

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

In the Matter of	)	
	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268
	)	
Office of Engineering and Technology Releases and Seeks Comment on Updated OET-69 Software	)	ET Docket No. 13-26
	)	
Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services	)	ET Docket No. 14-14
	)	

**THIRD REPORT AND ORDER AND FIRST ORDER ON RECONSIDERATION**

**Adopted: October 21, 2015**

**Released: October 26, 2015**

**By the Commission:** Commissioner Pai approving in part, concurring in part, and issuing a separate statement; Commissioner O’Rielly concurring and issuing a separate statement.

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## I. INTRODUCTION

1. In this Order we resolve the remaining technical issues affecting the operation of new 600 MHz wireless licensees and broadcast television stations<sup>1</sup> in areas where they operate on the same or adjacent channels in geographic proximity. Specifically, we adopt the methodology and the regulatory framework for the protection of both wireless services and broadcasting in the post-auction environment that we proposed in October 2014.<sup>2</sup> We affirm our decision regarding the methodology to be used during the incentive auction to predict inter-service interference between broadcasting and wireless services. We also affirm our decision declining to adopt a cap on the aggregate amount of new interference a broadcast television station may receive from other television stations in the repacking process.

## II. THIRD REPORT AND ORDER

2. In the *Incentive Auction R&O*, we adopted a flexible band plan framework that accommodates market variation, that is, areas where broadcast stations are assigned to channels in the 600 MHz Band.<sup>3</sup> Because the amount of spectrum repurposed through the incentive auction and the repacking

<sup>1</sup> The terms “broadcast television,” “broadcast television station,” or “television station” as used in this item are limited to full power television stations and Class A television stations that are eligible for protection in the repacking process associated with the incentive auction.

<sup>2</sup> *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, ET Docket No. 13-26, ET Docket No. 14-14, Second Report and Order and Further Notice of Proposed Rulemaking, 29 FCC Rcd 13071 (2014) (*ISIX R&O/FNPRM or ISIX R&O or ISIX Further Notice*).

<sup>3</sup> *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6567, 6604-07, paras. 81-87 (2014) (*Incentive Auction R&O*) (discussing how the 600 MHz Band Plan can accommodate market variation to avoid restricting the amount of repurposed

(continued....)

process depends on broadcaster participation and other factors, market variation will allow the Commission to avoid limiting the amount of spectrum repurposed across the nation to what is available in the most constrained market.<sup>4</sup> However, market variation creates the potential for inter-service interference (“ISIX”) because in markets where broadcast television stations are assigned to channels within the 600 MHz Band, television and wireless services will be operating in close geographic proximity on the same and/or adjacent frequencies.<sup>5</sup> There are four scenarios of potential interference when broadcast television and wireless operations are co-channel or on adjacent channels in nearby areas: (1) a digital television (“DTV”) transmitter causing interference to a wireless base station (Case 1); (2) a DTV transmitter causing interference to wireless user equipment (Case 2); (3) a wireless base station causing interference to a DTV receiver (Case 3); and (4) wireless user equipment causing interference to a DTV receiver (Case 4).<sup>6</sup>

3. In the October 2014 *ISIX R&O*, the Commission addressed potential interference between DTV stations and wireless service in areas with market variation.<sup>7</sup> The *ISIX R&O* adopted a methodology for predicting inter-service interference during the incentive auction (“ISIX Methodology”),<sup>8</sup> a methodology which necessarily is based on hypothetical 600 MHz Band network deployments, as the actual networks will not be deployed until after the auction.<sup>9</sup> The companion *ISIX Further Notice* proposed a post-auction inter-service interference methodology for evaluating interference from wireless base stations to television reception, set forth in the Office of Engineering and Technology Bulletin No. 74 (“OET-74”). The *ISIX Further Notice* also proposed rules for preventing interference from wireless to broadcasting services on the same or adjacent channels in nearby markets in the Cases 3 and 4 above.

4. In this *Third Report and Order*, we adopt the framework we proposed in the *ISIX Further Notice* to govern the interference environment in the 600 MHz Band where market variation results in

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spectrum that is available in most areas nationwide). See also *Procedures For Competitive Bidding in Auction 1000, Including Initial Clearing Target Determination, Qualifying to Bid, and Bidding in Auctions 1001 (Reverse) and 1002 (Forward)*, Public Notice, AU Docket No. 14-252, GN Docket No. 12-268, 30 FCC Rcd 8975, 8981-82, para. 7 (2015) (*Bidding Procedures PN*).

<sup>4</sup> The amount of spectrum recovered along the Canadian and Mexican borders and in some markets may vary from that recovered in most markets nationwide.

<sup>5</sup> Broadcast stations may be assigned to channels in the uplink, downlink, and/or guard band (including the duplex gap) portions of the 600 MHz Band in order to accommodate market variation. See *Bidding Procedures PN*, 30 FCC Rcd at 8990-93, paras. 25-35. See also *Incentive Auction R&O*, 29 FCC Rcd at 6605, para 82; *Comment Sought on Competitive Bidding Procedures for Broadcast Incentive Auction 1000, Including Auctions 1001 and 1002*, AC Docket No. 14-252, GN Docket No. 12-268, Public Notice, 29 FCC Rcd 15750, 15765, para. 35 (2014).

<sup>6</sup> *ISIX R&O*, 29 FCC Rcd at 13086, para. 30. Areas where potential interference between wireless operators and broadcast television operations are called “impairments.” Impaired license areas may include “infringed” and/or “restricted” areas. An infringed area is one where wireless operation is predicted to receive harmful interference from a television station that is placed in the 600 MHz Band (Cases 1 and 2). Wireless licensees will be free to operate in infringed areas, but will assume the risk of receiving interference from a television station. A “restricted” area is one where wireless operations would be predicted to cause harmful interference to the reception of a signal from a television station that is assigned to the 600 MHz Band, depending on how wireless operations are deployed (Cases 3 and 4). See *ISIX R&O*, 29 FCC Rcd at 13083, para. 23.

<sup>7</sup> *ISIX R&O/FNPRM*, 29 FCC Rcd 13071; *Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services*, Public Notice, 29 FCC Rcd 712, 715, 713-15 (2014) (*ISIX PN*).

<sup>8</sup> The ISIX Methodology is described in Appendix D.

<sup>9</sup> Forward auction bidders will be given information on DTV stations in the 600 MHz band from which they may determine impairments for particular 600 MHz wireless licenses before the start of the forward auction clock phase. See *Bidding Procedures PN*, 30 FCC Rcd at 9043-46, paras. 134-136.

wireless operations and television stations operating on the same or adjacent channels in nearby areas.<sup>10</sup> First, we establish a zero percent threshold for allowable harmful interference from 600 MHz wireless services to television stations assigned to channels in the 600 MHz Band. Second, we adopt with certain modifications the methodology proposed in OET-74 for predicting interference from wireless base stations to television receivers after the incentive auction. Third, we require 600 MHz wireless licensees to use OET-74 to predict potential interference to nearby co-channel or adjacent-channel television operations before deploying base stations, prohibit operation of wireless user equipment operating in the 600 MHz Band near these television stations' contours, and prohibit the expansion of television stations' contours that would result in additional impairments to wireless operations.<sup>11</sup> We also address the applicability of the ISIX Methodology in other interference contexts, including between LPTV and TV translators and wireless operations, between television and wireless operations during the post-transition period, and in identifying impairments to wireless licenses along the borders with Canada and Mexico.

#### A. Protecting Broadcast Television Receivers from Inter-Service Interference

5. In this section, we adopt the framework for the protection of the reception of signals of full power and Class A television stations assigned to the 600 MHz Band from harmful interference caused by wireless operations in the same or adjacent channels in nearby areas. There are three scenarios that present the potential for harmful interference to television receivers, depending on whether a station is assigned to the downlink, uplink, or duplex gap portion of the 600 MHz Band spectrum: (1) if a television station is in the downlink spectrum, there is a potential for harmful interference from wireless base stations to nearby TV receivers (Case 3); (2) if a television station is in the uplink spectrum, there is a potential for harmful interference from wireless user equipment to nearby TV receivers (Case 4); and (3) if the television station is in the duplex gap spectrum, there is a potential for harmful interference from both wireless user equipment and wireless base stations to TV receivers in nearby areas (Cases 3 and 4).<sup>12</sup> Below, we begin by adopting a zero percent threshold of allowable interference from wireless operations to the reception of television station's signals that are co-channel or adjacent channel for both Cases 3 and 4. For Case 3, we adopt the methodology of OET-74, with certain modifications from the proposal in the *ISIX Further Notice*, for use in predicting potential interference from wireless base stations to television receivers. For Case 4, we adopt small separation distances between television station contours and wireless user equipment operating on the 600 MHz Band, beyond which the equipment can operate without causing interference to television receivers. We then set forth the obligations wireless licensees

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<sup>10</sup> We dismiss NAB's suggestion that we abandon market variation as a late-filed Petition for Reconsideration of the *Incentive Auction R&O*. See NAB Comments at 2-4. The deadline for filing a Petition for Reconsideration of the *Incentive Auction R&O*, in which the Commission adopted a 600 MHz Band Plan that can accommodate market variation, *Incentive Auction R&O*, 29 FCC Rcd at 6605, para. 82, was September 15, 2014. 47 U.S.C. § 405(a); 47 C.F.R. § 1.429(d). See also 47 C.F.R. § 1.4(b)(1); 79 FR 48442 (Aug. 15, 2014). NAB did not seek reconsideration of the *Incentive Auction R&O*, nor has it attempted to demonstrate extraordinary circumstances that might justify a waiver. See *Reuters Ltd. v. FCC*, 781 F.2d 946, 951-52 (D.C. Cir. 1986). In any event, in the *Second Order on Reconsideration*, we considered and denied timely-filed Petitions for Reconsideration of the decision in the *Incentive Auction R&O* to accommodate market variation. See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Second Order on Reconsideration, 30 FCC Rcd 6746, 6748-6750, paras. 6-8 (2015) (*Second Order on Reconsideration*).

<sup>11</sup> By "contour" we mean either the "noise-limited contour" for full power television stations or "protected contour" for Class A television stations. See 47 C.F.R. §§ 73.622(e), 73.6010.

<sup>12</sup> *ISIX R&O*, 29 FCC Rcd. at 13086, para. 31. Both CEA and NAB raised issues regarding how the Commission should decide where to place broadcast television stations in the 600 MHz Band (*i.e.*, in the uplink, downlink, or the guard bands, including the duplex gap). CEA Comments at 19-21; NAB Reply at 8. The Commission addressed this issue in the recent *Bidding Procedures Public Notice*. *Bidding Procedures PN*, 30 FCC Rcd at 8990-99, paras. 25-35. NAB filed a petition seeking reconsideration of the *Bidding Procedures PN* and our decision to allow television stations to be located in the duplex gap as necessary to accommodate market variation. See NAB Petition at 2-5.

will have post-auction to ensure that the reception of television stations assigned to the 600 MHz Band is protected from inter-service interference that may be caused by wireless operations in the same or adjacent channels.

**1. Threshold for Interference from Wireless Operations to Television Receivers in the 600 MHz Band.**

6. We adopt a zero percent threshold for harmful interference from wireless operations to the reception of television station's signals in the 600 MHz Band, as proposed in the *ISIX Further Notice*.<sup>13</sup> Under this standard, 600 MHz wireless licensees will not be permitted to cause harmful interference at any level within the noise-limited contour of a full power television station or the protected contour of a Class A television station to the degree it affects populated areas within those contours.<sup>14</sup> We find that a zero percent threshold, with no rounding tolerance, as supported by NAB, is warranted in the post-auction environment.<sup>15</sup> For the reasons discussed below, any interference standard other than zero presents practical difficulties given the multiple sources of potential interference to the reception of signals from television stations assigned to the 600 MHz Band and the continuing evolution of wireless networks.

7. In the television bands, the sources of potential interference are limited because the six-megahertz television channels are aligned and only a limited number of other television stations operate co-channel or adjacent channel in a particular area. Moreover, television stations operate at fixed locations and at power levels, antenna heights, and with antenna patterns that do not change frequently. For these reasons, the 0.5 percent *de minimis* interference threshold for station-to-station interference in the television bands permitted under our rules is practical to implement and enforce.<sup>16</sup> In contrast, there will be numerous sources of potential interference to the reception of signals from television stations assigned to the 600 MHz Band because the five-megahertz wireless spectrum blocks will overlap in varying degrees with the six-megahertz television channels, creating the potential for multiple co- and adjacent-channel relationships between television stations and wireless operations in the same or nearby geographic areas. Moreover, wireless networks evolve over time with the deployment of additional base stations and the adjustment of base stations' technical parameters. Addressing the possibility of a television receiver receiving interference from multiple wireless networks that are continuously evolving presents significant practical difficulties, such as how to apportion the permitted interference among the multiple sources of interference and how to monitor compliance as wireless networks evolve.<sup>17</sup> Our decision to adopt a zero percent harmful interference limit – more stringent than the interference threshold for the TV bands – will ensure protection for broadcasters operating in the interference environment in the 600 MHz Band.

8. We reject CTIA's request that we establish an interference threshold above zero percent. Given the different interference environment that television stations will face in the 600 MHz Band, we

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<sup>13</sup> See *ISIX Further Notice*, 29 FCC Rcd at 13106, para. 65.

<sup>14</sup> We delegate authority to the Media Bureau to issue a Public Notice following completion of the incentive auction with the final contours of all television stations assigned to channels in the 600 MHz Band. The Public Notice will include the technical parameters by which the television station contours can be generated regardless of whether the station will remain on its pre-auction channel or has been reassigned to new a channel.

<sup>15</sup> NAB Comments at 4-5.

<sup>16</sup> See 47 C.F.R. § 73.616(e).

<sup>17</sup> Determining how to fairly apportion permitted interference among multiple wireless licensees would be difficult considering the different degrees of spectrum overlap and the location of the different 600 MHz Band PEAs in relation to a television station. Once the permitted interference from each wireless licensee is determined, verifying that the total aggregate interference meets the limit would be impractical considering the multiple potential sources of interference.

find that it would be impractical, if not infeasible, to manage any interference percentage other than zero percent. CTIA argues that the zero percent threshold is “impractical, overly conservative and inconsistent with Commission’s past treatment of interference issues.”<sup>18</sup> CTIA also contends that “given that the impact on a broadcast licensee is the same regardless of the source of interference, the Commission has not adequately justified the need for a zero percent interference threshold, and it is not appropriate given the significant burden such a standard would place on new wireless entrants in the 600 MHz band.”<sup>19</sup> Even though the impact of the interference on a television receiver may be the same regardless of whether the source is another television station or a wireless system, the interference environment in the 600 MHz Band is fundamentally different than that of the television band. For the reasons explained above, allowing any amount of interference above zero percent would not be feasible or practical to implement and enforce in the 600 MHz Band.<sup>20</sup>

9. We disagree with CTIA that adopting a zero percent threshold will negatively impact the incentive auction and post-auction wireless deployment because the standard will necessitate more 600 MHz spectrum to be labeled “impaired.”<sup>21</sup> The overall amount of potential inter-service interference will be strictly limited by the procedures we established in the *Bidding Procedures PN*, and bidders will receive detailed information about the potential for such interference.<sup>22</sup> Based on that information, bidders will be able to use the methodology of OET-74 to predict the potential for inter-service interference based on their actual network architecture.<sup>23</sup> Where there is a potential for inter-service interference, 600 MHz wireless licensees can configure their networks to avoid interference to broadcast operations through the use of directional antennas, antenna downtilt and other mitigation techniques. Establishing rules for the incentive auction and the post-auction environment requires us to balance a number of competing goals and interests, and we conclude that the zero percent threshold we adopt is necessary and appropriate for the reasons described above.

