, or whether it should simply allow users to manually enter the antenna height above ground in all cases.<sup>70</sup>

30. *Discussion.* We will not require that white space devices automatically determine their antenna height above ground as requested by NAB and Cohen et al.<sup>71</sup> Instead, we will allow the installer or operator of the device to manually enter the height but will also provide the option for devices to determine the antenna height automatically. As noted by Google, Microsoft, Runcom, and WISPA, the accuracy of height measurements determined by GPS is lower than the accuracy of geographic coordinates determined by GPS.<sup>72</sup> Further, a GPS receiver in a fixed white space device may be at a lower elevation than the transmit antenna (e.g., at the base of a tower), introducing another source of uncertainty into the height determination. Given the current state of technology, we find it inappropriate to require white space devices and databases to use automatically determined antenna height information that may be in error at a particular location. Erroneous height data could preclude operation of a fixed device if the antenna height above ground reported to the database is outside of the allowable range, i.e., less than the site elevation or greater than 30 meters (or 100 meters in less congested areas).

31. We recognize that improvements in technology in the future could enable white space devices to more accurately determine their antenna height above ground. For this reason, we are providing the option for fixed white space devices to automatically determine their antenna height above ground. An applicant for certification of a fixed white space device that relies on an automatic means to determine the antenna height above ground would have to describe the method used as well as its accuracy.<sup>73</sup>

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<sup>67</sup> Wi-Fi Alliance Comments at 5.

<sup>68</sup> *Geo-location NPRM*, 31 FCC Rcd at 1664, para. 21.

<sup>69</sup> See e.g., Global Positioning System Standard Positioning Service Performance Standard, 4<sup>th</sup> Edition, September 2008, at v (stating that “well-designed GPS receivers have been achieving horizontal accuracy of 3 meters or better and vertical accuracy of 5 meters or better 95% of the time”), available at <http://www.gps.gov/technical/ps/2008-SPS-performance-standard.pdf>.

<sup>70</sup> The antenna height above ground for fixed white space devices is limited to 100 meters in less congested areas as discussed above, or 30 meters in other areas, except that the antenna height above ground may not exceed 10 meters for fixed white space devices operating in the TV bands at 40 milliwatts EIRP or less, or for fixed devices operating across multiple contiguous TV channels at 100 milliwatts EIRP or less. 47 CFR § 15.709(g)(i). If the antenna height above ground reported to the database exceeds the applicable height limit, the database will not provide a list of available channels to the device. Thus, a fixed white space device that complies with the limit on antenna height above ground would not be able to operate if it reports to the database an automatically determined antenna height above ground that is inaccurate and in excess of the height limit.

<sup>71</sup> NAB Comments at 4-6, Cohen et al. Comments at 2.

<sup>72</sup> Google Comments at 6, WISPA Comments at 4, Runcom Comments at 1, Microsoft Reply at 3.

<sup>73</sup> We note that the Commission has rules and a separate proceeding on determining the vertical location (z-axis) accuracy of wireless handsets for Enhanced 911 (E911) calls. See 47 CFR §20.18(i)(2)(ii) and PS Docket No. 07-

32. With regard to NAB's suggestion to allow the database to assume a 10-meter default antenna height when an automatically determined height is outside the allowable range, we find this to be an inadequate method of compensating for errors.<sup>74</sup> Because the antenna height above ground determined by GPS could be in error, either greater than or less than the actual height, many white space devices could appear to be outside of the permissible height range, so the antenna heights for these devices would be assumed as 10 meters in the database, even if they are actually higher or lower.<sup>75</sup> Thus, we conclude that we should continue to permit the installer of a device to manually enter the antenna height above ground as suggested by certain commenters.<sup>76</sup> While we recognize NAB's concern about potential errors in antenna heights entered by a professional installer, we believe that installers will generally be able to accurately determine the antenna height above ground.<sup>77</sup> Further, minor errors in the reported antenna height above ground of a fixed white space device will in many cases have no impact on the protection of television services since the protection distances that a fixed device must meet are the same across ranges of antenna heights.<sup>78</sup>

## 7. Transition provisions

33. *Background.* The Commission recognized that it is important to provide manufacturers with sufficient time to design new products, obtain certification, and commence manufacturing, and to allow the sale of existing devices until new products are available in the marketplace.<sup>79</sup> It proposed that, effective six months after the effective date of new rules adopted in this proceeding, new applications for certification of fixed white space devices must comply with any new rules requiring incorporated geo-location capability, and that within one year after the effective date of any new rules, parties would no longer be able to manufacture or import fixed white space devices that do not comply with the new requirements.<sup>80</sup> To allow parties to deplete any inventory of devices that does not comply with new requirements, the Commission proposed to permit continued marketing of these devices for up to eighteen months after the effective date of the new rules.<sup>81</sup> The Commission also sought comment whether it should specify only certification and marketing cutoff dates and allow manufacturers to decide their

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114. However, we also note that handsets are inherently different from white space devices in that they are network based and adhere to 3GPP standards. Moreover, the Commission's z-axis accuracy rules apply only in the top 50 CMAs while the majority of white space devices are expected to be deployed in more rural areas. We will continue to monitor developments related to z-axis accuracy and may revisit the requirements for white space devices in the future as vertical location technologies continue to mature and become applicable to a wider range of devices.

<sup>74</sup> NAB Comments at 6. Microsoft opposes NAB's suggestion, stating that would likely result in databases' treating many ground-level white space devices as though they were mounted on masts at least 10 meters in the air. Microsoft Reply at 6.

<sup>75</sup> For example, if a device that is not in a less congested area has an antenna mounted at 30 meters above ground, but the automatically determined height is greater than this, the database would assume of height of 10 meters, resulting in a 20-meter error. Conversely, if a device has an antenna mounted close to the ground, but the automatically determined height is lower, the database would also assume a height of 10 meters, resulting in a 10-meter error.

<sup>76</sup> Google Comments at 6, WISPA Reply at 3, Microsoft Reply at 3.

<sup>77</sup> An installer with simple measuring equipment should generally be able to determine antenna height above ground more consistently and accurately than GPS. We recognize the potential for installers to inadvertently enter incorrect heights into the database, and we intend to continue working with white space device operators and database administrators as necessary to ensure the accuracy of the information in the databases.

<sup>78</sup> Protection distances for fixed white space devices are defined at nine ranges of antenna height above average terrain: less than 3 meters, 3-10 meters, 10-30 meters, 30-50 meters, 50-75 meters, 75-100 meters, 100-150 meters, 150-200 meters, and 200-250 meters. The protection distances are the same across a defined height above average terrain range.

<sup>79</sup> *Geo-location NPRM*, 31 FCC Rcd at 1668, para. 32.

manufacturing and importation cutoff dates.<sup>82</sup> It further proposed to permit users of fixed white space devices that do not comply with new rules to continue to operate their devices indefinitely.<sup>83</sup> With regard to previously approved devices, the Commission proposed that it would treat equipment changes that simply add an incorporated geo-location capability to an existing certificated device as a permissive change to expedite application processing.<sup>84</sup>

34. *Discussion.* We require that fixed white space devices that are approved by Telecommunication Certification Bodies (TCBs) beginning six months after the effective date of the rules adopted in this proceeding must comply with the new rules.<sup>85</sup> No parties commented on this proposal. We also permit the continued marketing of previously approved devices that do not comply with the new rules until 18 months after the effective date of the rules.<sup>86</sup> We believe that these deadlines will provide sufficient time to develop compliant products and will provide the industry with flexibility to tailor manufacturing and importation cutoff dates to suit the relevant circumstances. The 18-month marketing cutoff date will also apply to parties other than the manufacturer, so owners of white space devices that do not comply with the new rules will not be permitted to re-sell the non-compliant devices after this date. Finally, we will not establish any operational cutoff for users of previously approved fixed white space devices that do not comply with the new rules. The number of those devices is relatively small, as is the likelihood that they would cause interference, so we do not see any reason to require users to modify or replace them.

35. While we initially proposed to treat equipment changes that add a geo-location capability to a previously approved fixed device as a permissive change, upon further consideration we decline to do so. Incorporating an internal geo-location capability into a fixed white space device would necessitate hardware modifications, resulting in a device that is not electrically identical to the originally approved device, necessitating a new grant of certification and a new FCC Identification number.<sup>87</sup> Requiring a new FCC Identification number in this situation will allow the Commission to readily distinguish which fixed white space devices contain an internal geo-location capability.

## **B. Fixed device registration**

### **1. Responsible party**

36. *Background.* Section 15.713(g) of the rules requires that fixed devices, before operating for the first time or after changing location, register with a white space database.<sup>88</sup> The party responsible

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<sup>80</sup> *Id.* “Manufacturing” in this case refers to equipment manufactured within the United States and not intended for export.

<sup>81</sup> *Geo-location NPRM*, 31 FCC Rcd at 1668, para. 32.

<sup>82</sup> *Id.*

<sup>83</sup> *Id.*

<sup>84</sup> *Geo-location NPRM*, 31 FCC Rcd at 1669, para. 33. The provisions for permissive changes are set forth in Section 2.1043 of the rules, 47 CFR § 2.1043.

<sup>85</sup> All white space devices are approved by TCBs rather than the Commission. When a TCB approves a device, the Commission is notified only after the approval rather than when the applicant files an application for certification. Accordingly, we are specifying transition dates based on when a TCB approves a device rather than on when a party files an application for certification.

<sup>86</sup> “Marketing” as defined by the rules includes sale or lease, or offering for sale or lease, including advertising for sale or lease, or importation, shipment, or distribution for the purpose of selling or leasing or offering for sale or lease. 47 CFR § 2.803.

<sup>87</sup> Knowledge Database (KDB) Publication 178919 D01 at 3, 47 CFR § 2.1043.

<sup>88</sup> 47 CFR § 15.713(g).

for the device must provide all of the information listed below to the database and ensure that the registration information is current and up-to-date for the device being registered.

- 1) FCC identifier (FCC ID) of the device;
- 2) Manufacturer's serial number of the device;
- 3) Device's geographic coordinates (latitude and longitude (NAD 83));
- 4) Device's antenna height above ground level (meters);
- 5) Name of the individual or business that owns the device;
- 6) Name of a contact person responsible for the device's operation;
- 7) Address for the contact person;
- 8) E-mail address for the contact person;
- 9) Phone number for the contact person.

37. The current rules assign responsibility for the accuracy of the registration information either to the party who provides the information to the database (e.g., a professional installer) or to the party who is responsible for the white space device.<sup>89</sup> Because the rules are not clear as to which party is responsible for the white space device, and thus for entering and maintaining the registration information, the Commission sought comment in the *Geo-location NPRM* on whether the responsible party should be the owner, the contact person, or some other party.

38. *Discussion.* We will require that the operator of a fixed white space device be responsible for the accuracy of the registration information, because that is the party capable of shutting down the device as required by the Part 15 rules in the event the device causes harmful interference.<sup>90</sup> The operator could be the owner of the device or another party that has the capability to control and deactivate the device. The fixed device registration must therefore provide the contact information for the operator of the fixed device. We will permit a party such as a professional installer to submit the registration information on behalf of the owner or operator, but the operator of the device will ultimately be responsible for ensuring its accuracy. We disagree with WISPA's contention that the professional installer (unless that professional installer is also the operator) should be the responsible party given that the Part 15 rules appropriately place responsibility on the operator for shutting down a device that causes harmful interference.<sup>91</sup>

## 2. Verification of registration information

39. *Background.* In the *Geo-location NPRM*, the Commission proposed to require the white space database that originates a registration request for a fixed device to confirm the e-mail address and telephone number entered for the contact person. It also proposed that the database not provide service to the device nor share the registration information with other approved white space databases until it receives a confirming response from the party responsible for the device registration. The Commission further proposed that the white space database confirm the contact person's information if any of the identifying information is modified (e.g., updating the e-mail address or phone number).<sup>92</sup>

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<sup>89</sup> 47 CFR §§ 15.711(c) and 15.713(g)(2).

<sup>90</sup> 47 CFR § 15.5.

<sup>91</sup> WISPA Comments at 6.

<sup>92</sup> *Geo-location NPRM*, 31 FCC Rcd at 1670, para. 38. Under these proposals, a white space database administrator would be allowed to implement the confirmation requirement using a method of its choosing as long as that method obtains a confirming response that 1) the party addressed in the message is responsible for the operation of the subject fixed device, and 2) the e-mail address and telephone number for that party are correct and appropriate to reach that party in a timely manner.