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<sup>18</sup> CTIA Comments at 5. CTIA argues that the long-standing 0.5 percent interference threshold for “pairwise” interference between two television stations has not led to the degradation of over the air viewing of TV signals and that “the same level of signals from 600 MHz systems into a TV band would similarly not adversely affect the reception by over the air viewers.” CTIA Comments at 5-7.

<sup>19</sup> CTIA Comments at 6-7. CTIA further claims that a zero percent threshold will negatively impact wireless deployment, and will place significant burden on new wireless entrants in the 600 MHz Band because it may restrict where base stations are deployed. *Id.* at 6.

<sup>20</sup> CTIA also argues that a zero percent threshold if applied throughout the 600 MHz Band “would very likely preclude unlicensed White Space Devices and wireless microphone usage that the Commission is considering in other incentive auction-related proceedings.” *Id.* Under the Commission’s existing rules, however, white space devices and wireless microphones are not permitted to cause any harmful interference to licensed services. 47 C.F.R. §§ 15.5(b), 15.15(c), 73.861(g); *Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band*, WT Docket Nos. 08-166, 08-167, WT Docket No. 10-24, Report and Order and Further Notice of Proposed Rulemaking, 25 FCC Rcd 643, 683, para. 82 (2010). We recently addressed the operation of unlicensed white space devices and wireless microphones in the 600 MHz Band and affirmed that, although harmful interference to licensed services is extremely unlikely, the Part 15 rules require unlicensed devices to eliminate interference or cease operations. *See generally Amendment of Part 15 of the Commission’s Rules for Unlicensed Operation in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, ET Docket No. 14-165, GN Docket No. 12-268, Report and Order, 30 FCC Rcd 9551, 9604-05, para. 132 (2015).

<sup>21</sup> CTIA Comments at 6.

<sup>22</sup> *See Bidding Procedures PN*, 30 FCC Rcd at 8986-99, 9043-44, paras. 17-35, 134 (discussing how the optimization tool will minimize impaired weighted pops and listing the information to be made available to forward auction qualified bidders).

<sup>23</sup> *See infra* para. 12.

10. NAB supports a zero percent threshold but seeks clarification that the limit of predicted interference is “zero persons” rather than some fraction of the population that rounds to zero.<sup>24</sup> We clarify that the zero-percent interference threshold we are adopting will prohibit 600 MHz wireless licensees from causing any interference to television receivers in any populated area of the noise-limited contour of a full power television station or the protected contour of a Class A television station.

11. As proposed in the *ISIX Further Notice*, we adopt our proposal to treat interference between television stations assigned in the 600 MHz Band as “masking interference” in evaluating wireless interference to a television station.<sup>25</sup> Therefore, in a grid cell where masking interference to one television station from another television station is predicted, inter-service interference from wireless operations can be ignored. This is consistent with the treatment of interference between television stations under our rules.<sup>26</sup>

## **2. Determining Potential Interference from Wireless Operations to DTV Receivers**

### **a. Case 3: Interference to Television Receivers from Wireless Base Stations**

12. *Adoption of OET-74.* We adopt OET-74 as proposed in the *ISIX Further Notice*, with several modifications as described in more detail below. OET-74 is to be used following the incentive auction to predict interference to television receivers operating in the 600 MHz Band from co-channel and adjacent channel wireless base stations in nearby markets. OET-74 uses the ISIX Methodology that we established for identifying interference to DTV receivers from wireless base stations during the incentive auction, but with modifications to use actual, rather than hypothetical, base station parameters.<sup>27</sup> OET-74 uses the Longley-Rice propagation model which has long been used by the Commission to predict interference to television receivers. Additionally, the OET-74 methodology is supported by measurements showing that wireless LTE signals have similar interference characteristics to DTV signals.<sup>28</sup> The adopted OET-74 Bulletin is included in Appendix C.

13. We reject NAB’s claim that the Spectrum Act limits our authority to require the use of OET-74 to address inter-service interference following the auction.<sup>29</sup> NAB states that interference, regardless of its source, affects the population served for television broadcasters and that the Commission is required pursuant to Section 6402(b)(2) of the Spectrum Act, as codified in 47 U.S.C. §1452(b)(2), to use OET-69, not OET-74, to preserve the coverage area and population served when reassigning television stations.<sup>30</sup> As we explained in the *Second Order on Reconsideration of the Incentive Auction*

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<sup>24</sup> NAB Comments at 4-5. CTIA objects to NAB’s request as an unreasonable proposal and contends that it will undermine the auction’s success. CTIA Reply at 3-4. We disagree with CTIA for the reasons discussed above.

<sup>25</sup> *ISIX R&O*, 29 FCC Rcd at 13107, para. 67. We received no comments addressing masking interference.

<sup>26</sup> See 47 C.F.R. § 73.616(e).

<sup>27</sup> *ISIX R&O*, 29 FCC Rcd at 13107-108, paras. 69-72.

<sup>28</sup> *ISIX R&O*, 29 FCC Rcd at 13093, 13097, paras. 43, 49; see *Office of Engineering and Technology Seeks Comment on Measurements of LTE into DTV Interference*, GN Docket No. 12-268, ET Docket No. 14-14, Public Notice, 29 FCC Rcd 7415, 7433 (2014) (“OET Measurements Report”).

<sup>29</sup> NAB Comments at 8. Section 1452(b)(2) requires the Commission, in “making any reassignments or reallocations,” to “make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served of each broadcast television licensee, as determined using the methodology described in OET Bulletin 69 . . . .” 47 U.S.C. § 1452(b)(2).

<sup>30</sup> NAB Comments at 8.

R&O,<sup>31</sup> Section 1452(b)(2) applies “[i]n making any reassignments or reallocations” under Section 1452(b)(1)(B).<sup>32</sup> “Reassignments and reallocations” will be made during the repacking process, and become effective after the completion of the reverse auction and the forward auction, specifically upon release of the *Channel Reassignment PN*.<sup>33</sup> OET-74 will be used after the completion of the auction to predict potential interference from wireless service to the reception of television stations’ signal whose coverage areas and populations served have already been determined using the methodology described in OET-69, as required by Section 1452(b)(2).<sup>34</sup> Thus, our post-auction efforts to protect broadcasters from inter-service interference, including through use of OET-74, are not restricted by Section 1452(b)(2)’s reference to “the methodology described in OET Bulletin 69.”<sup>35</sup>

14. *D/U Ratio Adjustment.* We adopt slightly revised desired/undesired (D/U) ratio thresholds from those proposed in the *ISIX Further Notice*. Under the methodology of OET-74, the D/U ratio is calculated at the population centroid in each two kilometer square cell in the television station’s contour. This D/U ratio is compared to a threshold to determine if harmful interference is predicted to occur to DTV service in that cell.<sup>36</sup> The D/U threshold is defined in OET-74 to include an adjustment factor “ $\alpha$ ,” which is dependent on the signal-to-noise ratio (S/N ratio) of the received television signal.<sup>37</sup> The “ $\alpha$ ” factor in the D/U threshold is necessary to account for the effect of the television signal strength on the amount of interference that the television receiver can tolerate when the desired DTV signal is weak. When the television signal strength is weak (*i.e.*, closer to the noise floor), a lower amount of interference from the wireless base stations will impede television reception than if the television signal is

<sup>31</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Second Order on Reconsideration, 30 FCC Rcd 6746, 6823, para. 175 (2012).

<sup>32</sup> 47 U.S.C. § 1452(b)(2).

<sup>33</sup> 47 U.S.C. § 1452(f)(2); *Incentive Auction R&O*, 29 FCC Rcd at 6783-84, para. 529.

<sup>34</sup> See *ISIX R&O*, 29 FCC Rcd at 13103-04, paras. 59-60. See also *Incentive Auction R&O*, 29 FCC Rcd at 6575, 6621-6625, paras. 19, 119-26. OET-69 is available at [https://transition.fcc.gov/Bureaus/Engineering\\_Technology/Documents/bulletins/oet69/oet69.pdf](https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet69/oet69.pdf).

<sup>35</sup> As discussed in detail below, we do not expect third order intermodulation interference (“IM3”) to present a significant interference concern for reception of DTV stations and IM3 is not addressed in the Commission’s rules or in the methodology described in OET-69. See *infra* paras. 20-23. Therefore, we reject the claim of the Block Stations that failing to study IM3 further violates the Spectrum Act. See *Block Stations Reply* at 2-4. See also 47 U.S.C. § 1452(b)(2) (requiring the Commission, in “making any reassignments or reallocations,” to “make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served of each broadcast television licensee, as determined using the methodology described in OET Bulletin 69 . . .”).

<sup>36</sup> The D/U thresholds in the proposed OET-74 Bulletin are identical to the D/U thresholds used in the ISIX Methodology. *ISIX R&O*, 29 FCC Rcd at 13093, para. 43. In the ISIX Methodology, the D/U threshold for co-channel LTE-to-DTV signals was increased by one decibel from the DTV-to-DTV co-channel D/U threshold specified in OET-69. That was because measurements indicated that LTE equipment causes slightly more interference to DTV signals than other DTV signals. See *ISIX PN*, 29 FCC Rcd at 724. See also *ISIX R&O*, 29 FCC Rcd at 13093, para. 43. In addition, the ISIX Methodology adjusted the D/U threshold based on the amount of spectral overlap between the wireless and television signals. However, the one decibel threshold adjustment was not applied when there was no spectral overlap between the television and wireless signals. *ISIX R&O*, 29 FCC Rcd at 13151-52, App. E (Proposed OET-74 Bulletin).

<sup>37</sup> The adjustment factor “ $\alpha$ ” is defined by the following equation:  $\alpha = 10 \left[ \log_{10} \left[ \frac{1}{1 - \left( \frac{S}{N} \right)^{-10}} \right] \right]$  where  $x$

= S/N – 15.19 dB. See *ISIX R&O*, 29 FCC Rcd at 13151, App. E. The adjustment factor  $\alpha$  is an adjustment to the co-channel D/U ratio for DTV-to-DTV interference in the Part 73 rules for broadcast digital television service, see 47 C.F.R. § 73.623(c)(3)(i).

stronger.

15. The “ $\alpha$ ” adjustment factor for the D/U threshold proposed in the *ISIX Further Notice* is based on the equation for the co-channel DTV-to-DTV interference threshold in OET-69 and in section 73.616(e)(1)(i) of our rules.<sup>38</sup> The proposed “ $\alpha$ ” adjustment factor, however, differs from OET-69 and our rules in one respect. In both OET-69 and our rules, the adjustment factor “ $\alpha$ ” is not used when the television signal strength approaches its service threshold (very low S/N ratios).<sup>39</sup> Instead, the D/U threshold is set for a maximum of 23 dB when the S/N of the television signal is very low. In contrast, the proposed OET-74 Bulletin would use the equation from OET-69 and our rules to determine the D/U threshold even as the DTV signal strength decreases below the level that defines the edge of service. CEA points out that for faint television signals, “ $\alpha$ ” increases exponentially under this proposal, which can result in a high D/U threshold that will require a large separation distance between wireless base stations and the television station’s contour.<sup>40</sup>

16. To avoid such results and to conform OET-74 with the approach used in OET-69 and our rules, OET-74 as adopted will similarly limit the use of the D/U adjustment factor “ $\alpha$ ” to situations where the signal-to-noise ratio of the desired DTV signal is greater than 16 dB and less than 28 dB. Because we have increased the D/U threshold by 1 dB to compensate for the difference in interference from an LTE signal compared with a DTV signal,<sup>41</sup> OET-74 as adopted will limit the co-channel D/U threshold to 24 dB when the LTE signal completely overlaps the DTV signal and adjust the D/U thresholds for smaller spectral overlaps accordingly. Specifically, the “ $\alpha$ ” factor will be limited to a maximum value of 8.<sup>42</sup>

17. In addition, we remove the “ $\alpha$ ” factor in the D/U threshold in OET-74 as adopted when there is no overlap between the DTV signal and LTE signal (adjacent channel) in order to be consistent with the approach followed in our rules for DTV-to-DTV interference.<sup>43</sup> Our rules specify a constant D/U threshold for DTV-to-DTV adjacent channel interference.<sup>44</sup> Consequently, we will not use a D/U threshold that varies with “ $\alpha$ ” for adjacent channel LTE-to-DTV interference. Also, we set the required D/U threshold for LTE-to-DTV interference to -33 dB because the ATSC receiver guidelines specify that DTV receivers should have this level of tolerance of adjacent channel DTV interference,<sup>45</sup> and measurements have shown that actual DTV receivers do in fact meet or exceed this level of performance

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<sup>38</sup> See 47 C.F.R. § 73.616(e)(1)(i).

<sup>39</sup> The *ISIX PN* acknowledged that the equation for the DTV-to-DTV co-channel D/U ratios specified in our rules is only valid when the S/N is between 16 dB and 28 dB and that the D/U ratio at a S/N of 16 dB is 23 dB. *ISIX PN*, 29 FCC Rcd at 732. However, it was not considered when the *ISIX Methodology* was adopted.

<sup>40</sup> CEA Comments at 16-19; CTIA Reply at 7-8 (CTIA echoes CEA’s request to examine the “ $\alpha$ ” factor and how it is used to determine separation distances).

<sup>41</sup> See *supra* n.36.

<sup>42</sup> The maximum value of the “ $\alpha$ ” factor is derived in accordance with the formula in OET-74 by subtracting 16 dB (15 dB is the threshold level, per our rules, where co-channel interference is considered to occur in the DTV-to-DTV scenario plus 1 dB per our discussion above to compensate for the difference in interference from an LTE signal, see *supra* n.36) from the co-channel D/U threshold of 24 dB. See *infra* Table 1; see *infra* App. C (OET-74).

<sup>43</sup> The proposed OET-74 specified a D/U threshold of ‘ $\alpha-2$ ’ for a wireless signal immediately adjacent to a DTV signal and ‘ $\alpha-18$ ’ for adjacent channel signals that are 1 to 5 MHz away from the DTV signal to match the D/U thresholds we adopted in the *ISIX R&O*. See *ISIX R&O*, 29 FCC Rcd at 13153, App. E (Proposed OET-74).

<sup>44</sup> 47 C.F.R. § 73.623(c)(2). The D/U threshold for interference from the first adjacent channel below the television signal is -28 dB and for the first adjacent channel above the television signal is -26 dB.

<sup>45</sup> ATSC Recommended Practice: Receiver Performance Guidelines, April 7, 2010, at 15, available at [http://atsc.org/wp-content/uploads/2015/03/Receiver-Performance-Guidelines.pdf?zoom\\_highlight=a+74](http://atsc.org/wp-content/uploads/2015/03/Receiver-Performance-Guidelines.pdf?zoom_highlight=a+74).

in the presence of adjacent channel LTE interference.<sup>46</sup>

18. The D/U thresholds in OET-74 as adopted are shown below in Table 1.<sup>47</sup>

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5
Downlink to DTV D/U Required (dB)	$16 + \alpha$	$15.1 + \alpha$	$13.8 + \alpha$	$12.1 + \alpha$	$9.3 + \alpha$	-33	-33

Table 1. OET-74 D/U Thresholds for interference from Wireless Base Station into DTV

19. *Aggregate Interference.* As proposed in the *ISIX Further Notice*, OET-74 will incorporate the root sum square (RSS) method to predict the potential for aggregate interference to television receivers from multiple base stations for each co-channel or adjacent channel 600 MHz licensee.<sup>48</sup> Broadcasters expressed concerns about the potential interference from combined interfering LTE signals at the point of DTV reception.<sup>49</sup> Although we declined to consider aggregate wireless interference into DTV in the ISIX Methodology to be used during the auction, we find that the RSS method is appropriate in the post-auction environment.<sup>50</sup> The methodology of OET-74, which is based on real-world network deployments, will allow for the aggregation of the field strength of interfering signals at the DTV receiver from the wireless base stations of a co-channel or adjacent channel 600 MHz wireless licensee. We will not, however, require a 600 MHz wireless licensee to account for the aggregate interference generated by the wireless operations of other 600 MHz wireless licensees because it would require wireless licensees to incorporate each other's site-specific information into their OET-74 analysis.