40. *Discussion.* We decline to adopt the Commission's proposal to require database administrators to verify e-mail addresses or phone numbers for fixed device registrations. We are persuaded by Google, Spectrum Bridge, and Carlson et al. that this requirement is unnecessary and would be unduly burdensome for database operators because of the time and expense that would be required to redesign their systems to enable verification of contact information and to actually verify the information for each fixed device registration.<sup>93</sup> The database administrators have already taken steps to ensure that operators of fixed white space devices supply all necessary information for a device registration (i.e., all data fields populated), and to reject information that is clearly erroneous, e.g., telephone numbers and e-mail addresses that do not comply with standard formatting rules. Additionally, requiring database administrators to hold new or modified registrations inactive until they verify the registrant's contact information could delay service to fixed white space device users. For example, many white space deployments are in rural areas where there may be no wireless phone service and limited Internet access before the activation of white space devices. Thus, there would be no way in these instances to verify e-mail addresses or telephone numbers in a timely manner.

#### IV. ORDER ON RECONSIDERATION

41. In this Order on Reconsideration, we address a number of petitions for reconsideration of the actions the Commission took in the *TV White Spaces Order*. We affirm most of the Commission's decisions, with the exception of increasing the maximum permissible fixed white space device antenna height above ground level in less congested areas. We will address at a later time those petitions addressing push notifications and white space device operation on Channel 37. The Commission previously addressed petitions related to wireless microphones.<sup>94</sup>

##### A. Low power fixed devices

###### 1. Operations within adjacent channel television contours

42. *Background.* Under the earlier rules established in 2008 in the *White Spaces Second Report and Order*, fixed white space devices were required to operate outside of defined adjacent channel television station service contours by a minimum separation distance.<sup>95</sup> This separation distance was based on a maximum level of four watts (4000 milliwatts) EIRP, regardless of a fixed white space device's actual power.<sup>96</sup> Personal/portable devices were, however, permitted to operate within the service contour of adjacent channel television stations at 40 milliwatts EIRP.<sup>97</sup> The fixed white space device requirement to avoid operating within adjacent channel television station contours meant that they could operate only at locations where there are three contiguous vacant television channels, regardless of their operating power.<sup>98</sup> In the *TV White Spaces Order*, the Commission modified the rules to allow fixed white space devices to operate within the contour of occupied adjacent television channels at 40 milliwatts EIRP as it allows for personal/portable devices.<sup>99</sup> This action was adopted to provide

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<sup>93</sup> Spectrum Bridge Comments at 3-4, Google Comments at 7, Carlson et al. Reply at 9.

<sup>94</sup> *Promoting Spectrum Access for Wireless Microphone Operations, Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap*, Order on Reconsideration and Further Notice of Proposed Rulemaking, 32 FCC Rcd 6077 (2017).

<sup>95</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562, para. 26 and *Unlicensed Operation in the TV Broadcast Bands and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Second Report and Order, 23 FCC Rcd 16807, 16867, para. 170 (2008).

<sup>96</sup> *Id.*

<sup>97</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562, para. 27 and 47 CFR § 15.712(a)(2).

<sup>98</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562, para. 27.

<sup>99</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562, para. 29.

consistent treatment of similarly powered devices and allows fixed devices to operate in more locations, i.e., where there are fewer than three contiguous vacant channels, while at the same time protecting television reception from harmful interference.<sup>100</sup> The Commission also limited the maximum antenna height to 10 meters above ground level for 40-milliwatt fixed devices that operate in either the television bands or the 600 MHz guard band to limit their potential to interfere with adjacent channel television reception.<sup>101</sup>

43. In its petition, NAB argues that the Commission should not permit any low power fixed device operation within the contours of adjacent channel television stations. It states that the technical analysis provided in the *TV White Spaces Order* is flawed and incomplete, and that the potential for interference to viewers from low power fixed devices is substantially greater than suggested.<sup>102</sup> NAB argues that neither the fixed white space device power limit of 40 milliwatts nor the 10-meter antenna height limit are practically enforceable under the Commission's rules.<sup>103</sup> NAB also argues that the Commission's conclusion that limiting fixed device antenna height to 10 meters will limit interference is unavailing.<sup>104</sup> It states that there is no basis for the Commission's assertion that a television receive antenna will have less than its maximum vertical gain in the direction of a white space device since OET-69 assumes the same 10-meter antenna height for television receive antennas as the Commission adopted for 40-milliwatt fixed white space devices.<sup>105</sup> NAB also argues that although the Commission's analysis assumes that both white space device transmit antennas and television receive antennas are highly directional and that the probability that they are both pointed at one another is low, a number of white space devices have been approved with omnidirectional antennas, and there is nothing to prevent a device from being placed in line with the main beam of a television receive antenna.<sup>106</sup> It argues that because OET-69 assumes about a 46 degree beamwidth for a television receiving antenna, the probability that a television antenna will be pointed directly at a fixed white space device somewhere within 46 degrees is significant.<sup>107</sup> NAB states that in cases where a fixed white space device has a direct line of sight to a television receive antenna, the required separation distance between a 40-milliwatt fixed device with an antenna height at 10 meters and television receiver would be 160 meters or more.<sup>108</sup> It also states that when a viewer is using a 0 dBm gain television receive antenna in the direction of the white space device, the interference distance can be more than 67 meters. Therefore, if white space devices become more ubiquitous, the probability of interference to television reception will be substantial.<sup>109</sup> Finally, NAB argues that not allowing low power fixed operations to operate within the contour of adjacent channel television stations will place only a minimal burden on unlicensed operations, as personal/portable devices, which represent a much lower interference threat, will still be able to operate within the contour of adjacent channel stations.<sup>110</sup>

44. *Discussion.* We affirm the Commission's decision in the *TV White Spaces Order* to permit fixed white space devices to operate with 40 milliwatts EIRP within the contour of adjacent

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<sup>100</sup> *Id.*

<sup>101</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562-63, para. 29. As discussed below, the 600 MHz band plan that resulted from the incentive auction contains a single three megahertz wide guard band.

<sup>102</sup> NAB Petition at 10.

<sup>103</sup> *Id.*

<sup>104</sup> NAB Petition at 11-12.

<sup>105</sup> NAB Petition at 12.

<sup>106</sup> *Id.*

<sup>107</sup> *Id.*

<sup>108</sup> NAB Petition at 12-13.

<sup>109</sup> NAB Petition at 13.

<sup>110</sup> NAB Petition at 13-14.

channel television stations with an antenna height that does not exceed 10 meters above ground level.<sup>111</sup> We are not persuaded that permitting such operation poses a significant threat of harmful interference to adjacent channel television reception. Microsoft and Google agree that permitting adjacent channel fixed operation within television contours is unlikely to result in harmful interference to television reception.<sup>112</sup> As the Commission noted in its decision, interference to television reception from an adjacent channel transmitter occurs when the signal from that transmitter is substantially greater than the received television signal level (i.e., at least 33 dB greater, which corresponds to a -33 desired-to-undesired (D/U) signal ratio).<sup>113</sup> Thus, adjacent channel interference from a white space device to television reception is most likely to occur where the television signal is weak, such as at the edge of a station's coverage area where an outdoor directional rooftop television antenna would be needed to obtain good reception. The highest likelihood of harmful interference occurring would be when the main beams of both antennas are pointed towards each other when the devices are in close proximity. However, because fixed white space devices must use directional antennas with a gain of at least 6 dBi to reach the 40-milliwatt EIRP level allowed by the rules,<sup>114</sup> we expect this to be a low probability event.<sup>115</sup> Moreover, even if all factors were to align and create a worst-case situation, we disagree with NAB's claim that 160-meter separation would be required to protect television reception from a 40-milliwatt white space device.<sup>116</sup> Using the -84 dBm threshold for a UHF-television signal<sup>117</sup> and applying the -33 dB D/U ratio for adjacent channel interference results in a white space signal needing to be -51 dBm or less to protect television reception. Therefore, assuming worst-case free space loss, a 40-milliwatt (16 dBm) white space device need only be separated from a television antenna by 88 meters;<sup>118</sup> significantly less than the distance claimed by NAB. While we recognize that this distance is not *de minimis*, we note that it is based on the low probability event of several worst-case conditions occurring simultaneously. The majority of over-the-air television reception occurs at higher signal levels than assumed here, and an increase in the received signal level of even a few dB sharply reduces the interference distance. Additionally, white space device signals are

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<sup>111</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562-63, para. 29.

<sup>112</sup> Microsoft asserts that there are a number of factors that reduce the likelihood of interference in the real world, such as the significant power-level disparity required for adjacent-channel interference to a television receiver, the likelihood of antenna polarization diversity, and transmit power control requirements for white space devices. Microsoft Opposition at 24-25. Google argues that real-world network trials demonstrate that fixed unlicensed operations transmitting at significantly higher power levels on adjacent channels do not cause harmful interference to TV operations. Google Opposition at 16.

<sup>113</sup> *TV White Spaces Order*, 30 FCC Rcd at 9563, para. 31; *White Spaces Second R&O*, FCC Rcd 16867, para.171 (specifying use of the adjacent channel -33 dB D/U ratio as specified in ATSC Recommendation A/74). The ATSC provides recommended guidelines for DTV receiver performance in its document, "ATSC Recommended Practice: Receiver Performance Guidelines," ATSC Doc. A/74, 17 June 2004.

<sup>114</sup> *TV White Spaces Order*, 30 FCC Rcd at 9563-64, para. 31. A fixed white space device operating at 40 milliwatts EIRP has a conducted power limit of 10 milliwatts. It must use an antenna with a directional gain of at least 6 dBi (a factor of four) to achieve an EIRP of 40 milliwatts. This requirement is codified at 47 C.F.R. § 15.709(b)(1)(ii).

<sup>115</sup> *TV White Spaces Order*, 30 FCC Rcd at 9564, para. 31. NAB cites an example of a TV receive antenna with a 46-degree beamwidth, which corresponds to only 13% of a 360-degree circle. If the white space device transmit antenna has similar directivity or more, the probability that the main beam of each of these antennas would point towards each other is very low. Additionally, we note that the beamwidth of an antenna is defined by the angle between the half-power (-3 dB) points of the main lobe. Thus, for the example antenna cited by NAB, the maximum gain is along the boresight of the antenna and diminishes by up to 3 dB at angles up to 23 degrees from the boresight. We believe it unlikely that the boresight of both a white space device antenna and a TV receive antenna will be that closely aligned. Consequently, in most cases, there is additional protection afforded to TV reception over the worst-case possibility. Alternatively, if the white space device antenna has an omnidirectional pattern, the device cannot transmit at maximum power, also reducing the probability of causing harmful interference. We

likely to attenuate faster than assumptions of free space propagation would indicate.<sup>119</sup> Other factors are also likely to decrease the distance at which interference could occur, including the mismatch between the directivity of the white space transmit and the television receive antennas, both in the horizontal and vertical planes, as well as any intervening obstacles between the antennas. We do not believe that the low probability case where all worst-case conditions occur simultaneously should lead us to adopt overly restrictive requirements. We also point out that, as with all Part 15 devices, in the event that a white space device does cause harmful interference to television reception, it must remedy such interference up to and including ceasing operation.<sup>120</sup>

45. While NAB is correct that the rules permit fixed devices to operate with non-directional antennas, a low power fixed device with a non-directional (0 dBi gain) antenna would be limited to 10 milliwatts EIRP, thus reducing its interference potential.<sup>121</sup> We note that personal/portable devices may operate at up to 40-milliwatts EIRP with a non-directional antenna.<sup>122</sup> Therefore, with respect to operation within an adjacent channel television contour, the maximum EIRP-based interference potential of a fixed white space device with a non-directional antenna is lower than that of a similarly situated personal/portable device.

46. We also recognize NAB's argument that a fixed white space device antenna could possibly be located at the same height as a television receive antenna (10 meters). However, as Microsoft notes, that does not necessarily mean that all low power fixed devices will use a transmit antenna at this height.<sup>123</sup> The 40-milliwatt power level restricts white space device usefulness to short-range applications where lower antenna heights would more typically be used. If a party wishes longer range communications and has a 10-meter high antenna, it is likely to either use a channel where a fixed white space device can operate at a higher power level than 40 milliwatts, or use a different frequency band where higher power is allowed, e.g., the 2.4 GHz or 5.8 GHz bands where both higher power and higher gain antennas are allowed.<sup>124</sup>

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further note that other factors such as polarization mismatch, ground clutter, buildings or other obstacles in the signal path, etc. could further reduce the interference potential of TV reception from a white space device.