20. *Intermodulation Interference.* We reject arguments that we should study further the impact of third order intermodulation interference (IM3) from wireless services and television signals to

<sup>46</sup> See *OET Measurements Report*, 29 FCC Rcd at 7433; Letter from J. Kearney, CEA to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 14-14, at 95-100 (filed May 22, 2014) (*CEA Report*); see also *Request by LoJack Corporation for a Waiver of Part 90.20 and Part 2 of the Commission's Rules*, WT Docket No. 06-142, Declaratory Ruling and Order, 26 FCC Rcd 12991, 12999, para. 18 (2011) (noting that the D/U threshold ratio for lower adjacent DTV signals into a DTV receiver has been measured to be about -33 dB, citing *Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006*, OET Report FCC/OET 07-TR-1003, Technical Research Branch, Laboratory Division, Office of Engineering and Technology, Federal Communications Commission at A-2 (Mar. 30, 2007)). See also *Applications of Avista Corporation*, Order, 27 FCC Rcd 263, 266, para. 6 (WTB 2012).

<sup>47</sup> Table 4 and equation 1 of OET-74 have been updated to reflect that no off-frequency rejection (OFR) is specified for spectral overlaps of 0 to -5 MHz, because where there is no spectral overlap the D/U threshold is a constant rather than a function of the " $\alpha$ " adjustment factor or of the frequency gap between the DTV and wireless signals. In addition, we have updated the culling distances in Tables 7-12 to correct the inadvertent failure to account for the one decibel adjustment in the D/U threshold to compensate for the difference in how interference caused by an LTE signal affects DTV reception compared to interference from another DTV signal. See *supra* n. 36. The updated tables also reflect that no OFR is applied for spectral overlaps between 0 to -5 MHz. The culling distances are now calculated as the distance to the UHF F(50,10) {OFR (dB) + 17dB $\mu$ V/m} contour for co-channel signals and the UHF F(50,10){74 dB $\mu$ V/m} contour for adjacent channel signals. See *infra* App. C.

<sup>48</sup> *ISIX Further Notice*, 29 FCC Rcd at 13108, para. 70; see *infra* App. C (OET-74) § IV.B.

<sup>49</sup> See, e.g., SBE IA Comments at 6; Joint Broadcasters IA Comments at 15-18; see also NAB Comments at 6 ("it is vital to consider aggregate interference from multiple base-stations given the real-world density of carrier deployments.").

<sup>50</sup> We declined to consider aggregate wireless interference to DTV in the *ISIX R&O* because the ISIX Methodology relied on a hypothetical placement of wireless base stations every ten kilometers without regard to whether those locations are desirable or even possible for use. *ISIX R&O*, 29 FCC Rcd at 13101-02, para. 55.

television receivers.<sup>51</sup> In the *ISIX R&O*, the Commission rejected requests to account for intermodulation effects in the *ISIX* Methodology for predicting inter-service interference during the incentive auction.<sup>52</sup> CEA, however, claims that tests it conducted indicate that IM3 interference from LTE and DTV operations into DTV receivers poses a substantial risk to DTV reception, not only for legacy receivers currently in the market but also for future receivers that may need to continue receiving frequencies also used for LTE operations due to market variation.<sup>53</sup> CEA further argues that IM3 from two LTE signals is a distinct potential problem in the 600 MHz Band that has not been adequately analyzed.<sup>54</sup> CTIA does not share CEA's position and submits that "case-by-case resolution of any intermodulation interference events would be more practical than adding such considerations to the inter-service interference methodology."<sup>55</sup>

21. Based on the present record, further analysis of intermodulation effects, either from DTV and LTE signals or two LTE signals, is not warranted. We are not aware of any intermodulation interference concerns between DTV stations, which currently do not have to protect for intermodulation interference.<sup>56</sup> In coming to the decision to not address intermodulation effects in the DTV rules, one of

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<sup>51</sup> See CEA Comments at 3-19. See also Cohen, Dippell and Everist, P.C. ("CDE") Reply at 2-3; Block Stations Reply at 3; NAB Reply at 5-7.

<sup>52</sup> *ISIX R&O*, 29 FCC Rcd at 13095, para. 46 (explaining that the Commission's rules governing DTV-to-DTV interference do not address intermodulation, yet there is no evidence that the rules fail to adequately protect DTV signals, and equipment manufacturers are aware of the potential for intermodulation and are expected to consider it when designing receivers).

<sup>53</sup> CEA Comments at 3-5. CEA submits that its tests show that due to IM3 within a DTV receiver, two signals at levels approximately 20 dB weaker than a single interfering DTV signal can cause interference. IM3 can occur when two undesired signals are present in addition to the desired signal and the second undesired signal is at double the frequency separation ( $N \pm 2k$ ) of the first undesired signal ( $N \pm k$ ). Note that "N" is the channel of the desired station and "k" is the channel separation to the first undesired station. For example, if the desired station is on channel 20 and  $k=2$ , the  $N+k$  undesired station would be on channel 22 and the  $N+2k$  station would be on channel 24. CEA states that assuming a relatively weak DTV signal of -68 dBm, a single DTV undesired signal must be at a very strong level of -8 to -11 dBm to interfere with the desired weak signal. It then submits that when there is a second undesired signal that is at double the frequency separation ( $N \pm 2k$ ) of the first undesired signal ( $N \pm k$ ) and at an equal power level, the two undesired signals can cause interference when they are at a power level 20 dB less than the single interferer, that is, at a power level of approximately -29 to -32 dBm when the desired DTV signal level is weak. CEA contends that while these interference signal power levels are high, they are not very unusual. It also states that it found similar effects when the DTV and LTE interfering signals were not of equal power, albeit the undesired DTV and LTE signals must collectively be stronger than in the equal power case.

<sup>54</sup> *Id.* at 12.

<sup>55</sup> CTIA Reply at 11.

<sup>56</sup> *ISIX R&O*, 29 FCC Rcd at 13095, para. 46. The current interference protection standards for DTV service in our rules only provide protection of DTV signals from other DTV signals on the same (co-channel) or the first adjacent channels above or below in frequency. 47 C.F.R. §73.623(c). As noted in the *ISIX R&O*, the Commission's standards for DTV-to-DTV interference do not specifically address interference due to intermodulation products. However, as there are no protections against interference from signals on channels two or more channels removed from the desired channel, it is implicit that protection against such interference is not provided. The Commission has not provided for interference protection from DTV signals on other channels beyond the first adjacent channel. See *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket No. 87-268, Sixth Report and Order, 12 FCC Rcd 14588, 14685-88, paras. 215-22 (1997); see also *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket No. 87-268, Memorandum Opinion and Order on Reconsideration of the Sixth Report and Order, 13 FCC Rcd 7418, 7429, para. 26 (1998) (affirming, *inter alia*, interference protection criteria). Likewise, OET-69 does not consider taboo interference, which would include IM3 from DTV signals, in its calculations of interference to DTV reception, but rather considers only the interference protections provided in the rules. See OET-69 at 8.

the Commission's goals in the DTV transition was to achieve more efficient use of spectrum than was possible for analog stations, which had to be protected against interference from other stations operating on "taboo" channels as well as co-channel and adjacent channel stations.<sup>57</sup> The absence of interference protection for DTV receivers against signals on channels beyond the first adjacent channels has allowed the Commission to assign channels in the TV bands in a much more efficient manner while still preserving the service of those signals. Indeed, as CEA acknowledges, providing larger exclusions for interference protection reduces the efficiency of spectrum use.<sup>58</sup> Protection of DTV receivers from the combinations of signals that can produce IM3 interference would impose additional constraints on the repacking process that would impact our ability to clear spectrum for new uses in the incentive auction and limit use of the recovered spectrum.

22. We do not expect that the potential for interference from intermodulation products from a DTV signal and an LTE signal or from two LTE signals will be significantly higher than that expected from two DTV signals. The co-channel LTE-to-DTV interference tests our laboratory conducted showed that the LTE signals have co-channel interference potential that is slightly higher but very similar to that of DTV signals, because both signals are "noise-like."<sup>59</sup> From these co-channel measurements it is also reasonable to deduce that the interference potential from the IM3 products of a DTV and an LTE signal or two LTE signals would be similar to that of two DTV signals. We recognize that the signal strength conditions in which IM3 interference could be present might occur more frequently where an LTE signal is one of the interfering signals, because wireless network architecture involves more transmitter locations than DTV stations for the same geographic area.<sup>60</sup> However, there are environmental factors that will limit the number of such occurrences, such as terrain, clutter,<sup>61</sup> and building penetration loss. In addition, because the strength of a wireless signal varies with time and frequency, the instantaneous power output of wireless base stations scheduled to use a particular frequency will vary, effectively limiting the occasions and areas in which the collective signal strengths are high enough to cause IM3 to DTV operations.

23. In addition, potential intermodulation interference can be mitigated through DTV receiver design, antenna reorientation, and other factors. In order to meet consumers' expectations, receiver manufacturers should design their products to operate without experiencing interference from signals permitted by the Commission's rules.<sup>62</sup> The *CEA Report* notes that at least some models of

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<sup>57</sup> See *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket No. 87-268, Sixth Further Notice of Proposed Rulemaking, 11 FCC Rcd 10968, 10976, 10979, 11001 (1996); see also *Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service*, MM Docket No. 87-268, Sixth Report and Order, 12 FCC Rcd 14588, 14625 (1997). The requirements for protection of analog TV stations from stations operating beyond the co-channel and first adjacent channels are known as the "UHF taboos." These requirements are set forth in Sections 73.610(d), 73.623(c) and (d) of the Commission's rules. See 47 C.F.R. §§ 73.610(d), 73.623(c) and (d).

<sup>58</sup> CEA Comments at 1-2.

<sup>59</sup> See *OET Measurements Report*, *supra* n. 46.

<sup>60</sup> CEA Comments at 7-11; NAB Reply at 6-7.

<sup>61</sup> "Clutter" describes the environmental surrounding of the receiver and includes foliage, buildings, etc. Clutter tends to reduce the signal strength arriving at the receiver (even though some types of clutter, like water, may have the opposite effect).

<sup>62</sup> As described above, that interference environment includes the possible presence of signals on the  $N\pm k$  and  $N\pm 2k$  channel relationships that can produce third-order intermodulation products in receivers. Receiver manufacturers are aware of these and other potential interference factors. The ATSC DTV receiver performance guidelines include standards to address the presence of these conditions. See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.3, Taboo Channel Rejection, April 7, 2010, available at <http://atsc.org/recommended-practice/a74-receiver-performance-guidelines>. As we observed in the *ISIX R&O*, technical solutions exist to improve the performance of TV receivers on these taboo channels. For instance, tracking

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current DTV receivers could experience interference from IM3 products.<sup>63</sup> Such interference susceptibility is indicative of receiver designs that cannot receive service in the presence of certain signal combinations allowed under Part 73 of the rules.<sup>64</sup> To the extent that CEA and manufacturers believe that current models of DTV receivers are susceptible to IM3, the appropriate solution is for them to design their new products to be immune to such interference. To the extent that IM3 interference does occur, it can often be resolved by reorienting the antenna to reduce the received levels of undesired signals and/or increase the received levels of desired signals. Multipath effects,<sup>65</sup> “clutter” factors, and terrain also tend to reduce one or more of the received signal levels in a possible IM3 situation below predicted levels and further mitigate the likelihood of intermodulation interference.

24. *“Error Code 3” Messages.* When “error code 3” messages are returned by the software used to implement the Longley-Rice propagation model, OET-74 will use the desired and undesired signal strengths determined by the Longley-Rice propagation model in evaluating the subject cell for potential interference.<sup>66</sup> We used this same approach in the ISIX Methodology.<sup>67</sup> We decline to adopt NAB’s suggestion that when an “error code 3” warning is returned and the desired signal strength calculated by OET-74 is below 41 dB $\mu$ V/m, the threshold of service,<sup>68</sup> the calculated desired signal strength be replaced with a signal strength equal to the threshold of service or threshold of service plus 3 dB. The goal of OET-74 is to provide a methodology for predicting interference to television receivers based on the actual technical parameters of the television stations and wireless networks.<sup>69</sup> NAB’s approach would be contrary to this goal. Under NAB’s approach, OET-74 would use the signal strengths calculated by the Longley-Rice model to predict interfering signals while arbitrarily ignoring desired signal strengths calculated by the model if they are below the threshold of service and, therefore, unfavorable to the television station.

25. *Other OET-74 Technical Issues.* We reject NAB’s contention that we should evaluate interference to the reception of Class A station’s signals using a one-kilometer grid instead of the two-kilometer grid proposed in OET-74 so as to be “consistent with current practice.”<sup>70</sup> The Media Bureau’s

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filters could improve selectivity, double conversion tuners could improve intermodulation, and low-IF tuners could improve resiliency against interactions at 44 MHz from the desired channel. Some receivers made available more recently have already been designed this way. See e.g., Stephen R. Martin, *DTV Converter Box Test Program—Results and Lessons Learned*, FCC/OET Report 09-TR-1003, Oct. 9, 2009, Chapter 4. See also Lerstaveesin, S., et al., *A 48–860 MHz CMOS Low-IF Direct-Conversion DTV Tuner*, IEEE Journal of Solid-State Circuits, 43(9):2013-2024, Sept. 2008.

<sup>63</sup> See CEA Report, *supra* n. 46.

<sup>64</sup> See generally 47 C.F.R. §§ 73.616, 73.622, and 73.623.

<sup>65</sup> “Multipath” refers to a propagation condition where a wireless signal reaches a receiver via multiple paths. Because of the different lengths of the paths and the possible reflections along the path, signals arriving at a receiver from two or more paths will not be synchronized and may negate each other in the receiver.

<sup>66</sup> Error code 3 is returned by the software implementing the Longley-Rice propagation model most commonly when the absolute value of the angle to the horizon from either the transmitter or receiver exceeds 200 milliradians. *ISIX R&O*, 29 FCC Rcd at 13100-01, para. 54 n.199.

<sup>67</sup> *ISIX R&O*, 29 FCC Rcd at 13100-01, para. 54.

<sup>68</sup> Threshold of service is where the station’s signal strength is predicted to exceed the noise-limited service level. For a UHF station our rules define the threshold of service to be 41 dB $\mu$ V/m. 47 C.F.R. 73.622(e).

<sup>69</sup> Our confidence in the Longley-Rice model is strengthened by a staff comparison of Longley-Rice model versus Television Allocations Study Organization (TASO) measured data that shows a difference in median value of absolute error between the predicted value and the measured value of less than 1 dB when the warning flag is present. *ISIX R&O*, 29 FCC Rcd at 13100-01, para. 54, n.199.

<sup>70</sup> NAB Comments at 9.

application software, *tv\_process*, uses a one-kilometer station grid when processing Class A station applications. We use a two-kilometer grid for full power and Class A stations in the repacking process and in the ISIX Methodology, and have proposed to do the same in OET-74.<sup>71</sup> Using a different grid size for Class A stations than for full power stations would be inconsistent with our repacking methodology and would create a layer of unnecessary complexity for the ISIX and OET-74 calculations. Accordingly, we will use a two-kilometer grid for the ISIX and OET-74 calculations for both full power and Class A stations.