<sup>116</sup> NAB Petition at 13.

<sup>117</sup> The -84 dBm threshold is equivalent to the 41 dBu UHF-TV noise limited service contour defined in OET Bulletin No. 69 and takes into account all system parameters such as antenna gain, cable loss, etc.

<sup>118</sup> The loss needed to reduce a 40 milliwatt (16 dBm) signal to -51 dBm is 67 dB. Free space loss can be expressed as  $-27.55 + 20\text{Log}_{10}(f_{\text{MHz}}) + 20\text{Log}_{10}(D_{\text{meters}})$ . For a frequency of 608 MHz; the upper edge of channel 36, solving for D results in 88 meters for a 40 milliwatt EIRP device and 44 meters for a 10 milliwatt device.

<sup>119</sup> The Commission has based its propagation modelling for calculating interference from white space devices to television reception on the TM-91 propagation model which predicts more signal attenuation than free space propagation. See, e.g. *Unlicensed Operation in the TV Broadcast Bands*, Third Memorandum Opinion and Order, 27 FCC Rcd 3692, 3700 (2012) at ¶ 16.

<sup>120</sup> 47 CFR § 15.5(b).

<sup>121</sup> The conducted power limit for a low power fixed device that can operate within the contour of an adjacent channel TV station is 10 milliwatts. If the device used an omnidirectional (0 dBi gain) antenna, its EIRP would be 10 milliwatts. The device could only reach an EIRP of 40 milliwatts if it used a directional antenna with a gain of 6 dBi or greater.

<sup>122</sup> 47 C.F.R. § 15.709(b)(2).

<sup>123</sup> Microsoft argues that the fact that the Commission chose the same height for the fixed white space device height limit as OET-69 assumed for receive antenna height does not mean that all or even a significant number of white space devices and television receive antennas will operate at heights of exactly 10 meters. It states that most white space devices will likely operate at heights below this maximum, so the vertical directionality of television receive antennas will reduce received white space device signal strength. Microsoft Opposition at 23-24.

<sup>124</sup> 47 CFR § 15.247.

47. Because the permissible operating channels and maximum power levels for white space devices are determined by a database, we disagree with NAB that the 40-milliwatt EIRP and the 10-meter antenna height above ground level limits are not enforceable. When a white space device contacts a database, it must provide its geographic coordinates and antenna height above ground level. The database then provides a list of available channels at that location, including the maximum power permitted on each channel. A white space device may operate only on those channels, and at no greater than the power levels indicated by the database.<sup>125</sup> The database would indicate that operation of a fixed white space device at a location within the contour of an adjacent channel television station is permissible only if the antenna height above ground is 10 meters or less, and the database would indicate that the maximum permissible EIRP on that channel at that location is 40 milliwatts. If a fixed white space device reports to the database that its antenna height above ground level is greater than 10 meters, the database will not permit operation of the white space device at a location that is within the contour of an adjacent channel television station.

## 2. Power limits

48. *Background.* Under our Part 15 rules for fixed white space devices, limits are placed both on EIRP and on maximum conducted power. The conducted power limit is 6 dB below the EIRP limit, which requires a fixed device to use at least a 6 dBi gain directional antenna to transmit at maximum radiated power.<sup>126</sup> Personal/portable devices, however, are only required to comply with an EIRP limit (100 milliwatts maximum, or 40 milliwatts when operating within the contour of an adjacent channel television station), and not a conducted power limit, so they can transmit at the maximum EIRP limit using an omnidirectional antenna.<sup>127</sup>

49. In its petition, Microsoft requests that the Commission adjust the power limits for 40-milliwatt fixed devices to treat them similarly to personal/portable devices such that they may operate at 40 milliwatts EIRP using an omnidirectional antenna.<sup>128</sup> It argues that not making such a change could limit the usefulness of white space spectrum for many applications, including the Internet of Things (“IoT”).<sup>129</sup> Microsoft specifically requests that the Commission: (1) permit fixed devices with a 0 dBi antenna to operate indoors at 40 milliwatts EIRP; (2) clarify that home routers are fixed white space devices and thus eligible to use the same frequencies that other fixed devices may use (i.e., VHF as well as UHF television channels); (3) clarify the applicability of the professional installation rule to home routers; and (4) clarify that moving an access point from one area of a house to another is a *de minimis* change in location that does not require professional re-installation of the device.<sup>130</sup> In support of these requests, Microsoft asserts that an indoor-only fixed device presents even less interference risk than a personal/portable white-space device operating at the same power level.<sup>131</sup>

50. *Discussion.* We decline to change the rule adopted in the *TV White Spaces Order* that requires fixed devices to use a directional antenna with at least 6 dBi gain in order to transmit at the 40-milliwatt limit.<sup>132</sup> We note that NAB and Shure each objected to any changes to this rules for

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<sup>125</sup> 47 CFR § 15.711(c)(2).

<sup>126</sup> *Id.*

<sup>127</sup> 47 CFR § 15.709(b)(2) and 15.712(a)(2)(ii).

<sup>128</sup> Microsoft Petition at 15-16.

<sup>129</sup> Microsoft Reply at 2-3.

<sup>130</sup> Microsoft Petition at 16-17.

<sup>131</sup> Microsoft Petition at 16.

<sup>132</sup> 47 CFR § 15.709(b)(1)(i) and (c)(1). An antenna with a gain of greater than 6 dBi may be used if the conducted power is reduced by the amount in dB that the antenna gain exceeds 6 dBi, which ensures that the EIRP does not exceed 40 milliwatts.

40-milliwatt fixed devices.<sup>133</sup> While Microsoft may be correct that in many situations an indoor 40-milliwatt fixed device with an omnidirectional antenna would pose no more risk of interference to television reception than a personal/portable device operating at 40 milliwatts with an omnidirectional antenna, we note that in modifying the rules to allow low power fixed devices to operate inside the contour of an adjacent television channel, the Commission relied on the directional antenna requirement to ensure a low probability for causing interference.<sup>134</sup> We further note that devices do not specify to the database whether the operation is indoor or outdoor. Hence, there is no way to distinguish such operation and permit omnidirectional antennas indoors and require directional antennas outdoors. Because we are requiring all fixed devices, whether operated indoors or outdoors, to incorporate a geo-location capability and comply with minimum separation distances from registered licensed wireless microphones, we disagree with Shure's contention that a fixed white space device that operates indoors would have any greater potential for causing interference to wireless microphones than fixed devices used outdoors.<sup>135</sup>

51. We conclude that, based on the record, it is unnecessary to address whether in-home wireless routers are fixed devices and consequently whether moving a router from one area of a house to another would be a *de minimis* change in location that would require professional re-installation. The rules require that any white space device obtain a new set of operating channels from the database if it moves by more than  $\pm 50$  meters, and in the Report and Order above we decide to require both fixed and personal/portable devices to have an incorporated geolocation capability.<sup>136</sup> Thus, both fixed and personal/portable devices, if moved, will be functionally equivalent in determining if they exceed the distance threshold and need to contact the database for an updated channel list. In the case of a fixed device, that request will also entail sending registration information, but given that the device has been previously registered, there should be minimal burden on the user.<sup>137</sup>

52. Because both fixed and personal portable white space devices will, going forward, incorporate a geolocation capability, a manufacturer can decide which device rules it wants to follow (fixed or personal/portable) and certify that device accordingly.<sup>138</sup> Users will have flexibility to choose and install equipment certified as a personal/portable device or as a fixed device to best suit their needs.<sup>139</sup> We believe this flexibility addresses Microsoft's concerns as manufacturers can choose to certify routers as personal/portable devices operating at the full 40-milliwatt EIRP level.

53. Further, regarding Microsoft's concern about VHF television channel usage, no party asked us to reconsider the Commission's decision to limit personal/portable devices to channels 14 and

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<sup>133</sup> NAB Opposition at 7-8 and Shure Opposition at 7-8. NAB objects to Microsoft's request that the Commission clarify that indoor routers are fixed devices and that moving the device from one point in a house to another is a *de minimis* change that does not require professional re-installation of the device, arguing that a device that can be easily moved is not a fixed device. Shure contends that indoor-only fixed devices may operate in close proximity to wireless microphones, thus increasing the potential for interference.

<sup>134</sup> *TV White Spaces Order*, 30 FCC Rcd at 9562, para. 29. The Commission affirms that decision herein. See para. 44, *supra*.

<sup>135</sup> Shure contends that indoor-only fixed devices may operate in close proximity to wireless microphones, thus increasing the potential for interference. Shure Opposition at 7-8.

<sup>136</sup> See Section A of the Report and Order, *infra*.

<sup>137</sup> In many cases, the information will reside in the device's memory, so the registration process could be automated and done without or with minimal human intervention.

<sup>138</sup> In addition to the output power/directional antenna differences, fixed devices may have a detachable antenna whereas a personal/portable device must have a permanently attached antenna (See 47 C.F.R. § 15.709(g)(2)). The operating rules also differ; a fixed device must register certain information into the database and a personal/portable device need only obtain a channel list for its location without a registration requirement (See 47 C.F.R. § 15.713(b)(2)(iii)).

<sup>139</sup> We note that the rules do not prohibit a personal/portable device from being used in a permanent location.

above.<sup>140</sup> Therefore, we are not changing the rules which limit operation on VHF television channels to fixed devices. We disagree with Microsoft that this is an impediment because the rules already allow a fixed device to operate with an omnidirectional antenna to ensure uniform coverage. We acknowledge that such usage would have to be at a power level 6 dB below the 40-milliwatt EIRP level, but also note that free space propagation at VHF frequencies has, at a minimum, almost a 7 dB advantage over UHF frequencies,<sup>141</sup> which should allow a fixed device using an omnidirectional antenna in the VHF band to have roughly the same (possibly greater) coverage as a personal/portable device operating with 6 dB higher EIRP in the UHF band. For the reasons stated above, we believe it unnecessary to allow fixed devices to operate at 40 milliwatts with a non-directional antenna in either the UHF or VHF television bands as requested by Microsoft and decline to make these changes to the rules.

### 3. Operation on contiguous channels

54. *Background.* In the *TV White Spaces Order*, the Commission decided to allow fixed white space devices to operate with up to 100 milliwatts EIRP at locations where there are two or more contiguous vacant television channels available and the white space device's signal occupies one or more six megahertz bands, provided that there is at least three megahertz separating the white space emissions from the edge of lowest and highest vacant television channels.<sup>142</sup> This change allows a white space device to operate with 50 milliwatts EIRP in a three megahertz segment of each of the contiguous television channels (100 milliwatts total), leaving a frequency separation of three megahertz between a white space device's operating frequency band and the edges of the occupied adjacent television channels.<sup>143</sup> The rules previously permitted fixed devices to operate only at locations where there are at least three contiguous vacant television channels, with the white space device operating on the middle of the three channels, leaving the upper and lower channels vacant. While the Commission originally proposed to allow fixed white space devices to operate with up to four watts EIRP at locations where there are at least two contiguous vacant television channels, it determined after further analysis that it should limit fixed white space devices operating across two contiguous channels to 100 milliwatts EIRP (50 milliwatts EIRP in each channel) to reduce the likelihood of harmful interference to adjacent channel television stations.<sup>144</sup> However, the Commission also stated that if information becomes available showing that higher power fixed device operation is possible on contiguous television channels without causing interference to television reception, it may revisit this issue in the future.<sup>145</sup>

55. Carlson/Cal.net filed a petition requesting reconsideration of the Commission's decision to limit white space devices operating on contiguous vacant television channels to 100 milliwatts EIRP,

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<sup>140</sup> *TV White Spaces Order*, 30 FCC Rcd at 9585, para. 87. Personal/portable devices were previously permitted to operate only on channels 21 and above, and the Commission modified the rules to allow operation of personal/portable devices on channels 14 and above. The Commission rejected requests to allow operation on channels below 14, noting that devices that operate at lower frequencies typically require larger antennas that are better suited for use by fixed white space devices than personal/portable devices, and concluding that there would be no clear advantage to permitting personal/portable devices to operate below channel 14.

<sup>141</sup> Under free space conditions, the loss factor associated with the operating frequency is  $20 \cdot \text{Log}_{10}(f_{\text{MHz}})$  dB. The smallest advantage for VHF (6.7 dB) occurs when comparing a device operating at the top of the VHF-TV band (216 MHz; loss factor of 46.7 dB) to a device operating at the bottom of the UHF-TV band (470 MHz; loss factor of 53.4 dB). The VHF advantage can vary up to 21.1 dB and 10.9 dB when comparing the upper end of the UHF band (608 MHz; loss factor of 55.7 dB) to the lower end of the VHF low band (54 MHz; loss factor of 34.6 dB) and VHF high band (174 MHz; loss factor of 44.8 dB), respectfully.

<sup>142</sup> *TV White Spaces Order*, 30 FCC Rcd at 9565, para. 33.

<sup>143</sup> *TV White Spaces Order*, 30 FCC Rcd at 9565, para. 33.

<sup>144</sup> *TV White Spaces Order*, 30 FCC Rcd at 9567, para. 37.

<sup>145</sup> *Id.*

rather than allowing operation at four watts EIRP as proposed in the *Part 15 NPRM*.<sup>146</sup> Carlson/Cal.net argues that the Commission wrongly relied upon the interference analysis in NAB's comments in this proceeding when it reached its decision to permit a maximum of 100 milliwatts EIRP.<sup>147</sup> It states that NAB's assumptions of a -33 dB D/U ratio and a -83 dBm threshold for determining harmful interference to adjacent channel television stations are reasonable when there is zero frequency separation from an adjacent channel, but not in the case where there is a three megahertz buffer.<sup>148</sup> Carlson/Cal.net asserts that white space devices operating with four watts EIRP and a three megahertz buffer from occupied adjacent television channels would result in an interference distance of no more than 11 meters, comparable to that of a 40-milliwatt white space device operating with no frequency buffer, although it states that it has not performed testing to verify this.<sup>149</sup>

56. *Discussion.* We decline to increase the maximum allowable power for fixed white space devices that operate on two or more contiguous vacant channels with a three-megahertz frequency separation from occupied adjacent television channels.<sup>150</sup> NAB contends that higher power will significantly increase the likelihood of interference because adjacent channel signal rejection when using a three-megahertz buffer is insufficient to permit a power level of four watts.<sup>151</sup> While Carlson/Cal.net alleges that certain assumptions in NAB's interference analysis are incorrect (e.g., the D/U ratio and interference threshold), it does not explain what it believes to be the correct assumptions. It also does not justify its assumption that orthogonal polarization between a white space device transmit antenna and a television receive antenna will result in 12-15 dB of signal attenuation.<sup>152</sup> Carlson/Cal.net indicates that it has not performed testing to demonstrate whether fixed white space devices can operate at four watts EIRP without causing interference to television reception when operating with only three megahertz frequency separation from an occupied adjacent television channel, and no other party has provided relevant test results. For these reasons, we are upholding the Commission's decision to limit fixed white space devices that operate on contiguous vacant channels to 100 milliwatts EIRP, or to 50 milliwatts EIRP on a channel with a three-megahertz frequency separation from an occupied adjacent television channel.

57. We encourage parties to perform further testing to assess the impact, if any, of higher power operation on adjacent channel television reception. We would be open to reexamining the 100 milliwatts EIRP limit if testing shows no or minimal impact on adjacent channel television reception.<sup>153</sup>

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<sup>146</sup> Carlson/Cal.net petition at 4.

<sup>147</sup> Carlson/Cal.net petition at 6.

<sup>148</sup> Carlson/Cal.net petition at 5-6.

<sup>149</sup> Carlson/Cal.net petition at 6.

<sup>150</sup> As noted above, the rule also permits fixed white space devices to operate across more than two contiguous vacant channels, provided the power in any channel adjacent to an occupied TV channel is limited to 50 milliwatts EIRP and there is a three-megahertz frequency separation between the white space device signal and the occupied adjacent channel.

<sup>151</sup> NAB argues that the TV receive antenna gain may be 12 dB higher than the gain assumed by the Commission in its analysis of a 40 milliwatt portable device operating at a low height above ground level, so the Commission should assume that an additional 32 dB of adjacent channel signal rejection (20 dB for the power increase plus 12 dB for antenna gain) is required for a four watt fixed white space device to prevent harmful interference as compared to a 40 milliwatt personal/portable device. NAB states that its testing on five recent model DTV receivers showed that an additional three megahertz frequency buffer improves adjacent channel performance by significantly less than the 32 dB required. NAB opposition at 13-15.

<sup>152</sup> Carlson/Cal.net Reply at 4. Orthogonally polarized antennas are oriented at right angles to each other, e.g., a vertically polarized transmit antenna and a horizontally polarized receive antenna.

<sup>153</sup> Any such testing should account for changes in the TV bands due to the incentive auction. For example, increased channel sharing by TV stations may tax video stream coding such that there is less margin for interference.

**B. Variable power levels**

58. *Background.* Prior to the changes adopted in the *TV White Spaces Order*, the Commission allowed fixed devices to operate with up to four watts EIRP, and personal/portable devices to operate with up to 100 milliwatts EIRP, or 40 milliwatts EIRP when operating within the contour of an adjacent channel television station.<sup>154</sup> The prior rules specified minimum separation distances that fixed devices had to meet from the contours of co-channel and adjacent channel television stations at a number of antenna height above average terrain values, and these distances were calculated using the fixed device maximum power level of 4 watts EIRP.<sup>155</sup> Personal/portable devices had to comply with the same separation distances as fixed devices with a height above average terrain of three meters.

59. In the *TV White Spaces Order*, the Commission defined separation distances from the contours of co-channel and adjacent channel television stations at additional operating power levels for both fixed and personal/portable white space devices.<sup>156</sup> It took this action to allow fixed devices with a power level of less than four watts EIRP to operate closer to the contours of co-channel and adjacent channel television stations. In addition, because personal/portable devices are limited to less than four watts EIRP (i.e., 100 milliwatts or 40 milliwatts), this change allowed personal/portable devices to operate closer to the contours of co-channel and adjacent channel television stations than the rules previously allowed. The Commission also permitted fixed devices in less congested areas to operate at a higher power level of 10 watts EIRP, with appropriate separation distances to protect television and other services.<sup>157</sup> It required that fixed white space devices supply their geographic coordinates and antenna height above ground when querying a database for the list of available channels at their location, and that the database supply the list of available channels and the maximum permissible power level for each channel.<sup>158</sup> The Commission also prohibited white space devices from containing an interface that would allow users to select higher power levels than the database indicates are available for a channel at a given location.<sup>159</sup>

60. In its petition, NAB requests that the Commission modify the rules it adopted to ensure that white space devices operate only on authorized channels and at authorized power levels. NAB states that it has no objection to the changes in principle, and that the separation distances adopted by the Commission are generally acceptable, but argues that the Commission must adopt additional rules to give effect to these changes.<sup>160</sup> It argues that the rule changes provide no guidance or mechanisms to ensure that white space devices will actually operate as required.<sup>161</sup> NAB states that even with accurate and automatically determined geo-location data, permitting devices to operate at varying power levels and varying distances from protected licensed services creates a risk of harmful interference if devices are not limited to the power levels authorized for a given channel.<sup>162</sup> It states that the rules include no requirements that devices confirm they operate only on available channels at the appropriate power levels for their antenna heights, or that they report to the database or be controlled by the database to operate on

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<sup>154</sup> *TV White Spaces Order*, 30 FCC Rcd at 9568, para. 40.

<sup>155</sup> *TV White Spaces Order*, 30 FCC Rcd at 9568, para. 40.

<sup>156</sup> *TV White Spaces Order*, 30 FCC Rcd at 9578-79, para. 64. The Commission defined separation distances at 40 milliwatts, 100 milliwatts, 625 milliwatts, 1000 milliwatts, 1600 milliwatts, and 4000 milliwatts (four watts) EIRP.

<sup>157</sup> *TV White Spaces Order*, 30 FCC Rcd at 9572-73, para. 51-52.

<sup>158</sup> *TV White Spaces Order*, 30 FCC Rcd at 9570, para. 44.

<sup>159</sup> *Id.*

<sup>160</sup> NAB Petition at 14.

<sup>161</sup> *Id.*

<sup>162</sup> NAB Petition at 14-15.

specific frequencies at specified power levels.<sup>163</sup> NAB requests that the Commission require that white space devices provide the database with actual operating channel and power information. It argues that having this information in the database will allow more expeditious resolution of any harmful interference that may arise, and that such an approach would be consistent with Ofcom's requirements for white space devices in the UK.<sup>164</sup>

61. *Discussion.* We decline to change the rules to require white space devices to report their operating channels and power levels to the database. The Commission previously considered and rejected a similar request, stating that in the interest of keeping the rules simple and avoiding the imposition of unnecessary requirements that could hamper innovation, it was declining to require white space devices to report additional information to the database such as tracking active channel use.<sup>165</sup> Google concurs with the Commission's reasoning.<sup>166</sup> NAB has not provided any information that persuades us to change the Commission's previous decision. We disagree with NAB that the rules provide no guidance or mechanisms to ensure that white space devices will operate as required. Specifically, both fixed and Mode II personal/portable devices are subject to requirements that operation is permitted only on channels and at power levels that are indicated in the database as being available for the device, and that operation on a channel must cease immediately or power must be reduced to a permissible level if the database indicates that the channel is no longer available at the current operating level.<sup>167</sup> Also, as noted above, white space devices may not contain an interface that allows users to select higher power levels than the database indicates are available for a channel at a given location.<sup>168</sup> A manufacturer must demonstrate that a fixed or Mode II personal/portable device will comply with these requirements in order to obtain certification for the device. Thus, we conclude that we do not need to impose additional requirements on white space devices to implement the rules that allow operation at a variety of power levels. We recognize, however, that it may be appropriate to consider changes to the rules in the future to provide a more granular information flow between white space devices and the database to enable more efficient use of the spectrum while continuing to protect authorized services from harmful interference.

### C. Fixed white space device antennas

#### 1. Antenna height above ground level and average terrain

62. *Background.* The range at which a transmitted signal can be received is a function of a variety of factors, including the antenna height and radiated power.<sup>169</sup> All else being equal, increased antenna height and higher power will increase the reception range. Under the Commission's rules, fixed white space devices are permitted a maximum antenna height of 30 meters above ground level and 250

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<sup>163</sup> NAB Petition at 15.

<sup>164</sup> *Id.*

<sup>165</sup> *White Spaces Second MO&O*, 25 FCC Rcd at 18709, para. 117. The Commission stated that database administrators may perform additional functions besides those required by the rules, such as tracking active channel use if reported by the white space device or sending additional information to a device to enable it to determine the "best" available channel to use. It further stated that such functions are not prohibited by the rules, and the ability to add additional functionality could allow multiple database operators to distinguish their services and could be useful in the development of industry standards to enable more efficient spectrum sharing.

<sup>166</sup> Google argues that this change could significantly increase the burden on white space database operators, which would be required to receive, process, and store operational information for potentially millions of unlicensed devices. It states that NAB fails adequately to explain why this requirement is necessary to protect licensees, or why the benefits would exceed the costs to unlicensed users and database operators. Google Opposition at 18.

<sup>167</sup> 47 CFR §§ 15.711(c)(2)(ii) and 15.711(d)(3).

<sup>168</sup> *TV White Spaces Order*, 30 FCC Rcd at 9570, para. 44.