26. We also reject NAB's suggestion that OET-74 consider interference in all cells, and not only the populated cells.<sup>72</sup> We find no basis to depart from our current rules, which provide interference protection only for populated cells.<sup>73</sup> As proposed in the *ISIX Further Notice*, OET-74 will consider interference harmful only if the D/U ratio is below the threshold in a cell containing population.<sup>74</sup>

27. In addition, we reject NAB's argument that OET-74 should not rely on manufacturers' published antenna patterns for wireless base stations.<sup>75</sup> According to NAB, the manufacturers' published patterns may suggest unrealistically superior performance, while the wireless licensee may adjust the antenna after installation to manage coverage or interference conditions, or the antenna alignment during installation may be imprecise.<sup>76</sup> NAB recommends that OET-74 assume that base station antenna azimuths have a lower relative field limit of 0.1 and that the elevation patterns assume maximum radiation from 0 to 10 degrees below the horizontal.<sup>77</sup> While we are cognizant that wireless base station antenna installations may vary from the antenna manufacturer's specified patterns or may be misaligned,<sup>78</sup> we see no reason to modify the manufacturer's specified wireless base station antenna patterns based on NAB's assumptions, which may or may not be more accurate for any given base station installation. Using NAB's assumptions would be contrary to our decision to require wireless licensees to use actual system parameters when conducting OET-74 analyses. Using the manufacturer's specified antenna pattern with the intended alignment is more likely to reflect the actual antenna characteristics than using NAB's suggested assumptions, and is more consistent with established practice, because OET-69 allows for the use of specified antenna patterns where available.<sup>79</sup> Furthermore, NAB's concern that wireless licensees may adjust their antennas at a later time is misplaced because the rules require a new OET-74 analysis prior to any base station modification that could result in an increase in energy in the direction of

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<sup>71</sup> *OET-69* at 11 (prescribing the use of a two kilometer grid); *Incentive Auction*, 29 FCC Rcd at 6625-36, paras. 127-47 (adopting the use of a uniform grid for the repacking in accordance with the methodology in OET-69); *ISIX Further Notice*, 29 FCC at 13147 (App. E – Proposed OET-74).

<sup>72</sup> NAB Comments at 8-9.

<sup>73</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Declaratory Ruling, 29 FCC Rcd 12240, 12242, para. 6, 12242-43, para. 8 (2014) (explaining that according interference protection to unpopulated areas would depart from OET-69 and the Commission's rules; the processing software currently used by the Media Bureau to evaluate applications for and modifications to DTV television facilities does not routinely provide an indication of interference to unpopulated areas; and the Media Bureau does not consider interference in unpopulated areas in making licensing decisions). See also *Nat'l Ass'n of Broadcasters v. FCC*, 789 F.3d 165, 179 (D.C. Cir. 2015) (affirming decision not to protect unpopulated areas in the repacking process).

<sup>74</sup> *ISIX R&O*, 29 FCC Rcd at 13147, App. E (Proposed OET-74). See also *id.* at 13106, para. 65.

<sup>75</sup> *ISIX Further Notice*, 29 FCC Rcd at 13151 (providing for use of manufacturer-supplied antenna patterns).

<sup>76</sup> NAB Comments at 6-7.

<sup>77</sup> See *id.*

<sup>78</sup> An antenna pattern may be misaligned when the antenna is not oriented as intended.

<sup>79</sup> Broadcasting stations may submit the manufacturer's antenna pattern in the Commission's Consolidated Database System (Media Bureaus application database commonly referred to as "CDBS").

a DTV station's contour.<sup>80</sup> In addition, assuming maximum radiation from zero to ten degrees below the horizon as NAB suggests would discourage 600 MHz licensees from using an antenna downtilt to mitigate interference to television receivers because they could not account for it in an OET-74 analysis. We note that if the OET-74 analysis fails to predict interference because of an inaccurate antenna pattern, wireless licensees would still have an obligation to eliminate any actual harmful interference to television broadcast reception that occurs.<sup>81</sup>

28. We disagree with Cohen, Dippell, and Everist, P.C.'s ("CDE") claim that the FCC has not forecasted the potential interference to television receivers in cases where five megahertz 600 MHz licenses are aggregated.<sup>82</sup> OET-74 as proposed contains instructions on how to apply the methodology for signals with bandwidths larger or smaller than five megahertz.<sup>83</sup> In addition, both the *CEA Report* and the *OET Measurements Report* provide measurements of DTV receiver performance in the presence of 10 megahertz LTE signals.<sup>84</sup> Given the DTV receiver performance measurements in the record and the fact that OET-74 is applicable to aggregated channels, CDE fails to articulate the need for additional testing of the effects of inter-service interference where five megahertz wireless licenses are aggregated.

29. Nevertheless, based on examination of the record, we conclude that our proposal for a separate analysis for each frequency overlap when two five-megahertz blocks are aggregated into a ten megahertz block would require additional effort by the wireless licensee without providing increased protection for DTV signal reception compared with a combined analysis of aggregated five megahertz blocks. For this reason, OET-74 will require that only a single interference analysis be performed when five megahertz blocks are aggregated.<sup>85</sup> Therefore, in cases of aggregated wireless blocks the OET-74 analysis will be adjusted to reflect the amount of spectral overlap between the aggregated wireless signal and the DTV channel and the effective radiated power ("ERP") as described below. When the aggregated wireless signal completely overlaps the DTV channel, the analysis will use the values in the OET-74 tables associated with a spectral overlap of five megahertz and the ERP that is the portion of the power in the aggregated wireless signal that overlaps the six megahertz television channel.<sup>86</sup> When the aggregated wireless signal overlaps the DTV channel by five megahertz or less, the analysis will use the values in the OET-74 tables associated with the amount of spectral overlap and the ERP of the overlapping wireless five megahertz block (*i.e.* the analysis will ignore the other five megahertz blocks of the aggregated signal).<sup>87</sup> When the aggregate wireless signal is adjacent to the DTV channel (*i.e.* no overlap), the

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<sup>80</sup> See *infra* para. 35.

<sup>81</sup> See *infra* paras. 39-40.

<sup>82</sup> CDE Comments at 3.

<sup>83</sup> See *ISIX R&O*, 29 FCC Rcd 13154, App. E (Proposed OET-74) § IV.F.

<sup>84</sup> *OET Measurements Report*, 29 FCC Rcd at 7430, 7435-37; *CEA Report*, *supra* n. 46, at 82-83, 96-97, 99-100.

<sup>85</sup> See *infra* App. C (OET-74) § IV.F. A wireless licensee with non-contiguous spectrum blocks will be required to conduct a separate OET-74 interference analysis for each spectrum block. In addition, a wireless licensee that is adjacent or co-channel to multiple DTV stations, will have to perform separate OET-74 interference analysis for each of the DTV stations.

<sup>86</sup> Measurements performed by CEA demonstrate that the D/U ratio thresholds are not significantly different for 5 MHz and 10 MHz LTE signals that partially or completely overlap a DTV signal. *CEA Report*, *supra* n. 46, at 97, 100. Therefore, we do not expect that using OET-74 with up to a five megahertz overlap to represent interference from an LTE signal with bandwidths greater than five megahertz will under protect DTV reception.

<sup>87</sup> Since the D/U thresholds in OET-74 were determined assuming a five megahertz wireless signal, using the ERP of the entire aggregated wireless signal in the interference analysis would in effect treat the aggregated signal as a five megahertz signal with a much higher power spectral density. This would overestimate the interference from the aggregated wireless signal to DTV reception. Therefore, for spectral overlaps up to five megahertz, the OET-74 analysis will only consider the five megahertz block of the aggregate signal that overlaps the DTV channel. For the

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interference analysis will use the values in the OET-74 tables associated with the five megahertz block that is closest to the adjacent DTV channel and the ERP of that block.

**b. Case 4: Interference to Television Receivers from Wireless User Equipment**

30. We adopt fixed geographic separation distances for Case 4 as proposed in the *Further Notice*.<sup>88</sup> Specifically, 600 MHz wireless licensees will be required to limit the service area of their wireless networks so that wireless user equipment (i.e., mobile and portable devices) will not operate within the contour or within a set distance from the contour of a co-channel or adjacent channel television station.<sup>89</sup> As proposed in the *ISIX Further Notice*, we adopt a separation distance of five kilometers for co-channel operations, and one-half kilometer for adjacent channel operations.<sup>90</sup> Therefore, wireless licenses that will be co-channel or adjacent channel to a television station in the 600 MHz Band uplink spectrum will have impairments that cover the area of the station's contour and an additional five kilometers if the television station is co-channel or one-half kilometer if the television station is adjacent channel to the wireless operations. The separation distance for adjacent channel operation will only apply to the first adjacent channel. Consequently, wireless user equipment may be operated within the contour of a television station if there is a frequency separation of at least six megahertz or more between the wireless spectrum block edge and a television channel edge.

31. These separation distances are identical to the distances adopted for the prediction of Case 4 inter-service interference during the incentive auction.<sup>91</sup> As explained in the *ISIX R&O*, because wireless user equipment transmits with relatively low power and typically at heights above the ground on the order of 1.5 meters, the potential for wireless user equipment to cause interference to television receivers typically extends only a few kilometers.<sup>92</sup> These short distances make it impractical to use OET-74 or other similar propagation models.<sup>93</sup> NAB is in favor of using these separation distances and no parties objected.<sup>94</sup>

**3. Obligations of 600 MHz Licensees in Markets with Variation**

**a. Requirements on Wireless Base Station Deployment**

32. As proposed in the *ISIX Further Notice*, we will (1) prohibit a 600 MHz wireless licensee

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same reason, when the aggregate wireless signal is adjacent to the DTV channel, the OET-74 analysis will only consider the five megahertz block of the aggregate signal that is closest to the DTV channel.

<sup>88</sup> For co-channel operations, the *ISIX Further Notice* proposed that wireless user equipment would be prohibited from operating within the television station's contour and within five kilometers of that contour. For adjacent channels, the *ISIX Further Notice* proposed to prevent wireless user equipment operations within the television station's contour and within one-half kilometer of that contour. See *ISIX Further Notice*, 29 FCC Rcd at 13109, para. 73.

<sup>89</sup> By "contour" we mean either the "noise-limited contour" for full power television stations or "protected contour" for Class A television stations. See 47 C.F.R. §§ 73.622(e), 73.6010.

<sup>90</sup> See *ISIX PN*, 29 FCC Rcd at 727 (indicating that NAB suggested a uniform separation distance of five kilometers for co-channel operations).

<sup>91</sup> We calculated these separation distances to protect television service using the OET TM91-1 propagation model, which we concluded is appropriate for such short distances. See *ISIX R&O*, 29 FCC Rcd at 13102-03, paras. 56, 58.

<sup>92</sup> See *id.* at 13102-03, paras. 57-58.

<sup>93</sup> The Longley-Rice model is not designed for distances less than a kilometer and relies on line-of-sight or free-space for such distances. Use of Longley-Rice for these short distances would require the development of detailed maps of locations where user equipment could operate, which would be administratively inefficient. See *id.*

<sup>94</sup> NAB Comments at 5-6.

from operating base stations within the contour of a co-channel or adjacent-channel full power and Class A television station, (2) require the 600 MHz wireless licensee to use OET-74 to predict interference to television receivers within such a station's contour prior to deploying base stations within a specified culling distance<sup>95</sup> of the station's contour, and (3) prohibit operating base stations within that distance if harmful interference is predicted.<sup>96</sup> The culling distances are specified in OET-74 and are based on the spectral overlap between wireless operations and television operations, and the power and antenna height of wireless base stations.<sup>97</sup>

33. We find that prohibiting wireless base stations from operating within the contours of co-channel and adjacent channel DTV stations is an appropriate safeguard for preventing interference to television receivers. A wireless base station located within the contour of a co-channel DTV station will most likely interfere with television receivers within the contours because the strength of the wireless signal will overwhelm the broadcast television signal. Even for an adjacent channel base station, the power of the base station would have to be restricted to impractically low levels to prevent interference to nearby television receivers.<sup>98</sup> Therefore, to protect television receivers within a DTV station's contour it is necessary to exclude base stations from operating within the contour of co-channel and adjacent channel DTV stations. We also find that requiring the use of OET-74 to identify potential interference from base stations located within the culling distance, and prohibiting operation of base stations within that distance if harmful interference is predicted, will ensure that television stations assigned to channels in the 600 MHz Band are not subject to harmful interference from 600 MHz Band wireless operations following the auction. OET-74 is designed to predict whether interference to television receivers will occur taking into account the actual technical parameters of deployed base stations as well as terrain and population data to estimate potential interference.<sup>99</sup>

34. We decline CTIA's request that the required use of OET-74 apply only to 600 MHz wireless licenses that have been formally designated as impaired during the incentive auction.<sup>100</sup> Rather, as proposed, the OET-74 analysis must be performed for any base station located within the culling distance, even if the license was not identified as impaired during the auction.<sup>101</sup> Qualified forward auction bidders will be provided information about the degree of impairment to the license, but such impairments will be estimated using the ISIX Methodology based on assumptions of a hypothetical wireless network deployment.<sup>102</sup> Post-auction, our inter-service interference methodology will be based on the actual interference environment to protect DTV receivers. Impairments based on a wireless licensee's real-world, post-auction base station deployment will necessarily differ from the impairments

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<sup>95</sup> A culling distance is a contour-to-site distance: base stations beyond this distance are culled from further analysis, because their interference contribution to DTV service within the contour would not be considered significant.

<sup>96</sup> *ISIX Further Notice*, 29 FCC Rcd at 13107, 13110, paras. 68, 76.

<sup>97</sup> See *infra* App. C (OET-74) § IV.F.

<sup>98</sup> It is for this reason that our rules for unlicensed white space devices prohibit the devices from operating with an EIRP greater than 40 milliwatts within the contour of an adjacent channel television station. 47 C.F.R. § 15.712(a)(2).

<sup>99</sup> NAB supports the Commission's proposal to use the actual operating parameters of the wireless base stations rather than the technical assumptions used during the auction because it promotes the goal of preventing actual rather than predicted interference. NAB Comments at 6.

<sup>100</sup> CTIA Comments at 7-9.

<sup>101</sup> *ISIX Further Notice*, 29 FCC Rcd at 13107, para. 68.

<sup>102</sup> See *ISIX R&O*, 29 FCC Rcd at 13088, para. 33. We note that two categories of generic blocks will be offered in the forward auction, each of which may have potential impairments. See *Bidding Procedures PN*, 30 FCC Rcd at 8990, 9047-51, paras. 24, 144-148 (forward auction licenses will be categorized as Category 1 (zero to 15 percent impaired) or Category 2 (greater than 15 percent and up to 50 percent impaired)).

predicted using the ISIX Methodology during the auction, in some cases resulting in impairments not predicted by the ISIX Methodology. Furthermore, because the culling distances specified in OET-74 are based on deployed base station antenna heights, transmitted power, and distance from the DTV station's contour, the areas where base station deployments will require an OET-74 analysis will not be available during the auction. We note that qualified forward auction bidders will be able to determine prior to bidding whether they will be subject to regulatory requirements for a particular license because we will provide them with specific information about the television stations that will potentially cause impairments to wireless licenses (including the facility ID) prior to each stage of the auction.<sup>103</sup> Bidders can take into consideration that some licenses may be subject to restrictions depending on their specific network deployment, market variation, and spectrum overlap of the license and should have sufficient information at the bidding stage to make these determinations.<sup>104</sup>

35. We reject CTIA's claims that the OET-74 methodology is burdensome and impractical.<sup>105</sup> The rules we adopt will not require a wireless licensee to perform an OET-74 analysis every time there is an adjustment to its network. Rather, a new OET-74 analysis will be required only if a base station modification could result in an increase in energy in the direction of a full power or Class A television station's contour. These changes could include, for example, an increase in transmitted power, use of a higher antenna, or a change in the antenna pattern. To eliminate the need for future revisions, wireless licensees could perform an initial "worst case" OET-74 analysis that includes the possible future technical parameters that would potentially cause the most interference, so that any subsequent changes to the technical parameters that would reduce the interference potential would not require an additional analysis. For example, OET-74 specifically allows for the use of an omnidirectional antenna rather than actual antenna pattern, which will make the analysis more conservative and less prone to change with network adjustments.<sup>106</sup>

36. CTIA's concerns over the number of base stations subject to the OET-74 analysis, especially with the deployment of small cell architecture, are exaggerated.<sup>107</sup> Not all base stations in a small cell architecture will require such an analysis. The base stations will have to be within the culling

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<sup>103</sup> *Bidding Procedures PN*, 30 FCC Rcd at 9043-44, para. 134.