<sup>169</sup> The range is also affected by other factors such as intervening terrain, receive antenna type and height above ground level, receiver sensitivity, and the presence of interfering signals.

meters above average terrain.<sup>170</sup> In the *TV White Spaces Order*, the Commission made no changes to these height limits, but increased the maximum permissible power for fixed devices from four watts to 10 watts EIRP in less congested areas to increase their service range and provide opportunities for white space operators to serve more distant customers at less cost.<sup>171</sup> It defined “less congested” locations as those where at least half of the allocated television channels within the intended band of operation (low VHF, high VHF, or UHF) are unused for broadcast services and available for white space use, and where a fixed white space device is sufficiently separated from protected operations.<sup>172</sup> The Commission declined to increase the 30-meter above ground level limit out of concern that this change would increase the interference potential to protected services, as well as its belief that it is generally not necessary to mount an antenna at heights greater than 30 meters above ground level to avoid shadowing by trees and other obstructions in rural areas.<sup>173</sup>

63. WISPA requests that the Commission reconsider its decision to not increase the maximum allowable antenna heights above ground and average terrain for fixed white space devices, stating that the decision is unsupported by the record.<sup>174</sup> WISPA argues that any legitimate concerns about potential interference to protected facilities can be overcome by establishing reasonable distance separation criteria to adequately protect authorized facilities from fixed white space devices that use antenna heights greater than 250 meters height above average terrain.<sup>175</sup> It also argues that the Commission can amend Section 15.709(g)(1)(i) to increase the maximum antenna height above ground level while maintaining existing protection limits.<sup>176</sup>

64. *Discussion.* On reconsideration, we will increase the allowable fixed white space device antenna height above ground level from 30 meters to 100 meters in less congested areas. This action will allow for improved wireless broadband service to persons in rural and other underserved areas. As WISPA states, a 100-meter antenna height above ground level limit will benefit wireless broadband providers and users by permitting antennas to be mounted on towers or other structures at heights sufficient to clear intervening obstacles such as trees and hills that would attenuate the transmitted signal, thereby increasing the range at which the signal can be received.<sup>177</sup> As noted, our definition of less congested areas includes only those areas where at least half of the television channels in the white space device’s band of operation (low VHF, high VHF, or UHF) are vacant, i.e., available for use by white

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<sup>170</sup> 47 CFR § 15.709(g)(1). The antenna height above ground level is the distance from the antenna center of radiation to the ground directly below the antenna. To calculate the antenna height above average terrain, the average elevation of the surrounding terrain above mean sea level must be determined along at least 8 evenly spaced radials at distances from 3 to 16 km from the transmitter site. The height above average terrain is the difference between the antenna height above mean sea level (the height above ground level plus the site elevation) and the average elevation of the surrounding terrain. A higher height above average terrain will increase the maximum distance at which a signal can be received, while a higher antenna height above ground level can improve coverage at shorter distances by allowing the signal to clear obstacles in the vicinity of the transmitter.

<sup>171</sup> *TV White Spaces Order*, 30 FCC Rcd at 9572, 9573, para. 51, 53.

<sup>172</sup> *TV White Spaces Order*, 30 FCC Rcd at 9573, para. 51.

<sup>173</sup> *TV White Spaces Order*, 30 FCC Rcd at 9575, para. 57.

<sup>174</sup> WISPA Petition at 6-7.

<sup>175</sup> WISPA Petition at 7.

<sup>176</sup> *Id.*

<sup>177</sup> WISPA Petition at 6-7 (reiterating its previous comments to the *Part 15 NPRM* requesting an increase in the antenna height above ground level limit to 100 meters). Other parties stated in their comments to the *Part 15 NPRM* that a higher antenna height above ground level limit in less congested areas would allow improved signal coverage by fixed white space devices. Motorola Comments, ET Docket No. 14-165, at 5 (Feb 4, 2015) (permit an antenna height above ground of 75 meters); Google Comments, ET Docket No. 14-165, at 46 (Feb 4, 2015) (permit greater antenna height above ground in rural areas); Microsoft Comments, ET Docket No. 14-165, at 46 (Feb 4, 2015) (permit greater antenna height above ground in rural areas).

space devices.<sup>178</sup> We are limiting the higher antenna heights to these areas because they will have many vacant channels and therefore a low likelihood that increased antenna height above ground level will affect other operations in the television bands, including wireless microphone operations, about which Sennheiser is concerned.<sup>179</sup> Thus, we believe that even with this rule change, there will be sufficient spectrum resources available in these areas to support multiple users competing for spectrum.

65. This change will not alter the protection that television stations are entitled to under the rules. The minimum required white space device separation distances from television service contours are based on height above average terrain, with greater separation distances specified for higher height above average terrain values.<sup>180</sup> When a fixed white space device operates with a higher antenna height above ground level, and therefore a higher height above average terrain, it must comply with separation distances from television service contours based on that height above average terrain. Thus, when a fixed white space device operates with an antenna greater than 30 meters above ground level, its height above average terrain increases by a corresponding amount and television reception is protected to the same level as the rules currently provide.

66. While the Commission stated in the *TV White Spaces Order* that it saw no need to allow an antenna height above ground of more than 30 meters, on reconsideration we believe that real world experience has sufficiently demonstrated that increasing the allowable height above ground would be beneficial for operators in less congested areas. This is evidenced by several waiver and experimental licensing requests seeking authority to operate fixed white space devices in rural areas with antenna heights of more than 30 meters above ground in order to operate above the tree canopy.<sup>181</sup> Additionally, Q-Wireless advocates for an increase in the fixed device above ground level limit noting that water tower railings are ideal locations for mounting fixed device antennas, but that approximately 40% of such tower railings in rural Kentucky are more than 30 meters high and thus unable to be used under our current rules. Q-Wireless states that an increase in the above ground level limit to 64 meters would remedy this situation for the area it serves. Moreover, such a rule change will increase fixed device effectiveness because it would allow the near-field signal to clear most trees that are typically 20-40 meters in height.<sup>182</sup> Thus, contrary to NAB's assertion that a higher antenna height above ground level is not necessary, we now conclude that there is a need to allow fixed white space devices to use a higher antenna height above ground in less congested areas and that such operation can take place without increasing interference potential to other users.<sup>183</sup> These less-congested areas are frequently rural areas that are more challenging to serve with wired broadband and would therefore benefit the most from the resulting increase in the service range of white space devices.

67. We are affirming the Commission's decision to retain a maximum height above average terrain limit of 250 meters. We recognize WISPA's argument that a higher height above average terrain limit could allow for greater coverage by fixed white space devices but note the current rules already allow for a significant height above average terrain. Increasing the height above average terrain limit to 500 meters as WISPA suggests, in addition to the power increase to 10 watts in less congested areas that the Commission allowed in the *TV White Spaces Order*, would significantly increase not only the service

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<sup>178</sup> 47 CFR § 15.703(h).

<sup>179</sup> Sennheiser expressed concern that white space devices using a higher antenna height above ground could cause interference to wireless microphones. Sennheiser Opposition at 10.

<sup>180</sup> 47 CFR § 15.712(a)(2).

<sup>181</sup> Letter from Haiyun Tang, CEO, Adaptrum, Inc., to Julius P. Knapp, Chief, Office of Engineering and Technology, FCC, ET Docket No. 14-187, at 1 (filed October 23, 2014) and experimental license application 0492-EX-PL-2016, call sign WI2XMI, granted to Adaptrum, Inc. (August 3, 2016).

<sup>182</sup> Letter from Phil Lambert, General Manager, Q-Wireless LLC, to FCC, ET Docket No. 14-165, at 1 (filed March 2, 2017).

<sup>183</sup> NAB Opposition at 4.

range of fixed white space devices, but also the range at which harmful interference potentially could occur. For example, a fixed white space device operating at the previous maximum power level of 10 watts EIRP and a height above average terrain of 250 meters needs to be at least 39.5 kilometers outside the protected contour of co-channel television stations to prevent harmful interference.<sup>184</sup> A fixed device operating at 10 watts EIRP and a height above average terrain of 500 meters would have to be more than 50 kilometers outside the protected contour of co-channel television stations.<sup>185</sup> Accordingly, we will not at this time increase the height above average terrain limit for fixed white space devices, but may consider doing so in the future if we have a more complete record addressing this issue.<sup>186</sup>

## 2. Antenna directivity

68. *Background.* When establishing rules for fixed white space devices, the Commission assumed an omnidirectional transmit antenna when it calculated the minimum separation distances between co-channel and adjacent channel television contours and white space devices, but these separation distances apply whether the white space device uses an omnidirectional or directional antenna.<sup>187</sup> We note that a fixed white space device will often make use of a transmit antenna with some degree of directivity.<sup>188</sup> Accordingly, consideration of the directional pattern could affect the identification of available channels. In the case where the transmit antenna points away from a television contour, the resulting EIRP in the direction of the television contour would be lower than that for an omnidirectional antenna. Under such situations it may be possible to reduce the required separation distance between the white space device and the protected contours of co-channel and adjacent channel television stations. This change could potentially increase the number of locations where a fixed device could operate. In the *Part 15 NPRM*, the Commission sought comment on whether it should modify the rules to consider the directional antenna pattern for fixed space devices.<sup>189</sup> It noted that there are a number of factors that would have to be considered to ensure that white space devices with directional antennas provide adequate protection to television stations.<sup>190</sup> For example, antenna pattern information for fixed white space devices, including the orientation of the antenna as installed, would have to be stored in some format in the white spaces databases. The Commission also noted that it would have to develop appropriate protection criteria for fixed white space devices that use directional antennas.<sup>191</sup>

69. In the *TV White Spaces Order*, the Commission declined to modify the rules to allow consideration of fixed white space device transmit antenna directivity in determining channel

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<sup>184</sup> 47 CFR § 15.712(a)(2).

<sup>185</sup> This distance was calculated in accordance with the procedures specified in the *White Spaces Third MO&O*, 27 FCC Rcd at 3698-3700, para. 16-17.

<sup>186</sup> NAB notes that an increased HAAT limit would require increases in distance separation limits to protect licensed operations, which include TV, cable headend receivers, broadcast auxiliary and land mobile receiving facilities. NAB Opposition at 4-5.

<sup>187</sup> 47 CFR § 15.712(a)(2).

<sup>188</sup> Fixed white space devices may use a transmit antenna with a gain of up to 6 dBi, or 10 dBi in less congested areas, with no reduction in the maximum permitted conducted output power. Therefore, a fixed white space device must use an antenna with some gain, and therefore directivity, to operate at the maximum allowable power (up to 4 watts EIRP generally, or up to 10 watts EIRP in less congested areas). A fixed white space device may use a transmit antenna with a gain higher than 6 dBi or 10 dBi, provided the conducted power is reduced by one dB for every dB that the antenna gain exceeds these values. 47 CFR § 15.709(c)(2)-(3).

<sup>189</sup> *Part 15 NPRM*, 29 FCC Rcd at 12271, para. 75.

<sup>190</sup> *Part 15 NPRM*, 29 FCC Rcd at 12271, para. 74.

<sup>191</sup> For example, the Commission may need to specify the minimum arc size over which the power must be reduced in the direction of a protected TV station, since reduced power over a narrow arc may not adequately protect against harmful interference to reception of the station.

availability.<sup>192</sup> While a number of parties supported the concept of considering antenna directivity, the Commission found that there was not sufficient information in the record to show how to enable the use of antenna directivity without causing harmful interference to protected services.<sup>193</sup> For example, there was no consensus on the method for storing antenna patterns in the database, e.g., data format, and no information on how to ensure that accurate antenna orientation information is obtained by the antenna installer and entered into the white space databases. The Commission stated that it could consider this issue again in the future if parties are able to develop a standard to address implementation issues.<sup>194</sup>

70. In its petition, WISPA requests reconsideration of the Commission's decision to prohibit television white space databases from considering fixed device antenna directivity in determining channel availability.<sup>195</sup> It states that the reasons cited for prohibiting consideration of antenna directivity fail to recognize common industry practice, since the measurement of antenna horizontal beamwidth is universally recognized throughout the industry, and antenna beamwidth specifications are published for virtually all commercially manufactured antennas.<sup>196</sup> WISPA argues that an approach of using simple generic antenna patterns is sufficient to allow the databases to protect incumbents from interference without requiring the industry to undergo a lengthy and unnecessary process to reach consensus on the format for antenna patterns. WISPA argues that to the extent the Commission is concerned about the accuracy of information on antenna azimuth being accurately incorporated into the database, this is easily resolved through professional installation requirements.<sup>197</sup>

71. *Discussion.* We affirm the Commission's decision that the white space databases will not consider fixed white space device directional antenna patterns when determining vacant channel availability. Contrary to WISPA's assertion, we find that we continue to lack sufficient information in the record to develop rules that would ensure that television and other services are protected from harmful interference.<sup>198</sup> Rather, we do not believe that we could develop rules at this time without additional information. Allowing consideration of directional antenna patterns would add additional complexity to the operation of fixed devices and the white space databases, since there are many factors that would have to be addressed. As the Commission previously noted, the database would have to contain information describing the antenna azimuth as well as antenna pattern information for fixed white space devices, either the exact antenna pattern or a simplified version of it.<sup>199</sup> Also, we may need to specify additional requirements that fixed devices must meet, such the size of the arc over which white space devices must limit their power in the direction of a television station's protected contour, or minimum separation distances at additional power levels.<sup>200</sup> Additionally, we would need to address how to ensure that the orientation of a directional antenna is accurately reported to the white space database, e.g., by some automated means, by a professional installer, and if by an installer, what qualifications the installer must have.<sup>201</sup> We find that the record in this proceeding does not at this time provide an adequate solution.<sup>202</sup>

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<sup>192</sup> *TV White Spaces Order*, 30 FCC Rcd at 9579, para. 69.

<sup>193</sup> *Id.*

<sup>194</sup> *Id.*

<sup>195</sup> WISPA Petition at 4.

<sup>196</sup> WISPA Petition at 4.

<sup>197</sup> WISPA Petition at 5-6.

<sup>198</sup> *TV White Spaces Order*, 30 FCC Rcd at 9579, para. 67.

<sup>199</sup> *Part 15 NPRM*, 29 FCC Rcd at 12271, para. 74.

<sup>200</sup> *Id.*

<sup>201</sup> For example, the Commission requires that a licensed land surveyor verify the orientation of FM directional antennas. 47 CFR § 73.316(c)(2)(viii).

<sup>202</sup> We recognize the concerns of NAB with respect to the use of directional antennas by fixed white space devices, but since we are denying WISPA's petition on this issue, its objections are moot.

We could consider this issue again in the future as we gain experience with the rules the Commission adopted in the *TV White Spaces Order*.<sup>203</sup>

#### D. Geo-location accuracy requirement

72. *Background.* The rules the Commission adopted in the *White Spaces Second Report and Order* required fixed and Mode II personal/portable devices to incorporate a geo-location technology with an accuracy of  $\pm 50$  meters.<sup>204</sup> In the *TV White Spaces Order*, the Commission decided to allow fixed and Mode II personal/portable devices to use location technologies that have a lower degree of precision than  $\pm 50$  meters.<sup>205</sup> It required fixed and Mode II devices to inform the database of their location uncertainty with a 95% confidence level when requesting a list of available channels, and required that the database consider this uncertainty in determining the list of available channels at the device's location.<sup>206</sup> To implement this requirement, the Commission required the databases to increase the minimum separation distances from all protected services by the amount that the location uncertainty exceeds  $\pm 50$  meters. For example, no increase in separation distances is required for a device that meets the  $\pm 50$ -meter level of accuracy, while an adjustment of 50 meters would be required for a device with an accuracy of  $\pm 100$  meters. In such a case, because the protection zones would be larger, either the same channel list or a smaller channel list will be returned from the white space databases to the white space device.<sup>207</sup>

73. In its petition for reconsideration, NAB requests that the Commission modify the location uncertainty rules in certain respects to ensure they function as intended.<sup>208</sup> It argues that to ensure devices can meet the rules, the Commission should require use of the ETSI EN 301 598 standard which provides test procedures for geo-location capability, and require that manufacturers seeking equipment authorization for white space devices submit testing results to the Commission.<sup>209</sup> NAB also argues that unlimited location uncertainty would make determining the cause of harmful interference essentially impossible, as there would be no practical way to locate an individual device or determine if it was the cause of interference, and that the Commission should instead establish a location accuracy limit of  $\pm 100$  meters.<sup>210</sup>

74. *Discussion.* We decline to make any changes to the geo-location accuracy requirements the Commission adopted in the *TV White Spaces Order*. We find that NAB's request to limit the maximum geo-location uncertainty to  $\pm 100$  meters is overly restrictive and would eliminate most of the flexibility that the Commission provided in adopting this rule since it would allow only an additional 50 meters of uncertainty for less precise location technologies. We do not agree with NAB that it is necessary to specify an upper limit on location uncertainty. Because the geo-location uncertainty for a device must be added to the minimum required separation distances from protected services, a higher geo-location uncertainty means that a device must comply with greater separation distances from protected services, potentially precluding the use of channels that would otherwise be available if the device's location accuracy were more accurate. Thus, as noted by Microsoft and Google, manufacturers will have

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<sup>203</sup> *TV White Spaces Order*, 30 FCC Rcd at 9579, para. 67. Key Bridge states that registering directional antennas for white space devices can be made to work. Key Bridge Reply at 3.

<sup>204</sup> *White Spaces Second Report and Order*, 23 FCC Rcd at 16842, para. 91.

<sup>205</sup> *TV White Spaces Order*, 30 FCC Rcd at 9583, para. 77.

<sup>206</sup> *Id.*

<sup>207</sup> *TV White Spaces Order*, 30 FCC Rcd at 9583, para. 78.

<sup>208</sup> NAB Petition at 7.

<sup>209</sup> NAB Petition at 8. European Technical Standards Institute (ETSI) EN 301 598, *White Space Devices (WSD): Wireless Access Systems operating in the 470 MHz to 790 MHz TV broadcast band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive*.

<sup>210</sup> NAB Petition at 8-9.

an incentive to determine a device's location as precisely as possible to maximize the number of channels that a device can use.<sup>211</sup>

75. We also do not believe it is necessary to modify the rules to require the use of the ETSI EN 301 598 standard for determining a device's location accuracy. We expect that many manufacturers may wish to use this standard because it addresses the measurements they need to make, but we do not want to preclude the use of other standards or measurement methods that may be developed in the future.<sup>212</sup>

#### **E. Rule updates**

76. The broadcast television incentive auction closed on April 13, 2017.<sup>213</sup> As a result, the 600 MHz Band Plan is now finalized, and the specific frequencies associated with the revised television bands, 600 MHz guard band, 600 MHz duplex gap, and 600 MHz service band are now established. Accordingly, we are updating certain white space device rules to reflect the final 600 MHz Band Plan.<sup>214</sup> Specifically, we are modifying the definitions of the 600 MHz guard band, 600 MHz duplex gap and 600 MHz service band to reflect the actual frequency ranges as determined by the incentive auction, which were not known when the Commission adopted these rules, as well as other definitions that reference the frequency range of the revised television bands.<sup>215</sup> We are also modifying the rules regarding the permissible channels of operation and technical requirements for white space devices to reflect the frequencies available for their use under the final 600 MHz Band Plan.<sup>216</sup> Additionally, we are updating the rules for white space device operation in Channel 37 to reflect the maximum power of 40 milliwatts that is permissible under the final 600 MHz Band Plan.<sup>217</sup>

77. We are also reinstating a white space rule that was inadvertently removed from Part 95. In the *TV White Spaces Order*, the Commission added a new paragraph (d) to Section 95.1111 that states that parties operating WMTS networks on Channel 37 must register with the white space database to obtain interference protection from white space devices.<sup>218</sup> The Commission subsequently renumbered

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<sup>211</sup> Microsoft Opposition at 20-21 and Google Opposition at 16-17. When a white space device reports to the database that it is using a location technology that is less precise than  $\pm 50$  meters, the database will require the device to operate at greater distances from protected services to compensate for the lower precision. 47 CFR § 15.712(a). This requirement addresses Sennheiser's concern about the need for increased protection distances for wireless microphones when less precise geo-location methods are used. Sennheiser Comments at 2.

<sup>212</sup> The Commission will accept data which have been measured in accordance with: (1) procedures set forth in bulletins or reports prepared by the Commission's Office of Engineering and Technology (OET); (2) procedures acceptable to the Commission and published by national engineering societies; or (3) any other measurement procedure acceptable to the Commission. 47 CFR § 2.947(a). Manufacturers may contact OET for guidance on measurement procedures at [www.fcc.gov/labhelp](http://www.fcc.gov/labhelp).

<sup>213</sup> *Incentive Auction Closing and Channel Reassignment Public Notice - The Broadcast Television Incentive Auction Closes; Reverse Auction and Forward Auction Results Announced; Final Television Band Channel Assignments Announced; Post-Auction Deadlines Announced*, Public Notice, DA 17-314, 32 FCC Rcd 2786 (2017) (*Channel Reassignment PN*).

<sup>214</sup> These rule updates are ministerial in nature, implementing instructions that the Commission ordered in prior rulemaking decisions issued following notice-and-comment procedures. Accordingly, for good cause, we find that further notice and public procedure before these updates is unnecessary under the terms of the Administrative Procedure Act (APA). See 5 U.S.C § 553(b)(B) (setting forth the "good cause" exception to the notice-and-comment requirements of the APA).

<sup>215</sup> 47 CFR § 15.703(a), (b), (c), (o) and (r).

<sup>216</sup> 47 CFR § 15.707(a)(3)-(6), 15.709(b)(1)(ii), (b)(2) and (g), 15.713(a)(1), and 15.714(a). In modifying Section 15.714(a), we also clarify that the provision in this section allowing white space database administrators to charge fees for registering fixed devices and providing lists of available channels includes channel 37. The Commission stated in the *TV White Spaces Order* that this provision includes channel 37, but the final rule did not. *TV White Spaces Order*, 30 FCC Rcd at 9657-58, para. 258 and 47 CFR § 15.714(a).

and revised Section 95.1111 but failed to include the text of paragraph (d) in the revised section.<sup>219</sup> Accordingly, we are restoring the inadvertently deleted text to Section 95.2309.<sup>220</sup>

## V. PROCEDURAL MATTERS

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

79. *Paperwork Reduction Act.*—This document contains modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. It will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA. OMB, the general public, and other Federal agencies are invited to comment on the new or modified information collection requirements contained in this proceeding. In addition, we note that pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4), we previously sought specific comment on how the Commission might further reduce the information collection burden for small business concerns with fewer than 25 employees.

80. We have assessed the effects of the policies adopted in this Report and Order and Order on Reconsideration with regard to information collection burdens on small business concerns, and find that these policies will benefit many companies with fewer than 25 employees by providing unlicensed white space devices and unlicensed wireless microphones with access to spectrum in the television broadcasting band and the 600 MHz band, while at the same time protecting licensed users from harmful interference. In addition, we have described impacts that might affect small businesses, which includes most businesses with fewer than 25 employees, in the Final Regulatory Flexibility Analysis in Appendix C.

81. *Congressional Review Act.*—The Commission will send a copy of this Report and Order and Order on Reconsideration to Congress and the Government Accountability Office pursuant to the Congressional Review Act.

82. *Contact Person.*—For additional information concerning this Report and Order and Order on Reconsideration, please contact Mr. Hugh L. Van Tuyl at (202) 418-7506, or [Hugh.VanTuyl@fcc.gov](mailto:Hugh.VanTuyl@fcc.gov).

## VI. ORDERING CLAUSES

83. Accordingly, IT IS ORDERED that, pursuant to the authority contained in Sections 4(i), 302, 303(b), (c), (e), (f), (r), and 307 of the Communications Act of 1934, as amended, and sections 6403 and 6407 of the Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat.

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<sup>217</sup> In the *TV White Spaces Order*, the Commission adopted rules that would allow operation of white space devices in channel 37 at levels up to 4 watts EIRP, depending on the outcome of the incentive auction. It stated that if the incentive auction recovered 84 megahertz of spectrum, white space device operation in channel 37 would be limited to 40 milliwatts EIRP. *TV White Spaces Order*, 30 FCC Rcd at 9633, para. 199. Consistent with that auction outcome, we are modifying Section 15.709(a)(3) to specify that operation in channel 37 is limited to 40 milliwatts EIRP. We are also modifying the tables of minimum separation distances between white space devices and WMTS operating locations in Section 15.712(j)(1) to remove entries for white space devices operating in channel 37 at power levels greater than 40 milliwatts. These actions are taken without prejudice to Commission action on the pending petitions for reconsideration of the rules allowing white space device operation in channel 37.

<sup>218</sup> *TV White Spaces Order*, 30 FCC Rcd at 9654, 9709, para. 247 and Appx. A, §95.1111(d).

<sup>219</sup> *Review of the Commission's Part 95 Personal Radio Services Rules; Petition for Rulemaking of Garmin International, Inc.; Petition for Rulemaking of Omnitronics, L.L.C.*, Report and Order, 32 FCC Rcd 4292 (2017). In this *Report and Order*, Section 95.1111 was renumbered as Section 95.2309.