<sup>104</sup> *See Bidding Procedures PN*, 30 FCC Rcd at 9048, para. 145.

<sup>105</sup> CTIA Comments at 11 (claiming that OET-74 does not define the scope of changes to an existing base station that will require a new analysis; the number of base stations requiring analysis will be substantial, especially as wireless networks move to a small cell architecture; and OET-74 would serve as a hurdle to the rapid deployment and modification of wireless networks). *See also* NAB Comments at 6-7 (stating that because carriers routinely adjust or "tune" their installations to manage coverage and interference conditions as their networks change, "on a daily basis or even more frequently," it would be unrealistic and unreasonable to expect them to recalculate interservice interference levels every time the parameters change).

CTIA submits as an alternative that the Commission establish an interference protection framework, with safe harbor approaches for wireless licensees that allow the wireless licensees to manage compliance with the requirements. *See* CTIA Comments at 12 ("The Commission should apply a less burdensome, 'bright-line' approach to compliance with interference protection requirements and allow 600 MHz licensees the flexibility to determine the most effective approach for compliance instead of mandating an overly rigorous and unnecessary approach as proposed."). *See also* Letter from Meredith Baker, President and CEO, CTIA to Chairman Wheeler, Commissioners Clyburn, Rosenworcel, Pai, O'Rielly, FCC at 3 (filed Jul. 9, 2015) ("We believe that common objective can be best met without the need for repetitive interservice interference analysis"). However, CTIA has failed to provide any concrete details as to how such an alternative would be implemented. As discussed above, we have concluded that a zero percent interference threshold is appropriate given the interference environment. This would preclude the adoption of the type of interference protection framework CTIA advocates. *See supra* para. 6.

<sup>106</sup> *See* App. C (§ IX.B. Evaluation of Interference).

<sup>107</sup> CTIA Comments at 11; CTIA Reply at 9, n.17. CTIA argues that as wireless network architecture moves towards a small cell architecture the number of base stations that will require an OET-74 analysis will be substantial.

distance of the television station. Moreover, culling distances will be shorter for base stations in a small cell architecture. The culling distances prescribed in OET-74, as reflected in Tables 7-12, depend on three different elements: (i) the spectral overlap between the wireless license and the television station; (ii) the antenna height (HAAT); and (iii) the ERP. The base stations for small cell architecture are, by definition, lower power and lower height than traditional base stations.<sup>108</sup> As the Tables show, antennas at lower power and lower height result in shorter culling distances, as small as three kilometers in some cases, thereby reducing the likelihood that an OET-74 analysis will have to be performed for small cell antennas.

37. As proposed in the *ISIX Further Notice*, we will require a 600 MHz wireless licensee to retain the latest copy of its OET-74 interference analysis for each co-channel or adjacent channel partial economic area (“PEA”) license area<sup>109</sup> where any of its base stations fall within the specified OET-74 culling distances. The wireless licensee will be required to make this analysis available for inspection by the Commission at any time and to make this analysis available to a television station upon request when there are complaints of interference either from the subject television station or a station viewer. CTIA claims this requirement “would be a tremendous logistical burden for new 600 MHz licensees.”<sup>110</sup> We disagree. We expect that licensees will implement the OET-74 methodology through use of a computer program that uses as inputs a database of the licensees’ base station technical parameters. We anticipate releasing a version of the *TVStudy* software that performs these analyses prior to the incentive auction.<sup>111</sup> We also anticipate that wireless licensees will use their own network planning software for this purpose. As stated above, wireless licensees will need to update the analysis only when they add new base stations or modify existing ones in a manner that increases energy in the direction of a DTV station’s contour. Considering that wireless carriers regularly do engineering analysis when upgrading and modifying their networks, we do not believe that this additional effort will be unduly burdensome. The requirement to retain the OET-74 analysis is also not unduly burdensome because we expect wireless licensees will maintain them electronically.

38. We reject NAB’s request that wireless licensees be required to send all of their OET-74 analyses to all potentially affected broadcasters.<sup>112</sup> Such a requirement would impose undue burdens on both wireless licensees and broadcasters, and we are not persuaded that they would significantly reduce potential interference complaints or resolve interference conflicts before they begin, as NAB claims. Instead, we find that requiring wireless licensees to retain their most recent OET-74 analyses, which they may store electronically, and make them available in cases of interference complaints will more efficiently assist in the investigation and resolution of any complaints.<sup>113</sup>

#### **b. Elimination of Actual Interference to Broadcast Television Stations in the 600 MHz Band**

39. We adopt our proposal to require wireless licensees to eliminate any actual harmful interference to television reception within the contours of a full power or Class A television station in the 600 MHz Band, even if OET-74 did not predict such interference.<sup>114</sup> This obligation on wireless licensees

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<sup>108</sup> Small cells are localized in high traffic areas and provide limited coverage for capacity. Their antennas tend to be placed much lower than traditional base stations, usually below clutter.

<sup>109</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6597, para. 71.

<sup>110</sup> CTIA Comments at 11.

<sup>111</sup> Instructions in the *TVStudy* manual will be available for importing base station information via xml file format.

<sup>112</sup> NAB Comments at 5.

<sup>113</sup> NAB Comments at 5-6.

<sup>114</sup> *ISIX Further Notice*, 29 FCC Rcd at 13109, para. 74. We recognize that the requirement to eliminate any actual harmful interference departs from how we treat interference between DTV broadcasters where a new DTV station is permitted to cause interference to up to half a percent of the population of an existing station. 47 C.F.R. § 73.616(e).

(continued...)

further ensures that co-channel or adjacent channel television stations in the 600 MHz Band will be protected from co-channel or adjacent channel wireless operations. NAB supports this proposal, stating that “the goal is not merely to predict zero interference, it is to cause zero interference and prevent harm to viewers.”<sup>115</sup>

40. We also adopt our proposal for handling such interference incidents. As proposed in the *ISIX Further Notice*, a television station operating in the 600 MHz Band that experiences harmful interference from co-channel or adjacent channel wireless operations must first contact the wireless licensee to resolve the issue.<sup>116</sup> The wireless licensee must provide to the television station the latest OET-74 analysis showing that no harmful interference was predicted to occur in the specific geographic area at issue.<sup>117</sup> Wireless licensees and television stations are required to cooperate in good faith to resolve any disputes, so as not to unreasonably disrupt wireless and broadcast operations. In the event the parties do not reach resolution, the broadcaster can submit a claim of harmful interference to the Commission.

41. We decline CDE’s requests that the Commission create a toll-free number and a website for consumers to report potential inter-service interference problems or that we create an interference handbook that demonstrates how a television viewer may face interference.<sup>118</sup> Rather, over-the-air television viewers who are experiencing reception problems will likely contact the broadcast television station with complaints. Accordingly, we will rely on the framework described above, which requires television stations experiencing interference problems to contact wireless licensees to resolve the potential interference issues. Television stations will be in a better position to determine whether an interference problem exists and the source of that interference—information that an individual television viewer would most likely not possess or be able to otherwise ascertain.

**c. Effect of Interference-Related Restrictions on Wireless Licenses**

42. As we proposed in the *ISIX Further Notice*, a 600 MHz wireless licensee will hold a license for its entire PEA service area, but its operations will be limited only to those portions of the PEA where the licensee will not cause harmful interference to the reception of signals from television stations assigned to the 600 MHz Band consistent with the standards set forth above.<sup>119</sup>

43. As discussed in the *Incentive Auction R&O*, 600 MHz licensees will be required to meet the 600 MHz Band interim and final build-out requirements, except that they may show they are unable to operate in areas where they may cause harmful interference to the reception of the signals of television stations that remain in the 600 MHz Band due to market variation.<sup>120</sup> The same exception to interim and final build-out requirements will apply to cases where 600 MHz licensees receive harmful interference

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However, as discussed above the interference environment in the 600 MHz Band requires the adoption of a zero percent interference threshold. *See supra* paras. 6-8. The requirement to eliminate any actual harmful interference is necessary to implement this interference threshold.

<sup>115</sup> NAB Comments at 5. No commenters opposed this proposal.

<sup>116</sup> The Commission generally encourages licensees to work together to resolve interference issues. See, for example, the interference dispute resolution procedures for fixed microwave services. 47 C.F.R. § 101.105(e).

<sup>117</sup> *See ISIX Further Notice*, 29 FCC Rcd at 13109, para. 75.

<sup>118</sup> CDE Comments at 3. CTIA objects to these proposals as unnecessary because over-the-air television viewers will have no ability to gauge why their television reception is disrupted and the conservative inter-service interference protection requirements make interference unlikely to be the cause of reception disruptions. CTIA Reply at 17-18.

<sup>119</sup> *ISIX Further Notice*, 29 FCC Rcd at 13109-10, para. 76

<sup>120</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86.

from television stations assigned to channels in the 600 MHz Band.<sup>121</sup> We adopt our proposal to require wireless licensees to use the ISIX Methodology we adopted for use during the auction for prediction of interference in the Case 1, 2 and 4 scenarios and the methodology in OET-74 for the Case 3 interference scenario to demonstrate that they cannot serve the entire PEA service area for purposes of fulfilling the build-out requirements of their license.<sup>122</sup> If a licensee is not able to serve its entire license area, it must demonstrate why certain areas are excluded from its service area due to impairments when it files its construction notification.<sup>123</sup> If the impairing television station ceases to operate before the construction benchmarks, the wireless licensee will be permitted to use the entire license area, and will be obligated to serve the area that was previously restricted in demonstrating that it has met its build-out requirements.<sup>124</sup>

## **B. Protecting Wireless Licensees in the 600 MHz Band from Inter-Service Interference**

44. In this section, we adopt rules to ensure that 600 MHz wireless licenses obtained in the forward auction do not experience additional impairments following the incentive auction.

### **1. Limitation on Expanding 600 MHz Broadcast Television Stations' Contours**

45. We limit full-power and Class A television stations assigned to channels in the 600 MHz Band from expanding their noise-limited and protected contours, respectively, if doing so would increase the impairments to co-channel or adjacent channel 600 MHz wireless licenses, unless an agreement is reached with the co-channel or adjacent channel wireless licensee allowing for such expansion. For purposes of this limitation, impairments refer to both additional interference from a television station anywhere in the 600 MHz Band in a PEA (Cases 1 and 2), and to any increased restriction on wireless operations within a PEA in order to avoid causing harmful interference to television receivers within a television station's expanded contour (Cases 3 and 4).<sup>125</sup> For purposes of this limitation, a television station's baseline contours are those set forth in its initial post-auction construction permit application.<sup>126</sup> As we stated in the *Incentive Auction R&O*, we will carefully consider requests for waiver of the limitation in extraordinary circumstances.<sup>127</sup>

<sup>121</sup> See *id.* at 6884, para. 781.

<sup>122</sup> See *ISIX R&O*, 29 FCC Rcd at 13110, para.77; see *infra* App. D (Updated ISIX Methodology).

<sup>123</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6883, 684, paras. 778, 781; 47 C.F.R. § 1.946(d). The construction notification will have to be filed within 15 days of the relevant milestone certifying that it has met the applicable performance benchmark within its permitted boundaries (the portion of the license area within which operations are permitted under the inter-service interference rules). Along with the technical analysis, the licensee would need to provide population data for the areas it can and cannot serve, with a detailed explanation of the impairment, in addition to any other relevant information to demonstrate that it has met its performance benchmarks in the permitted boundaries of its license area. *Incentive Auction R&O*, 29 FCC Rcd at 6606, 6884, paras. 86, 781.

<sup>124</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 n.277.

<sup>125</sup> The *ISIX Further Notice* proposed to prohibit television licensees in the 600 MHz Band from expanding their contours if doing so would increase interference to a co-channel or adjacent channel wireless licensee. *ISIX Further Notice*, 29 FCC Rcd at 13111, para. 79. But in addition to increased interference to wireless licensees, we are also concerned that a wireless licensee not be required to restrict its operations to protect television reception within the expanded portion of the television station's contour.

<sup>126</sup> The rules and procedures we established in the *Incentive Auction R&O* permit a television station, under limited circumstances, to request a slight coverage increase in its initial post-auction construction permit application and this increase will be permitted even it does increase impairments to wireless licensees. This contour increase is permitted if necessary to achieve the coverage contour specified in the *Channel Reassignment PN* or to address loss of coverage area resulting from a television station's new channel assignment. *Incentive Auction R&O*, 29 FCC Rcd at 6791, paras. 547-48; 47 C.F.R. § 73.3700(b)(ii). The impact on a wireless licensee of allowing a broadcast station reassigned to the 600 MHz Band to avail itself of the one percent contour increase, is *de minimis*.

<sup>127</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606-07, para. 87. In the *ISIX Further Notice* we proposed a rule allowing television stations to request a waiver to allow expansion of their contour. *ISIX Further Notice* 29 FCC

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46. CEA argues for a set distance between the edge of a wireless license area and the contours of a co-channel or adjacent channel television station beyond which the television station would be allowed to expand.<sup>128</sup> We reject this proposal because the appropriate distance would depend largely on factors like transmitted power, antenna height, and antenna pattern, as well as terrain and frequency overlap, that vary by station.<sup>129</sup> However, if the distance between the proposed expanded contour and a co-channel or adjacent channel wireless licensee's service area is greater than 500 kilometers, the television station will not be required to make a showing that its expanded contour does not cause additional impairments to the wireless operations.<sup>130</sup>

47. We recognize that this limitation will effectively constrain many television stations assigned to frequencies in the 600 MHz Band from expanding their contours. As a threshold matter, we note that our mandate under the Spectrum Act is to make all reasonable efforts to preserve stations' existing coverage areas and populations served, not their ability to expand their facilities in the future.<sup>131</sup> Moreover, despite the fact they will be constrained in expanding their contours, television stations assigned to channels in the 600 MHz Band will have certain advantages compared to television stations assigned to channels in the remaining television bands following the auction. Stations in the TV bands will be more densely packed after the incentive auction and the repacking process, and may face increased interference in the future from new stations or as a result of modification of existing stations' contours.<sup>132</sup> By contrast, very few television stations will be assigned to channels in the 600 MHz Band, and the ones that are will be protected from inter-service interference under the zero percent interference threshold we adopt herein.<sup>133</sup> Moreover, unlike the TV bands, the zero percent interference protection framework requires 600 MHz wireless licensees to eliminate any harmful interference that occurs to the reception of television station's signals in the 600 MHz Band after the wireless systems are up and operating.<sup>134</sup> On the whole, therefore, we do not believe that stations in the 600 MHz Band will be disadvantaged.

48. We have adopted procedures for the incentive auction to ensure that we meet the Spectrum Act's mandate to preserve "the coverage area and population served of each broadcast television licensee," and as set forth above we are adopting rules to protect television receivers within the contours of television stations assigned to the 600 MHz Band from interference.<sup>135</sup> Just as our rules will

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Rcd at 13142, Appendix D proposed 47 C.F.R. § 73.3700(i)(2). Because our rules generally permit waiver request under 47 C.F.R. § 1.3 we shall not adopt the proposed waiver provision.

<sup>128</sup> CEA Comments at 22.

<sup>129</sup> We rejected a proposal to handle inter-service interference during the auction through fixed distance-based separation requirements for similar reasons. See *ISIX R&O*, 29 FCC Rcd 13091, para. 39.

<sup>130</sup> The *TVStudy* software considers interference to wireless licensees from television stations within approximately 500 kilometers. See *ISIX R&O*, 29 FCC Rcd at 13120, App. A (Technical Appendix), para. 8.

<sup>131</sup> 47 U.S.C. § 1452(b)(2). See *Second Order on Reconsideration*, 30 FCC Rcd at 6823, para. 175 (explaining that preservation mandate applies to the repacking process).

<sup>132</sup> Existing television stations modifying their contours and new television stations may cause interference in up to 0.5 percent of the contour of another station. 47 C.F.R. §§ 73.612(a), 73.616(e). As a result of being more densely packed, stations in the remaining TV bands may be more limited in their future ability to expand their contours than they were prior to the incentive auction.

<sup>133</sup> See *supra* para. 6. Although the Commission's rules treat 0.5 percent—the interference threshold in the TV bands—as “no new interference” because 0.5 percent is equivalent to zero when rounded to an integer value, see *IA R&O*, 29 FCC Rcd at 6649 para. 177 n. 598, a zero percent threshold obviously provides greater interference protection by prohibiting even *de minimis* amounts of new interference. See *supra* paras. 6-8.

<sup>134</sup> See 47 C.F.R. § 73.612(a).

<sup>135</sup> 47 U.S.C. § 1452(b)(2).

protect television receivers from interference from 600 MHz wireless licensees, however, they must also protect 600 MHz wireless licensees from new or additional interference from television broadcasters after the incentive auction. The limitation we adopt here is consistent with our proposal in the *ISIX Further Notice* to prohibit television licensees in the 600 MHz Band from expanding their contours if doing so would increase interference to a co-channel or adjacent channel wireless licensee<sup>136</sup> It also will ensure that a wireless licensee need not restrict its operations to protect television receivers within the expanded portion of a television station's contour.<sup>137</sup> Further, the limitation we adopt will promote our goals for the auction by ensuring that 600 MHz wireless licensees can rely on the information available at the time of the auction as to the nature of potential impairments from broadcast TV stations.<sup>138</sup> Wireless licensees need to know that they will not be subject to increased interference in the future, both when they participate in the auction and when they invest in building out their wireless networks.<sup>139</sup>

## 2. Predicting Potential Interference from LPTV or TV Translator into Wireless Service

49. As set forth in the *Incentive Auction R&O*, LPTV and TV translator stations in the 600 MHz Band may continue operating indefinitely unless a 600 MHz wireless licensee provides advance notice that it intends to commence operations and that the LPTV or TV translator station is likely to cause harmful interference to the wireless operations, based “on the methodology we adopt to prevent inter-service interference.”<sup>140</sup> In the *ISIX R&O*, as modified by the accompanying *First Order on Reconsideration*, we adopted the ISIX Methodology and input values to predict interference from full power and Class A television stations to wireless services during the course of the auction.<sup>141</sup> As proposed in the *ISIX Further Notice*, 600 MHz wireless licensees will use the ISIX Methodology, as modified in the *First Order on Reconsideration*, for predicting interference to their operations from LPTV and TV translator stations for purposes of providing these stations with advance displacement notice.<sup>142</sup>

50. For this analysis, 600 MHz licensees will use the threshold values for the prediction of

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<sup>136</sup> *ISIX Further Notice*, 29 FCC Rcd at 13111, para. 79.

<sup>137</sup> See *Bidding Procedures PN*, 30 FCC Rcd at 8994, para. 28. Because television stations may be assigned to channels in the uplink, downlink, and guard band portions of the 600 MHz Band, including the duplex gap, all interference scenarios (Cases 1-4) to adjacent or co-channel 600 MHz operations from the potential expansion of television station contours may have to be considered.

<sup>138</sup> See *Bidding Procedures PN*, 30 FCC Rcd at 9043-46, paras. 134-136.

<sup>139</sup> As discussed above, the Media Bureau will issue a Public Notice with the contours of all television stations assigned to channels in the 600 MHz Band which will provide wireless licensees with notice of the contours they must protect from interference. See *supra* n. 14. The contours of television stations assigned to the same channels in the 600 MHz Band as they were assigned prior to the auction will be their licensed contours as those appear in the final baseline coverage area and population served information recently released. See *Application for Broadcast Incentive Auction Scheduled to Begin on March 29, 2016, Reverse Auction Opening Prices; Forward Auction Minimum Opening Bids and Upfront Payments; Technical Formulas for Competitive Bidding*, AU Docket No. 14-252, GN Docket No. 12-268, WT Docket No. 12-269, Public Notice, DA 15-1183 (October 15, 2015), App. L.

<sup>140</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6834-35, 6839-41, paras. 657, 668-71, n.1872. The Commission has determined that a 600 MHz Band wireless licensee “commences operations” when it conducts site commissioning tests. In this context, the Commission defines that term to include site activation and commissioning tests using permanent base station equipment, antennas and/or tower locations as part of its site and system optimization in the area of its planned commercial service infrastructure deployment. *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, FCC 15-140, para. 7 (adopted Oct. 21, 2015).

<sup>141</sup> See *ISIX R&O*, 29 FCC Rcd 13083-103, paras. 23-58; see *infra*. paras. 74-75 (*First Order on Reconsideration*).

<sup>142</sup> *ISIX Further Notice*, 29 FCC Rcd at 13112, para. 81-82; see also *Incentive Auction R&O*, 29 FCC Rcd at 6839-40, para. 668.

interference from full power television to wireless operations from the ISIX Methodology. Because the co-channel interference potential of digital LPTV and TV translator stations is the same as that of full power stations, it is appropriate to use the field strength thresholds of full power television stations adopted in the *ISIX R&O* to predict co-channel interference from LPTV and TV translators.<sup>143</sup> With regard to adjacent channel interference, LPTV and TV translator stations are allowed to operate using either the same emission mask as a full power station or one of the other two alternative emission masks specified in our rules.<sup>144</sup> When using one of the two alternative emission masks, LPTV and TV translator stations could have slightly higher emissions levels in the first adjacent channel. This will pose a marginally higher potential for interference to adjacent channel wireless operations than a station operating with the same power and the full power emission mask.<sup>145</sup> As we explained in the *ISIX Further Notice*, however, we analyzed the frequency dependent rejection (“FDR”) performance of wireless receivers in the presence of DTV signals using the three different emission masks and found that there is only a 1 dB difference in the threshold values for adjacent channel interference to the wireless service across the three masks, for both wireless base stations and user equipment.<sup>146</sup> We do not find this 1 dB difference to be significant enough to warrant using separate thresholds for each emission mask option. Additionally, no comments were submitted on this issue. Therefore, we adopt the same field strengths for co-channel and adjacent channel emissions from LPTV and TV translator stations to wireless service as the ISIX Methodology provides for full power television stations, as shown below in Table 2.<sup>147</sup> We will also use the antenna elevation patterns for LPTV and TV translator stations in the Consolidated Database System (CDBS) or LMS (Licensing and Management System), the successor system to CDBS.<sup>148</sup> If CDBS/LMS does not include elevation pattern values for a given LPTV or TV translator station, the elevation pattern of these stations as they are defined in section 74.793(d) of our rules will apply.<sup>149</sup>

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
LPTV Field Strength into Wireless Uplink (dBμV/m)	17.3	18.2	19.5	21.2	24.0	34.4	61.4	62.5	63.7	65.5	68.6
LPTV Field Strength into Wireless Downlink (dBμV/m)	33.8	34.7	36.0	37.6	40.4	50.7	65.8	66.6	67.6	68.9	70.8

Table 2. Interference Field Strength Values for DTV into Wireless

51. We agree with CTIA that the more conservative F(50,10) statistical measure, rather than

<sup>143</sup> See *ISIX R&O*, 29 FCC Rcd at 13122, App. A (Technical Appendix), Tables 1 and 2.

<sup>144</sup> Low power stations are allowed to operate using the full power DTV emission mask, a “simple” emission mask or a “stringent” emissions mask. See 47 C.F.R. § 74.794.

<sup>145</sup> Section 74.793(c) specifies higher D/U ratios for adjacent channel protection of DTV signals from low power stations operating using the simple or stringent masks. See 47 C.F.R. § 74.793(c).

<sup>146</sup> *ISIX Further Notice*, 29 FCC Rcd at 13112, para. 82. Frequency dependent rejection (FDR) is an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations of acceptable interference levels. See *id.* at 13124, App. A, note 13 (Technical Appendix). This technique has been accepted for use by the ITU and is documented in its publication ITU-R SM.337-6. NTIA provides a computer-based implementation of this method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See *id.* FDR values were derived for all three emission masks versus the LTE wireless base station and user equipment receiver performance using NTIA’s MSAM FDR computer program. See *id.* at 13112, para. 82. The maximum difference in FDR was observed in the adjacent channel region and was less than 1 dB across the three emission masks.

<sup>147</sup> See *id.* at 13112, para. 82.

<sup>148</sup> *Id.* at 13113, para. 83.

<sup>149</sup> See 47 C.F.R. § 74.793(d).

F(50,50),<sup>150</sup> is appropriate when predicting the likelihood of harmful interference from LPTV and TV translator stations to 600 MHz wireless operations.<sup>151</sup> LPTV and TV translator stations, as secondary users, cannot cause interference to a licensee with primary status, including 600 MHz wireless licensees.<sup>152</sup> For purposes of the displacement notice, the goal is to predict harmful interference from secondary LPTV and TV translator stations so that wireless operators can commence operations on their primary licensed frequencies without suffering harmful interference. In this context, we find that the more conservative F(50,10) measure is appropriate when 600 MHz wireless licensees use the ISIX Methodology to predict if they will experience interference from LPTV or translator stations.

52. In the *ISIX Further Notice*, we sought comment on predicting potential interference from analog LPTV and TV translator stations using *TVStudy*'s capability to replicate an analog signal as an equivalent digital signal and analyze the station as though it were operating in digital.<sup>153</sup> *TVStudy* is software developed by the Commission's Office of Engineering and Technology to implement the methodology of OET-69.<sup>154</sup> No commenters addressed our proposal or suggested an alternative approach. Therefore, we will require that interference from analog LPTV and TV translator stations be analyzed using the approach proposed in the *ISIX Further Notice*. The interfering field strength of the "replicated" analog television signal should be treated the same as an interfering digital television signal when conducting the interference analysis.

### C. Inter-Service Interference During the Post-Auction Transition Period

53. We adopt our proposal in the *ISIX Further Notice* to protect full power and Class A television stations that have not yet relocated from the 600 MHz Band during the Post-Auction Transition Period in the same manner that we will protect stations that remain in or relocate to the 600 MHz Band. Inter-service interference is a potential concern during the Post-Auction Transition Period, the 39-month period following release of the *Channel Reassignment PN* during which television stations will relocate to their new channel assignments in order to clear the spectrum repurposed through the incentive auction and the repacking process for new 600 MHz Band licensees.<sup>155</sup> The clearing and relocation of television stations will occur in stages, as will the deployment of wireless networks in the 600 MHz Band. 600 MHz licensees may commence operations prior to the end of the Post-Auction Transition Period, as soon as their licensed frequencies are vacated by any full power or Class A television station that occupied

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<sup>150</sup> The F(50, 10) statistic indicates that the Longley-Rice model will return the signal level at which there is a 50% likelihood that the signal will be greater than this signal level 10% of the time. Thus, the overall area where the signal strength based on F(50,10) is greater than the interference threshold would be larger than the area using F(50,50).

<sup>151</sup> CTIA Comments at 12-13. In its Petition for Reconsideration of the *ISIX R&O*, Sprint raised the same issue. See *Sprint Petition for Reconsideration* at 15-16 (arguing that "applying F(50,50) as the protection requirement for LPTV and TV translators to wireless would mean that wireless operations are protected to a much lesser extent than would be required for interference from LPTV and TV translators to full power DTV stations"). In the accompanying *First Order on Reconsideration*, we explain why the less conservative F(50,50) statistical measure is appropriate when predicting interference from full power and Class A television stations to wireless operations for the purpose of identifying impairments during the auction. See *infra* paras. 64-72.

<sup>152</sup> CTIA Comments at 12-13.

<sup>153</sup> *ISIX Further Notice*, 29 FCC Rcd at 13113, para. 84.

<sup>154</sup> *Office of Engineering and Technology Releases Final Version of TVStudy and Releases Baseline Coverage Area and Population Served Information Related to Incentive Auction Repacking*, ET Docket No. 13-26, GN Docket No. 12-268, Public Notice, 30 FCC Rcd 6964 (OET 2015); *Office of Engineering and Technology Releases and Seeks Comment on Updated OET-69 Software*, ET Docket No. 13-26, GN Docket No. 12-268, Public Notice, 28 FCC Rcd 950 (OET 2013) (TVStudy PN).

<sup>155</sup> See 47 C.F.R. § 27.4.

those frequencies prior to the incentive auction, creating a potential for interference between the wireless operations and television stations that have not transitioned yet.<sup>156</sup>

54. Under the proposal we adopt, a wireless operator commencing operations before the end of the Post-Auction Transition Period must perform an OET-74 analysis when it intends to deploy base stations within the culling distance of a co-channel or adjacent channel full power or Class A television station that is operating in the 600 MHz Band to predict whether its wireless operations in all or part of its license area would cause harmful interference to the reception of signals from nearby television stations, regardless of whether these television stations will be relocated by the end of the Post-Auction Transition Period.<sup>157</sup> Consistent with the requirements adopted above, the wireless licensee must retain the latest copy of its OET-74 interference analysis, make this analysis available for inspection by the Commission at any time, and make this analysis available to a television station upon request when there are complaints of interference either from the subject television station or a station viewer.<sup>158</sup> In addition, if there are co-channel or adjacent channel television stations in the wireless licensee's uplink spectrum, the wireless provider must limit its service area to ensure that user equipment does not operate within five kilometers of the contour when co-channel or within a half kilometer when adjacent channel.<sup>159</sup> Consistent with the rules set forth above, once a nearby full power or Class A station has transitioned from its pre-auction channel, the 600 MHz Band licensee need no longer limit its operations in order to protect the station from inter-service interference.

55. Television stations assigned to the 600 MHz Band in the repacking process may not actually relocate to their assigned channel until late in the 39-month transition period. However, we will not permit wireless licensees to deploy networks in the period before the station relocates in areas that will potentially interfere with these television stations once they commence broadcasting. This is to prevent consumers from becoming reliant on wireless networks that will have to discontinue service after a relatively short time period. Consequently, television stations that have not yet constructed their new facilities will be protected from inter-service interference during the Post-Auction Transition Period based on the contours specified in their initial post-auction construction permits.<sup>160</sup> An initial post-auction construction permit may include a slight contour increase from that assigned in the *Channel Reassignment PN*.<sup>161</sup> Therefore, a 600 MHz wireless licensee that wants to commence operations prior to the end of the Post-Auction Transition Period will have to protect television stations that are operating co-channel or adjacent channel at that time and television stations that will be operating co-channel or adjacent channel by the end of the Post-Auction Transition Period.