<sup>220</sup> As with the other rule updates discussed above, this update is ministerial in nature, implementing instructions that the Commission ordered in prior rulemaking decisions issued following notice-and-comment procedures. *See supra* note 214 **Error! Bookmark not defined.**

156, 47 U.S.C. §§ 154(i), 302, 303(b), (c), (e), (f), (r), 307, 1452, 1454, this Report and Order and Order on Reconsideration IS HEREBY ADOPTED.

84. IT IS FURTHER ORDERED that Part 15 of the Commission's rules IS AMENDED as specified in Appendix A, and such rule amendments WILL BECOME EFFECTIVE 30 days after the date of publication in the *Federal Register*, except that the amendments to section 95.2309, which contains new or modified information collection requirements that require approval by the Office of Management and Budget under the Paperwork Reduction Act, WILL BECOME EFFECTIVE after the Commission publishes a notice in the *Federal Register* announcing such approval and the relevant effective date.

85. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of the Report and Order and Order on Reconsideration, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the U.S. Small Business Administration.

86. IT IS FURTHER ORDERED that the Commission SHALL SEND a copy of the Report and Order and Order on Reconsideration in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, see 5 U.S.C. § 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch  
Secretary

## Appendix A

### Final Rules

For the reasons set forth in the preamble, the Federal Communications Commission amends part 15 of Title 47 of the Code of Federal Regulations to read as follows:

1. The authority citation for part 15 continues to read as follows:

[INSERT CURRENT AUTHORITY CITATION]

2. Section 15.37 is amended by revising paragraph (j) and adding a new paragraph (q) to read as follows:

#### § 15.37 Transition provisions for compliance with the rules.

\* \* \* \* \*

(q) All fixed white space devices which are approved by Telecommunication Certification Bodies on or after **[six months after the effective date of the rules]** or that are marketed on or after **[18 months after the effective date of the rules]** shall comply with the requirements of §15.711(c) of this part. Fixed white space devices which are approved or marketed before those dates shall comply with either the requirements of §15.711(c) of this part or the requirements of §15.711(c) that were in effect immediately before **[effective date of the rules]**.

3. Section 15.703 is amended by removing the note following paragraph (c), and revising paragraphs (a), (b), (c), (o) and (r) to read as follows:

#### § 15.703 Definitions.

\* \* \* \* \*

(a) *600 MHz duplex gap*. An 11 megahertz guard band at 652-663 MHz that separates part 27 600 MHz service uplink and downlink frequencies.

(b) *600 MHz guard band*. Designated frequency band at 614-617 MHz that prevents interference between licensed services in the 600 MHz service band and channel 37.

(c) *600 MHz service band*. Frequencies in the 617-652 MHz and 663-698 MHz bands that are reallocated and reassigned for 600 MHz band services under part 27.

\* \* \* \* \*

(o) *Sensing only device*. A personal/portable white space device that uses spectrum sensing to determine a list of available channels. Sensing only devices may transmit on any available channels in the frequency bands 512-608 MHz (TV channels 21-36).

\* \* \* \* \*

(r) *Television bands*. The broadcast television frequency bands at 54-72 MHz (TV channels 2-4), 76-88 MHz (TV channels 5-6), 174-216 MHz (TV channels 7-13) and 470-608 MHz (channels 14-36).

\* \* \* \* \*

4. Section 15.709 is amended by removing paragraphs (a)(5) and (a)(6) and revising paragraphs (a)(2) through (a)(4) to read as follows:

**§ 15.707 Permissible channels of operation.**

(a)(1) \* \* \*

(2) *600 MHz duplex gap.* White space devices may operate in the 657-663 MHz segment of the 600 MHz duplex gap.

(3) *600 MHz service band.* White space devices may operate on frequencies in the bands 617-652 MHz and 663-698 MHz in areas where 600 MHz band licensees have not commenced operations, as defined in §27.4 of this chapter.

(4) *Channel 37 guard band.* White space devices are not permitted to operate in the band 614-617 MHz.

\* \* \* \* \*

5. Section 15.709 is amended by revising paragraph (a)(3), revising paragraphs (b)(1) and (b)(2), and revising paragraph (g)(1)(i) to read as follows:

**§15.709 General technical requirements.**

(a) \* \* \*

(3) 608-614 MHz band (channel 37): Up to 40 mW (16 dBm) EIRP.

\* \* \* \* \*

(b) \* \* \*

(1) *Fixed white space devices.* (i) Technical limits for fixed white space devices are shown in the table and subject to the requirements of this section.

(ii) For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) shall follow the requirements for 40 dBm (10,000 mW).

(iii) The conducted power spectral density from a fixed white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission.

<b>EIRP (6 MHz)</b>	<b>Conducted power limit<sup>1</sup> (6 MHz)</b>	<b>Conducted PSD limit (100 kHz)</b>	<b>Conducted adjacent channel emission limit (100 kHz)</b>
16 dBm (40 mW)	10 dBm (10 mW)	-7.4 dBm	-62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	-3.4 dBm	-58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	-54.8 dBm

28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	-50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	-46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm

(2) *Personal/Portable white space devices.* (i) Technical limits for personal/portable white space devices are shown in the table and subject to the requirements of this section.

(ii) The radiated power spectral density from a personal/portable white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission.

<b>EIRP (6 MHz)</b>	<b>Radiated PSD limit EIRP<sup>1</sup> (100 kHz)</b>	<b>Radiated adjacent channel emission limit EIRP (100 kHz)</b>
16 dBm (40 mW)	-1.4 dBm	-56.8 dBm
20 dBm (100 mW)	2.6 dBm	-52.8 dBm

\* \* \* \* \*

(g) *Antenna requirements-(1) Fixed white space devices-(i) Above ground level.* The transmit antenna height shall not exceed 100 meters above ground level in less congested areas or 30 meters above ground level in other areas, except that the antenna height may not exceed 10 meters above ground level in any area for fixed white space devices operating in the TV bands at 40 mW EIRP or less or operating across multiple contiguous TV channels at 100 mW EIRP or less.

\* \* \* \* \*

6. Section 15.711 is amended by revising paragraphs (c)(1), (c)(1)(i), (c)(2)(iii) and adding new paragraphs (c)(1)(iii)-(iv) to read as follows:

**§15.711 Interference avoidance methods.**

\* \* \* \* \*

(c) *Requirements for fixed white space devices.* (1) The geographic coordinates of a fixed white space device shall be determined at the time of installation and first activation from a power off condition by an incorporated geo-location capability. The antenna height above ground shall be determined by the installer or operator of the device, or by an automatic means. This information shall be stored internally in the white space device and transmitted automatically by the device to the white space database. The operator of a fixed white space device shall be responsible for assuring the accuracy of the information registered in the white space database. If a fixed white space device is moved to another location or if its stored coordinates become altered, the operator shall reestablish the device's:

(i) Geographic location through the incorporated geo-location capability and the antenna height above ground level and store this information in the white space device; and

(ii) \* \* \*

(iii) A fixed white space device may obtain its geographic coordinates through an external geo-location source when it is used at a location where its internal geo-location capability does not function. An external geo-location source may be connected to a fixed device through either a wired or a wireless connection, and a single geo-location source may provide location information to multiple fixed devices. An external geo-location source must be connected to a fixed device using a secure connection that ensures that only an external geo-location source that has been approved with a particular fixed device can provide geographic coordinates to that device. The geographic coordinates must be provided automatically by the external geo-location source to the fixed device; users may not manually enter them. Alternatively, an extender cable may be used to connect a remote receive antenna to a geo-location receiver within a fixed device.

(iv) The applicant for certification of a fixed device must demonstrate the accuracy of the geo-location method used and the location uncertainty as defined in paragraph (b) of this section. For fixed devices that are not using an internal geo-location capability, this uncertainty must account for the accuracy of the geo-location source and the separation distance between such source and the white space device.

(2)\*\*\*

(iii) Each fixed white space devices shall access the database at least once a day to verify that the operating channels continue to remain available. Each fixed white space device must adjust its use of channels in accordance with channel availability schedule information provided by its database for the 48-hour period beginning at the time the device last accessed the database for a list of available channels. The fixed device’s registration information shall be updated if the geographic coordinates reported to the database differ by more than ±50 meters from the previously registered coordinates.

\*\*\*\*\*

7. Section 15.712 is amended by revising paragraph (j) to read as follows:

\*\*\*\*\*

(j) *Wireless Medical Telemetry Service:*

(1) White space devices operating in the 608-614 MHz band (channel 37) are not permitted to operate within an area defined by the polygon described in § 15.713(j)(11) plus the distances specified in the tables below:

(i) Mode II personal/portable white space devices

	Required co-channel separation distances in kilometers from edge of polygon
	16 dBm (40 mW)
Communicating with Mode II or Fixed device	0.38
Communicating with Mode I device	0.76

(ii) Fixed white space devices, except that when communicating with Mode I personal/portable white space devices, the required separation distances must be increased beyond the specified distances by 0.38 kilometers.

Antenna height above average terrain of unlicensed devices (meters)	Required co-channel separation distances in kilometers from edge of polygon*
	16 dBm (40 mW)
Less than 3	0.38
3 - 10	0.70
10 - 30	1.20
30 - 50	1.55
50 - 75	1.90
75 - 100	2.20
100 - 150	2.70
150 - 200	3.15
200-250	3.50

(2) White space devices operating in the 602-608 MHz band (channel 36) and 614-620 MHz band (channel 38) are not permitted to operate within an area defined by the polygon described in § 15.713(j)(11) plus the distances specified in the tables below:

(i) Mode II personal/portable white space devices

	Required adjacent channel separation distances in meters from edge of polygon	
	16 dBm (40 mW)	20 dBm (100 mW)
Communicating with Mode II or Fixed device	8	13
Communicating with Mode I device	16	26

(ii) Fixed white space devices, except that when communicating with Mode I personal/portable white space devices, the required separation distances must be increased beyond the specified distances by 8 meters if the Mode I device operates at power levels no more than 40 mW EIRP, or 13 meters if the Mode I device operates at power levels above 40 mW EIRP.

Required adjacent channel separation distances in meters from edge of polygon*					
16 dBm (40 mW)	20 dBm (100 mW)	24 dBm (250 mW)	28 dBm (625 mW)	32 dBm (1600 mW)	36 dBm (4 watts)
8	13	20	32	50	71

\* \* \* \* \*

8. Section 15.713 is amended by revising paragraph (a)(1) to read as follows:

**§ 15.713 White space database.**

(a) \* \* \*

(1) To determine and provide to a white space device, upon request, the available channels at the white space device's location in the TV bands, the 600 MHz duplex gap, the 600 MHz service band, and 608-614 MHz (channel 37). Available channels are determined based on the interference protection requirements in §15.712. A database must provide fixed and Mode II personal portable white space devices with channel availability information that includes scheduled changes in channel availability over the course of the 48-hour period beginning at the time the white space devices make a recheck contact. In making lists of available channels available to a white space device, the white space database shall ensure that all communications and interactions between the white space database and the white space device include adequate security measures such that unauthorized parties cannot access or alter the white space database or the list of available channels sent to white space devices or otherwise affect the database system or white space devices in performing their intended functions or in providing adequate interference protections to authorized services operating in the TV bands, the 600 MHz duplex gap, the 600 MHz service band, and 608-614 MHz (channel 37). In addition, a white space database must also verify that the FCC identifier (FCC ID) of a device seeking access to its services is valid; under this requirement the white space database must also verify that the FCC ID of a Mode I device provided by a fixed or Mode II device is valid. A list of devices with valid FCC IDs and the FCC IDs of those devices is to be obtained from the Commission's Equipment Authorization System.

\* \* \* \* \*

9. Section 15.714 is amended by revising paragraph (a) to read as follows:

**§ 15.714 White space database administration fees.**

(a) A white space database administrator may charge a fee for provision of lists of available channels to fixed and personal/portable devices and for registering fixed devices. This provision applies to devices that operate in the TV bands, the 600 MHz service band, the 600 MHz duplex gap, and 608-614 MHz (channel 37).

\* \* \* \* \*

10. The authority citation for part 95 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 303, 307.

11. Section 95.2309 is revised by adding a new paragraph (h) to read as follows:

**§ 95.2309 WMTS frequency coordination.**

\* \* \* \* \*

(h) To receive interference protection, parties operating WMTS networks in the 608-614 MHz frequency band shall notify one of the white space database administrators of their operating location pursuant to §§ 15.713(j)(11) and 15.715(p) of this chapter.