#### **D. Assessing Interference from and to International Broadcast Television Stations During the Auction**

56. We adopt our proposal to use the ISIX Methodology to identify impairments to repurposed 600 MHz spectrum along the international borders during the auction.<sup>162</sup> The U.S.-Canada

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<sup>156</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6782, para. 525. The Commission has determined that a 600 MHz Band wireless licensee "commences operations" when it conducts site commissioning tests. *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, FCC 15-140, para. 7 (adopted Oct. 21, 2015).

<sup>157</sup> *ISIX Further Notice*, 29 FCC Rcd at 13113, para. 86. See *supra* paras. 32-33.

<sup>158</sup> See *supra* para. 37.

<sup>159</sup> See *supra* para. 30.

<sup>160</sup> See CEA Comments at 23-24 (seeking clarification on this point); CTIA Reply at 8; see also 47 C.F.R. § 73.3700(b)(1).

<sup>161</sup> See *supra* n.126.

<sup>162</sup> See *ISIX Further Notice*, 29 FCC Rcd at 13114, paras. 88-89.

*Statement of Intent* provides that Canadian television stations will not be placed in the 600 MHz Band, and therefore Canadian television stations will not cause interference to U.S. wireless operations in the 600 MHz spectrum.<sup>163</sup> By the same token, U.S. wireless operations in the 600 MHz Band will not cause interference to the reception of Canadian television station's signals. However, U.S. television stations in the 600 MHz Band could cause interference to or experience interference from Canadian wireless operations. During the incentive auction, the ISIX Methodology will be used to predict interference from U.S. television stations to Canadian wireless operators (Cases 1 and 2). In accordance with the *Statement of Intent*, the ISIX Methodology will use F(50,10) signal strength predictions for the signals from U.S. television stations and will assume the Canadian wireless base stations are 50 meters above ground level.<sup>164</sup> Even though the U.S. and Mexico have not reached an agreement on inter-service interference between television and wireless operations across the U.S.-Mexico border, coordination letters have been exchanged which provide a channel plan for the reassignment of broadcast television stations in the border region.<sup>165</sup>

57. Because the ISIX methodology is not designed for analog signals, and Canada and Mexico have not completed their digital transitions, we will use *TVStudy's* capability to "replicate" a Canadian or Mexican analog signal as an equivalent digital signal and analyze the station as though it is transmitting a digital signal.<sup>166</sup>

### III. FIRST ORDER ON RECONSIDERATION

#### A. ISIX Methodology

58. In the *ISIX R&O*, we adopted the ISIX Methodology for use during the incentive auction to predict the extent to which 600 MHz Band wireless licenses may be impaired due to potential interference to, and from, broadcast television stations assigned to the 600 MHz Band as a result of market variation.<sup>167</sup> We received several petitions for reconsideration regarding the ISIX Methodology. We are reaffirming our decision to use the ISIX Methodology for predicting impairments during the incentive auction and will not make the changes to the methodology requested by the petitioners. However, we will make a number of adjustments to the ISIX Methodology to be consistent with the decisions we have made in the accompanying *Third Report and Order* regarding OET-74, to reflect recent Commission decisions, and to reflect updates and revisions of input values and settings of the ISIX software.

#### 1. Using the ISIX Methodology to Determine Wireless License Impairments During the Auction

59. *Background.* As we explained in the *ISIX R&O*, the ISIX Methodology accommodates market variation in a more spectrally efficient manner than a fixed geographic separation distances approach.<sup>168</sup> A fixed distance-based approach would group together different inter-service interference

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<sup>163</sup> Statement of Intent Between the Federal Communications Commission of the United States of America and the Department of Industry of Canada Related to the Reconfiguration of Spectrum Use in the UHF Band for Over-The-Air Television Broadcasting and Mobile Broadband Services (Aug. 2015) (*Statement of Intent*), available at <https://transition.fcc.gov/ib/sand/agree/files/PASIIC.pdf>, paragraph 1.7.1; *but see* n.4 (recognizing that clearing targets of 130 MHz or 144 MHz would require additional measures agreed to by both countries).

<sup>164</sup> *Id.* at App. 4 (Planning Factors for Limiting Inter-Service Interference (ISIX)).

<sup>165</sup> See Letter from Mindel De La Torre, Chief, International Bureau, FCC to Ricardo Castaneda Alvarez, Director General de Ingenieria y Estudios Tecnicos, IFT (dated July 15, 2015); Letter from Alejandro Navarrete Torres to Mindel De La Torre, Chief, International Bureau, FCC (dated July 15, 2015) available at <https://www.fcc.gov/encyclopedia/international-agreements> (*Coordination Letters*).

<sup>166</sup> See *ISIX R&O*, 29 FCC Rcd at 13114, para. 89.

<sup>167</sup> *ISIX R&O*, 29 FCC Rcd. 13083-104, paras 23-60.

<sup>168</sup> See *id.* at 13084, para. 25, 13085, para. 28.

scenarios (e.g., wireless base station to television receiver, television transmitter to wireless user equipment, etc.) and apply separation distances based on worst case scenarios without considering factors like technical characteristics (i.e. antenna height, power), terrain variability, and density of population.<sup>169</sup> By contrast, the ISIX Methodology's tailored approach to different interference scenarios and its ability to account for factors that will mitigate interference in individual cases make it significantly more spectrally efficient than a fixed distance-based approach.<sup>170</sup> Moreover, we determined that the granularity of the data produced by the ISIX Methodology is better suited to the requirements of conducting the incentive auction than a fixed distance-based approach.<sup>171</sup> Although we noted that the ISIX Methodology may be characterized as more complex than a fixed distance-based approach, we determined that the costs of any increased complexity were outweighed by the benefits the ISIX Methodology produces in terms of more accurate predictions and more granular data.<sup>172</sup>

60. In its Petition for Reconsideration, NAB claims that the ISIX Methodology will fail to predict wireless impairments "with any useful degree of accuracy" because wireless carriers will have to use a "different methodology" following the auction based on real-world deployments.<sup>173</sup> NAB repeats its recommendation made in several of its filings in this proceeding that, instead of the ISIX Methodology, we should use a fixed distance-based approach, because doing so would be "far easier to implement and will not sacrifice meaningful spectral efficiency."<sup>174</sup> CTIA opposes NAB's request, stating that the "ISIX Methodology adopted by the Commission is the best available means of addressing a highly challenging post-repacking interference environment."<sup>175</sup>

61. *Discussion.* We deny NAB's Petition for Reconsideration of the use of the ISIX Methodology to predict inter-service interference for the purpose of determining license impairments in the forward auction. NAB offers no basis to revisit our conclusion that the ISIX Methodology accommodates market variation in a more spectrally efficient manner than a fixed distance-based approach, and that any costs in terms of increased complexity resulting from the ISIX Methodology are outweighed by the benefits of increased accuracy and granularity. We disagree with NAB's claim that the decision to use a different methodology to predict inter-service interference after the auction calls into question the accuracy of the ISIX Methodology for predicting impairments during the auction.<sup>176</sup> The differences in methodology reflect the fact that wireless networks will not be deployed at the time of the auction, thus requiring certain assumptions to be made regarding their technical characteristics when predicting impairments. Our decision to base post-auction interference predictions on real-world deployments does not undermine the reasonable assumptions we have made to predict impairments during the auction before wireless networks have been deployed.

## 2. Assumed Technical Parameters for Wireless Base Stations

62. *Background.* The ISIX Methodology assumes that hypothetical 600 MHz wireless base stations will operate with non-directional transmitting antennas at 30 meters height above average terrain

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<sup>169</sup> *See id.*

<sup>170</sup> *See id.* at 13084, para. 25, 13085, para. 28, 13092, para. 41.

<sup>171</sup> *See id.* at 13092, para. 41 ("The ISIX Methodology provides for a cell-by-cell determination of license impairments which will allow the Commission to make more informed decisions about the appropriate clearing targets for the reverse auction and which wireless spectrum blocks to auction in the forward auction, and also provide additional certainty to bidders in the forward auction.") (footnote omitted).

<sup>172</sup> *See id.* at 13084, para. 25, 13092, para. 41.

<sup>173</sup> NAB Petition for Reconsideration at 6-7; NAB Reply at 5.

<sup>174</sup> NAB Petition for Reconsideration at 7; NAB Reply at 6.

<sup>175</sup> CTIA Opposition and Reply at 5-6.

<sup>176</sup> NAB Petition for Reconsideration at 6-7.

(HAAT) and 120 W/MHz Effective Radiated Power (ERP).<sup>177</sup> NAB notes that these assumed technical parameters are less than what is permitted by the Commission's rules governing 600 MHz operations.<sup>178</sup> Repeating arguments it made earlier in the proceeding, NAB contends that the ISIX Methodology understates the potential for inter-service interference because carriers are permitted to use taller towers and operate at higher power than these assumed technical parameters.<sup>179</sup>

63. *Discussion.* We reject NAB's claims that the technical parameters for wireless base stations we adopted in the ISIX Methodology understate that potential for inter-service interference and should be adjusted to reflect the maximum values permitted under our rules.<sup>180</sup> NAB's claims were fully considered and rejected in the *ISIX R&O*.<sup>181</sup> As we explained there, the typical values for wireless base station power and height were obtained from advisory committees and industry submissions in the record.<sup>182</sup> NAB does not refute this evidence and fails to offer any new evidence for revisiting this issue.<sup>183</sup>

### 3. Use of the F(50,50) Statistical Parameter

64. *Background.* For inter-service interference Case 1 (DTV to wireless base station) and Case 2 (DTV to wireless user equipment), the ISIX Methodology predicts interference using a F(50,50) statistical measure, which assumes that a DTV signal is strong enough to interfere with the wireless base station or wireless user equipment in 50 percent of the locations within the wireless license area 50 percent of the time.<sup>184</sup> We determined that the F(50,50) statistical measure would be more appropriate than the more conservative F(50,10) measure.<sup>185</sup> First, we noted that the majority of wireless providers, who have the greatest stake in the accuracy of predicted inter-service interference to wireless operations, supported use of the F(50,50) measure.<sup>186</sup> Second, we explained that the F(50,50) measure will not risk harming broadcasters because it will be applied only during the incentive auction and only to predict interference to wireless operations from television stations for auction-related purposes, not to protect

<sup>177</sup> See *ISIX R&O*, 29 FCC Rcd at 13098-100, paras. 51-53.

<sup>178</sup> NAB Petition for Reconsideration at 8; NAB Reply at 5. The Commission's rules authorize a HAAT of up to 305 meters and an ERP of up to 1000 W/MHz. 47 C.F.R. § 27.50(c).

<sup>179</sup> NAB Petition for Reconsideration at 8.

<sup>180</sup> NAB Petition for Reconsideration at 8; NAB Reply at 5. See also *ISIX R&O*, 29 FCC Rcd at 13098-99, para. 51.

<sup>181</sup> Under Commission rules, if a petition for reconsideration simply repeats arguments that were previously fully considered and rejected in the proceeding, it will not likely warrant reconsideration. 47 C.F.R. § 1.429(l)(3); *Connect America Fund*, WC Docket No. 10-90, Sixth Order on Reconsideration and Memorandum Opinion and Order, 28 FCC Rcd 2572, 2573, para. 3 (2013) (*Connect America Fund*).

<sup>182</sup> See *ISIX R&O*, 29 FCC Rcd at 13098-100, paras. 51-53.

<sup>183</sup> NAB claims that wireless carriers in the 600 MHz Band are "likely" to use the spectrum to enhance coverage, rather than for densification of their networks, which NAB claims "may" result in higher towers and higher powers for wireless base stations than assumed by the ISIX Methodology. NAB Petition for Reconsideration at 8. NAB offers no support for this assertion, nor have wireless carriers made such claims or otherwise objected to the technical parameters for wireless base stations assumed in the ISIX Methodology. Further, NAB's concerns will be addressed under the post-auction inter-service interference framework, where interference from wireless operations to broadcast television is prohibited.

<sup>184</sup> See *ISIX R&O*, 29 FCC Rcd at 13090, para. 37.

<sup>185</sup> See *id.* at 13087, 13720, paras. 32, 37. The ISIX Methodology compares the DTV field strength calculated using the Longley-Rice model to an interference threshold to estimate whether interference will occur. The F(50, 10) statistic indicates that the Longley-Rice model will return the signal level at which there is a 50% likelihood that the signal will be greater than this signal level 10% of the time. Thus, the overall area where the signal strength based on F(50,10) is greater than the interference threshold would be larger than the area using F(50,50).

<sup>186</sup> See *id.*

television signals after the auction.<sup>187</sup> Third, we explained that use of the F(50,50) measure is appropriate because various techniques are available to wireless operators to avoid harmful interference to wireless base stations that are not available to television stations or viewers.<sup>188</sup>

65. Sprint and NAB, supported by CTIA and CCA, seek reconsideration of this decision.<sup>189</sup> They argue that use of F(50,50) measure will underestimate the harmful interference that a wireless operator is likely to experience from co-channel or adjacent channel television stations,<sup>190</sup> and thereby create bidder uncertainty, reduce forward auction participation, and reduce auction revenue.<sup>191</sup> Sprint provides a study of the differences in the predicted amount of interference when the F(50,50) and F(50,10) statistical measures are used, demonstrating very little difference in predicted interference to wireless operations in areas near a television station, but more significant differences as the distance from the television station increases.<sup>192</sup> Sprint also questions the feasibility of mitigation techniques, arguing there are limits to how much can be done to mitigate interference problems in Case 1 (DTV to wireless base station) without also jeopardizing wireless coverage and significantly increasing deployment costs.<sup>193</sup> Petitioners contend that use of the F(50,10) measure would better inform forward auction bidders of the interference environment and the limitations on their 600 MHz licenses.<sup>194</sup> By contrast, T-Mobile and U.S. Cellular support use of the F(50,50) statistical measure, arguing that it provides ample information for use during the auction.<sup>195</sup>

66. *Discussion.* We deny Sprint's and NAB's Petitions for Reconsideration and affirm our decision in the *ISIX R&O* to use the F(50,50) statistical measure in the ISIX Methodology during the auction to predict the strength of an interfering television signal within wireless license areas (Cases 1 and 2). As discussed below, we affirm our conclusion that F(50,50) is an appropriate statistical measure for this purpose, whereas the F(50,10) measure is unnecessarily conservative. In any event, bidders in the forward auction will have the necessary information to make their own calculations of impairments based on any number of factors they wish to consider, including their choice of statistical parameter.

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<sup>187</sup> See *id.*

<sup>188</sup> See *id.*

<sup>189</sup> See Sprint Petition for Reconsideration at 1-15; NAB Petition for Reconsideration at 8-9. See also CCA Reply at 2-5; CTIA Opposition and Reply at 2-4. Sprint states that new facts and circumstances have emerged since the release of the *Second Report and Order* that require reconsideration of our decision to use F(50,50). See Sprint Petition for Reconsideration at 3-5 (citing 47 C.F.R. § 1.429(b)(2)-(3)). Specifically, Sprint notes that, after release of the *Second Report and Order*, the Commission released the *Comment PN*, which provided potential forward auction bidders with substantial additional information about how the Commission proposed to apply the ISIX Methodology. See *id.* (citing *Comment Sought on Competitive Bidding Procedures for Broadcast Incentive Auction 1000, Including Auctions 1001 and 1002*, GN Docket No. 12-268, AU Docket No. 14-252, Public Notice, 29 FCC Rcd 15750 (2014) (*Comment PN*)).