**Appendix B****List of Parties Filing Comments – ET Docket No. 16-56**Comments

1. Cohen et al.
2. GE Healthcare
3. Google Inc.
4. Harkirat Singh
5. Microsoft Corp.
6. National Association of Broadcasters (NAB)
7. Runcom Communications
8. Sennheiser Electronic Corp.
9. Spectrum Bridge
10. Wi-Fi Alliance
11. Wireless Internet Service Providers Association (WISPA)

Reply Comments

1. American Society for Healthcare Engineering of the American Hospital Association (ASHE)
2. Carlson Wireless Technologies/Koos Technical Services/Meld (Carlson et al.)
3. Microsoft Corp.
4. NAB
5. WISPA

**Appendix C****List of Parties Filing Petitions for Reconsideration – ET Docket No. 14-165**Petitions for Reconsideration

1. Audio-Technica U.S., Inc.
2. Carlson Wireless Technologies, Inc. and Cal.net, Inc.
3. GE Healthcare
4. Google, Inc.
5. Microsoft Corp.
6. National Association of Broadcasters
7. Sennheiser Electronic Corp.
8. Shure Incorporated
9. Wireless Internet Service Providers Association
10. WMTS Coalition

Oppositions to Petitions for Reconsideration

1. CTIA
2. GE Healthcare
3. Google, Inc.
4. Microsoft Corp.
5. National Association of Broadcasters
6. Sennheiser Electronic Corp.
7. Shure Incorporated
8. Wireless Internet Service Providers Association
9. WMTS Coalition

Replies to Oppositions to Petitions for Reconsideration

1. Audio-Technica U.S., Inc.
2. Carlson Wireless Technologies, Inc. and Cal.net, Inc.
3. GE Healthcare
4. Google, Inc.
5. Key Bridge LLC
6. Microsoft Corp.
7. National Association of Broadcasters
8. Sennheiser Electronic Corp.
9. Shure Incorporated
10. Theatre Communications Group and 11 Others
11. Wireless Internet Service Providers Association
12. WMTS Coalition

## Appendix D

### Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),<sup>221</sup> an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notices of Proposed Rule Making* (NPRMs) in ET Docket Nos. 14-165 and 16-56.<sup>222</sup> The Commission sought written public comment on the proposals in the *NPRMs*, including comment on the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.<sup>223</sup>

#### A. Need for, and Objectives of, the Report and Order and Order on Reconsideration

The Report and Order adopts new Part 15 rules to provide greater assurance of the accuracy of location data for fixed white space devices while providing flexibility in the methods used by devices to determine their location.

The Order on Reconsideration addresses petitions for reconsideration of certain rules the Commission adopted in ET Docket No. 14-165 to provide additional flexibility for the operation of white space devices in the television bands and the UHF television spectrum that is being repurposed for licensed wireless services (the “600 MHz Band”). It upholds the Commission’s previous decisions, with one exception. Specifically it increases the antenna height above ground limit for fixed white space devices in less congested areas where more vacant television channels are available.

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

There were no comments filed that specifically addressed the rules and policies proposed in the IRFA.

#### C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

Pursuant to the Small Business Jobs Act of 2010, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

#### D. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply

The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.<sup>224</sup> The RFA generally defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and “small governmental jurisdiction.”<sup>225</sup> In addition, the term “small business” has the

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<sup>221</sup> 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

<sup>222</sup> *Amendment of Part 15 of the Commission’s Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37*, Notice of Proposed Rulemaking, 29 FCC Rcd 12248 (2014) and *Amendment of Part 15 of the Commission’s Rules for Unlicensed White Space Devices*, Notice of Proposed Rulemaking and Order, 31 FCC Rcd 1657 (2016).

<sup>223</sup> *See* 5 U.S.C. § 604.

<sup>224</sup> *See* 5 U.S.C. § 603(b)(3).

<sup>225</sup> *See* 5 U.S.C. § 601(6).

same meaning as the term “small business concern” under the Small Business Act.<sup>226</sup> A “small business concern” is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).<sup>227</sup>

### **Radio and Television Broadcasting and Wireless Communications Equipment**

**Manufacturing.** This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.<sup>228</sup> In the context of this FRFA, manufacturers of Part 15 unlicensed devices that are operated in the UHF-television band (channels 14-51) for wireless data transfer fall into the category of Radio and Television and Wireless Communications Equipment Manufacturing. The Small Business Administration has established a size standard for this industry of 750 employees or less.<sup>229</sup> U.S. Census data for 2012 shows that 841 establishments operated in this industry in that year. Of that number, 828 establishments operated with fewer than 1,000 employees, 7 establishments operated with between 1,000 and 2,499 employees and 6 establishments operated with 2,500 or more employees.<sup>230</sup> Based on this data, we conclude that a majority of manufacturers in this industry is small.

**Television Broadcasting.** This Economic Census category “comprises establishments primarily engaged in broadcasting images together with sound.”<sup>231</sup> These establishments operate television broadcast studios and facilities for the programming and transmission of programs to the public.<sup>232</sup> These establishments also produce or transmit visual programming to affiliated broadcast television stations, which in turn broadcast the programs to the public on a predetermined schedule. Programming may originate in their own studio, from an affiliated network, or from external sources. The SBA has created the following small business size standard for such businesses: those having \$38.5 million or less in annual receipts.<sup>233</sup> The 2012 Economic Census reports that 751 firms in this category operated in that year. Of that number, 656 had annual receipts of \$25,000,000 or less, 25 had annual receipts between \$25,000,000 and \$49,999,999 and 70 had annual receipts of \$50,000,000 or more.<sup>234</sup> Based on this data

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<sup>226</sup> See 5 U.S.C. § 601(3) (incorporating by reference the definition of “small-business concern” in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies “unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register.”

<sup>227</sup> See 15 U.S.C. § 632.

<sup>228</sup> The NAICS Code for this service is 334220. 13 C.F.R. 121/201. See also [http://factfinder.census.gov/servlet/IBQTable?\\_bm=y&-fds\\_name=EC0700A1&-geo\\_id=&-skip=300&-ds\\_name=EC0731SG2&-lang=en](http://factfinder.census.gov/servlet/IBQTable?_bm=y&-fds_name=EC0700A1&-geo_id=&-skip=300&-ds_name=EC0731SG2&-lang=en).

<sup>229</sup> 13 CFR § 121.201, NAICS Code 334220.

<sup>230</sup>

[http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2012\\_US\\_31SG2&prodType=table](http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_31SG2&prodType=table)

<sup>231</sup> U.S. Census Bureau, 2012 NAICS Definitions, “515120 Television Broadcasting,” <http://www.census.gov/cgi-bin/sssd/naics/naicsrch>.

<sup>232</sup> U.S. Census Bureau, 2012 NAICS Definitions, “515120 Television Broadcasting,” <http://www.census.gov/cgi-bin/sssd/naics/naicsrch>

<sup>233</sup> 13 C.F.R. § 121.201; 2012 NAICS code 515120.

<sup>234</sup> U.S. Census Bureau, Table No. EC1251SSSZ4, *Information: Subject Series - Establishment and Firm Size: Receipts Size of Firms for the United States: 2012* (515120 Television Broadcasting).

we therefore estimate that the majority of commercial television broadcasters are small entities under the applicable SBA size standard.

The Commission has estimated the number of licensed commercial television stations to be 1,384.<sup>235</sup> Of this total, 1,264 stations (or about 91 percent) had revenues of \$38.5 million or less, according to Commission staff review of the BIA Kelsey Inc. Media Access Pro Television Database (BIA) on February 24, 2017, and therefore these licensees qualify as small entities under the SBA definition. In addition, the Commission has estimated the number of licensed noncommercial educational (NCE) television stations to be 394.<sup>236</sup> Notwithstanding, the Commission does not compile and otherwise does not have access to information on the revenue of NCE stations that would permit it to determine how many such stations would qualify as small entities.

We note, however, that in assessing whether a business concern qualifies as “small” under the above definition, business (control) affiliations<sup>237</sup> must be included. Our estimate, therefore likely overstates the number of small entities that might be affected by our action, because the revenue figure on which it is based does not include or aggregate revenues from affiliated companies. In addition, another element of the definition of “small business” requires that an entity not be dominant in its field of operation. We are unable at this time to define or quantify the criteria that would establish whether a specific television broadcast station is dominant in its field of operation. Accordingly, the estimate of small businesses to which rules may apply does not exclude any television station from the definition of a small business on this basis and is therefore possibly over-inclusive.

#### **E. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities**

White space devices are unlicensed devices that operate in the television bands or 600 MHz band at locations where frequencies are not in use by licensed services. These devices may be either fixed or portable. Fixed devices may operate at power levels up to four watts, or up to 10 watts in less congested areas. Portable devices operate at up to 100 milliwatts if they are outside the service contours of adjacent channel television stations or 40 milliwatts within the service contour of an adjacent channel television station. To prevent harmful interference to broadcast television stations and other protected users of these bands, white space devices must obtain a list of available channels that may be used at their location from databases administered by private entities selected by the Commission.

Most RF transmitting equipment, including white space devices, must be authorized through the certification procedure. Certification is an equipment authorization issued by a designated Telecommunication Certification Body based on an application and test data submitted by the responsible party (e.g., the manufacturer or importer). The Report and Order and Order on Reconsideration does not change the authorization procedure for white space devices. However, it modifies certain technical requirements for white space devices, and establishes cutoff dates for the certification and marketing of equipment that does not meet the modified requirements.

The Order on Reconsideration increases the maximum permissible antenna height above ground from 30 meters to 100 meters for fixed white space devices operating in less congested areas, i.e., those where at least half the television channels are vacant within a device’s band of operation. The Report and Order requires all fixed white space devices to incorporate a geo-location capability, such as GPS, and

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[https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2012\\_US\\_51SSSZ4&prodType=table](https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ4&prodType=table).

<sup>235</sup> *Broadcast Station Totals as of December 31, 2016*, Press Release (MB, rel. January 5, 2017) (*January 5, 2017 Broadcast Station Totals Press Release*), <https://www.fcc.gov/document/broadcast-station-totals-december-31-2016>.

<sup>236</sup> *January 5, 2017 Broadcast Station Totals Press Release*.

<sup>237</sup> “[Business concerns] are affiliates of each other when one concern controls or has the power to control the other or a third party or parties controls or has the power to control both.” 13 C.F.R. § 21.103(a)(1).

eliminates the option that permitted the geographic coordinates of a fixed device to be determined by a professional installer. It also allows the use of external geo-location sources by a fixed white space device when the device is used at a location where its internal geo-location capability does not function, such as deep within a building. In addition, it requires fixed white space devices to automatically re-check their geographic coordinates at least once a day and report the coordinates to the white space database. Fixed white space devices that are certified beginning six months after the effective date of the rules, or that are marketed beginning 18 months from the effective date of the rules, must comply with the new geo-location requirements.

**F. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered**

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): “(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rule for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities.”<sup>238</sup>

The increase in the maximum antenna height above ground level in less congested areas is permissive and will allow operators of white space devices greater flexibility in the locations where they can mount antennas (e.g., on taller towers or other existing structures). It will also allow for improved transmission range in locations where there are obstacles such as tall trees that could block the signal if the antenna is mounted at a lower height.

The requirements to incorporate a geo-location capability in all fixed white space devices will require manufacturers to make design changes to their equipment if it does not already incorporate such a capability. To reduce the compliance burden on manufacturers for implementing this requirement, we are providing a transition period of six months to make the required changes, and also allowing time to continue marketing previously approved and manufactured devices that do not incorporate the changes. In addition, to reduce the compliance burden on the users of white space devices, we will allow equipment that is marketed before the cutoff dates and that does not include a geo-location capability to be operated indefinitely.

**Report to Congress:** The Commission will send a copy of the Report and Order and Order on Reconsideration, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.<sup>239</sup> In addition, the Commission will send a copy of the Report and Order and Order on Reconsideration, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Report and Order and Order on Reconsideration and FRFA (or summaries thereof) will also be published in the Federal Register.<sup>240</sup>

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<sup>238</sup> See 5 U.S.C. § 603(c)(1) – (c)(4).

<sup>239</sup> See 5 U.S.C. § 801(a)(1)(A).

<sup>240</sup> See 5 U.S.C. § 604(b).