<sup>190</sup> See Sprint Petition for Reconsideration at 2-3, 8-15; NAB Petition for Reconsideration at 8-9. See also CCA Reply at 2-3; CTIA Opposition and Reply at 3-4.

<sup>191</sup> See Sprint Petition for Reconsideration at 2-3, 15; NAB Petition for Reconsideration at 8-9. See also CCA Reply at 2-3; CTIA Opposition and Reply at 3-4.

<sup>192</sup> See Sprint Petition for Reconsideration at 8-12.

<sup>193</sup> See Sprint Petition for Reconsideration at 13-14.

<sup>194</sup> See Sprint Petition for Reconsideration at 3, 11-12; NAB Petition for Reconsideration at 8-9. See also CCA Reply at 3-4; CTIA Opposition and Reply at 2-4.

<sup>195</sup> Letter from Trey Hanbury, Hogan Lovells, Counsel to T-Mobile USA, to Marlene H. Dortch, Secretary, FCC, GN Docket 12-268 (filed Apr. 2, 2015) (*T-Mobile Ex Parte*); Letter from Leighton T. Brown, Holland & Knight, LLP, Counsel for United States Cellular Corporation to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, AU Docket No. 14-252 at 1 (filed May 12, 2015) (*U.S. Cellular Ex Parte*).

67. Contrary to petitioners' concerns, the ISIX Methodology will not underestimate impairments even when using the F(50,50) statistical measure given the approach the methodology employs to assess potential interference to wireless deployments. The ISIX methodology for Case 1 (DTV to wireless base station) and Case 2 (DTV to wireless user equipment) predicts only the field strength of the undesired signal—the signal of the television station causing interference. It does not consider the desired signal—the wireless signal—at each of the prediction points evaluated. It also does not consider any environmental factors in the area like clutter that could weaken the undesired DTV signal.<sup>196</sup> These simplifications are necessary because during the auction the Commission will not know specific information about the networks that wireless licensees will deploy.<sup>197</sup> Under the ISIX Methodology, any DTV signal predicted to be at a level above the minimum wireless receiver interference threshold is considered an impairment.<sup>198</sup> The amount of interference that a receiver can actually tolerate, however, is a function of the strength of the wireless signal received and not just the sensitivity level of the receiver. This approach will tend to overestimate interference because, in most instances, the wireless signal will be strong enough to enable the receiver to tolerate a stronger DTV signal without experiencing harmful interference. In addition, because we do not consider environmental factors like clutter in our predictions, the actual undesired DTV signal would likely be weaker than the Longley-Rice model predicts. Thus, actual harmful interference is less likely to occur than use of the F(50,50) statistical measure would predict.

68. The support of the wireless industry for median propagation statistics, like F(50,50), in other contexts lends further support for our use of F(50,50) for Cases 1 and 2. Specifically, studies by several working groups of the Commerce Spectrum Management Advisory Committee (CSMAC), which is composed of spectrum policy experts from the government and the wireless industry, have used median propagation statistics when evaluating the interference environment between commercial wireless operations and federal ground operations.<sup>199</sup> The results of those studies created the foundation upon which sharing between these services will occur in the AWS-3 band. Median propagation statistics were also used to evaluate LTE interference to Federal Government stations and to create protection zones around the Federal Government station locations, rather than more conservative propagation statistics like F(50,10).<sup>200</sup>

69. While Sprint claims that the interfering signal levels predicted using the F(50,50) and F(50,10) measures can differ by more than 10 dB at distances beyond 50 kilometers from the DTV station,<sup>201</sup> these differences do not persuade us to adopt F(50,10). First, as we noted in the *ISIX R&O*, there are various techniques available to wireless operators to avoid harmful interference.<sup>202</sup> While Sprint

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<sup>196</sup> See *ISIX R&O*, 29 FCC Rcd at 13089-90, para. 36.

<sup>197</sup> For example, the exact locations of towers, the power of each base station, the orientation of antennas, etc. will impact the probability of wireless licensees experiencing actual interference. This information will not be known until wireless licensees begin designing, building, and operating their networks.

<sup>198</sup> This receiver interference threshold is based on the receiver's sensitivity level as specified in the 3GPP Technical Specification. *ISIX R&O*, 29 FCC Rcd at 13122-23, Appendix A: para. 13, Table 3, Table 4.

<sup>199</sup> CSMAC approved reports by a number of working groups, one of which was Working Group 5 for aeronautical mobile operations, with SubWorking Group 5 which studied ACTS. See CSMAC WG5, ACTS SWG ACTS Final Report at 14 (Commerce Spectrum Management Advisory Committee Working Group 5, 1755-1850 MHz Airborne Operations, Air Combat Training System, Sub-Working Group Report).

<sup>200</sup> Moreover, given that other considerations such as clutter were not used, the median interference predictions were considered to be conservative enough to identify triggers for coordination.

<sup>201</sup> See Sprint Petition for Reconsideration at 9.

<sup>202</sup> *ISIX R&O*, 29 FCC Rcd at 13090, para. 37 (noting Multiple-Input Multiple-Output (MIMO) antenna technology and resource block provisioning).

previously agreed with this point,<sup>203</sup> it now claims that there is a limit to those techniques because they can jeopardize wireless coverage and significantly increase deployment costs.<sup>204</sup> Sprint's arguments are not persuasive. Current wireless broadband technologies include features like smart antennas and beam forming, and the LTE standard supports several MIMO configurations in multiple bands.<sup>205</sup> The fact that a wireless operator may choose to deploy only the minimal MIMO configuration is no reason to discount the benefit of available interference mitigation techniques that will allow for more efficient use of spectrum between services. Nonetheless, even use of the minimum configuration supported by the LTE standard provides interference mitigation advantages over traditional network technologies. Moreover, all of these features are expected to be prevalent by the time wireless networks are deployed in the 600 MHz Band because they will allow for avoidance of capacity constraints or network congestion and provide users with an improved quality of experience.

70. Second, the higher DTV signal levels predicted using F(50,10) will generally be offset by operating margins wireless licensees build into the operation of their networks. Specifically, wireless licensees design their networks to achieve reliable service with a robust wireless signal, with propagation statistics of 90 percent or greater.<sup>206</sup> This increases the planned wireless signal strength over the median value by 10 dB or more and helps to maintain the reliability of mobile operations.<sup>207</sup> The margin provided in this planned signal level will more than offset any differences between F(50,50) and F(50,10) in the Commission's inter-service interference predictions.<sup>208</sup>

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<sup>203</sup> Comments of Sprint Corp. to *ISIX PN*, ET Docket No.14-14, GN Docket No. 12-268 (filed Mar. 18, 2014) at 3.

<sup>204</sup> Sprint Petition at 13-14. Sprint agrees that base station antenna down-tilt could help lower the interfering signal by a few dBs, but claims it would not be able to overcome increased levels of interference of 10 dB or more. While Sprint is correct in its assertion regarding the effect of antenna downtilt, it assumes that a wireless operator will operate its network at service threshold values used in our predictions. Usually wireless operators construct their networks in such manner that target population areas are served with a higher service reliability, which means with a higher signal strength than the threshold value.

<sup>205</sup> Comments of 4G Americas, ET Docket 14-14, GN Docket 12-268 (filed Mar.18, 2014).). In addition, LTE standards continue to evolve, with each new release including more techniques for interference avoidance. See 4G Broadband Mobile Evolution, 3GPP Release 11 & 12 and Beyond (Feb. 2014) available at [http://www.4gamericas.org/files/2614/0758/7473/4G\\_Mobile\\_Broadband\\_Evolution\\_Rel-11\\_Rel\\_12\\_and\\_Beyond\\_Feb\\_2014\\_-\\_FINAL\\_v2.pdf](http://www.4gamericas.org/files/2614/0758/7473/4G_Mobile_Broadband_Evolution_Rel-11_Rel_12_and_Beyond_Feb_2014_-_FINAL_v2.pdf).

<sup>206</sup> See, e.g., *Wireless Communications Systems Performance in Noise and Interference-Limited Situations, Part 1: Recommended Methods for Technology Independent Performance Modeling*, TIA Bulletin TSB-88.1-D, April 2012. Specifically, see *id.* at Section 5.2 – *Channel Performance Criterion (CPC)*: “The CPC is the specified design performance level in a faded channel. ... It is defined as a ratio of the Rayleigh faded carrier magnitude ... [c]onstantly Rayleigh faded (e.g. 100% of the time) ... to the sum of all the appropriate interfering and noise sources.” See also *id.* at Section 5.3.4 – *Tile Reliability*: “The Tile Reliability is the probability that the received local median signal strength predicted at a given tile equals or exceeds the desired CPC” and Section D.3: *General Assumptions, Table D.6: Estimated Coverage Area Reliability*, recommending the use of at least 90 percent as an appropriate value for coverage area reliability for wireless communications systems in general. Taken together, these recommendations would imply that F(90,100) is a typical planning metric for predicting the coverage of wireless communications systems.

<sup>207</sup> We analyzed the difference in the F(50,90) and F(50,50) field strength curves based on our ISIX assumptions for LTE eNB ERP and HAAT. At field strengths equal to the co-channel ISIX interference threshold (17.3 dB $\mu$ V/m) the difference in the two curves was approximately 10 dB.

<sup>208</sup> Where a typical DTV signal is predicted to be at the threshold sensitivity value for the wireless receiver, F(50,50) is approximately 10 dB lower than the signal level that is predicted using F(50,10). However, where a typical wireless signal is predicted to be at its threshold value, F(50,50) is approximately 10 dB higher than the signal level that is predicted using F(50,90). Thus, when planning for service in a particular area, the margin applied to achieve reliable service will meet or exceed the margin applied to consider a DTV signal as interfering in the ISIX model.

71. We find that the costs of using the more conservative F(50,10) statistical measure would be significant, with no significant offsetting benefits. Use of a more conservative statistical measure would potentially result in fewer wireless blocks being available for auction.<sup>209</sup> Moreover, while CCA argues for “a more granular” F(50,10) statistical measure,<sup>210</sup> there is no “more detail” to a F(50,10) calculation than there is with an F(50,50) calculation. Both statistical measures can be used with a variety of grid sizes, and an F(50,10) prediction on a two-by-two kilometer grid does not provide any higher resolution than an F(50,50) prediction. The difference is that with F(50,10) there may be more points above the assumed threshold over any given area than with F(50,50). This difference, however, goes to the signal levels predicted by the F(50,10) statistical measure rather than its detail.

72. Finally, we emphasize that forward auction bidders will have the necessary information during the auction to perform their own interference analyses, including using the information to conduct an analysis using the more conservative F(50,10) statistical measure if they so choose.<sup>211</sup> In response to the requests of prospective forward auction bidders, the Commission in the *Bidding Procedures PN* decided that prior to the commencement of forward auction bidding in any given stage, it will release to forward auction bidders detailed information on the impairments potentially affecting a particular PEA, including the source and location of the impairments.<sup>212</sup> With this detailed information bidders will know for each impaired license block the percentage of impairment (by population), whether it is located in the uplink or downlink band, and the geographic location of the impairment, and can use facility information about the impairing station to determine how their wireless networks could be deployed around the impairment.<sup>213</sup> Bidders will be able to conduct their own detailed analysis of how the impairing television stations will affect their specific planned network deployment, including using the statistical measure of their choosing.

#### 4. Revisions to D/U Thresholds for Case 3 (Wireless Base Station to Digital Television Receiver)

73. *Background.* The ISIX Methodology for Case 3 adopted in the *ISIX R&O* predicts potential interference from wireless base stations to television receivers by comparing the ratio of the desired DTV signal to the undesired wireless signal (D/U ratio) against a D/U threshold. These D/U thresholds include an adjustment factor “ $\alpha$ ”.<sup>214</sup> In the companion *Third Report and Order*, we adjusted the D/U thresholds and the adjustment factor “ $\alpha$ ” in the context of predicting potential interference post-auction.<sup>215</sup> As discussed above, these adjustments address concerns CEA raised in the record about the value of the adjustment factor “ $\alpha$ ” and bring the adjacent channel thresholds in line with the ATSC receiver guidelines and Commission rules.<sup>216</sup>

74. *Discussion.* We revise the ISIX Methodology to reflect the adjustments to the D/U thresholds for the Case 3 interference scenario we adopted above in the companion *Third Report and*

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<sup>209</sup> See *T-Mobile Ex Parte* at 2.

<sup>210</sup> CCA Reply at 2.

<sup>211</sup> See *T-Mobile Ex Parte* at 3 (“the Commission should make available enough information to allow carriers to perform the F(50,10) calculations themselves”); *U.S. Cellular Ex Parte* at 1 (“Bidders do not . . . specifically require the results of the F(50,10) model so long as the Commission provides them with sufficient information to make these calculations themselves”).

<sup>212</sup> See *Bidding Procedures PN*, 30 FCC Rcd at 9043-44, para. 134.

<sup>213</sup> *Id.* at para. 131.

<sup>214</sup> The scaling factor “ $\alpha$ ” is dependent on the signal-to-noise ratio (S/N ratio) of the received television signal. See *supra* para. 14.

<sup>215</sup> See *supra* paras. 14-17.

<sup>216</sup> See CEA Comments at 16-19; see also *supra* paras. 15-17.

*Order*.<sup>217</sup> These interference threshold values are an integral part of predicting inter-service interference both during and after the auction. These values are not assumptions that will change once the wireless networks are deployed. Accordingly, there is no basis to have interference threshold values applied during the auction to determine impairments that differ from the interference threshold values applied after the auction to determine interference. Therefore, we will update the interference threshold values in the ISIX Methodology to be consistent with the values adopted above. These updated values are listed in the revised version of the ISIX Methodology attached as Appendix D that will be used during the auction.

## 5. Miscellaneous Changes to the ISIX Methodology

75. The following is a list of miscellaneous changes made to the ISIX Methodology, which are reflected in Appendix D. These changes were made to reflect updates and revisions of input values and software settings to improve functionality and to reflect the U.S.-Canada *Statement of Intent* and decisions the Commission made in the *Bidding Procedures PN*.<sup>218</sup>

- Updated references to the LPTV digital transition.
- Updated references to license categories which were adopted in the *Bidding Procedures PN*.
- Revised references to emission limits and receiver standards in paragraph 13 to reflect the use of the FCC's emission limits for DTV and wireless receiver performance standards published by 3GPP.
- Provided threshold values for inter-service interference calculations in the repacking process along the border regions. These values do not relate to the computation of impairments on 600 MHz licenses.
- Added an explanation in paragraph 31 that for Case 3, the base station transmitter azimuth pattern is assumed to be non-directional and is based on UHF DTV vertical pattern described in OET Bulletin No. 69, Table 8. However, the elevation pattern is assumed to be symmetrical above and below the maximum.
- Table 14 lists the *TVStudy* settings unique to the ISIX Methodology.<sup>219</sup>
- In Table 15, the entry HAS\_EPAT was changed from "False" to "True" because *TVStudy* will import the pattern in the XML scenario.
- Paragraph 38 updated to indicate that the elevation pattern for each base station must be imported in the XML file and lists the values for the symmetrical generic pattern.

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<sup>217</sup> See *supra* at paras.14-17. Specifically, we revise the equation for the D/U thresholds and Table 7 (Threshold Interfering D/U Ratios for Wireless Base Station into DTV) and Table 12 (Calculated Off-Frequency Rejection (OFR) values for Wireless into DTV) of the Case 3 interference scenario of the ISIX Methodology. See *ISIX R&O*, 29 FCC Rcd at 13128, 13130-31, Appendix A: para. 27, Table 7, Table 12.

<sup>218</sup> See *supra* at para. 56.

<sup>219</sup> The updated ISIX Methodology reflects a change in a default setting in *TVStudy*. In the *ISIX Second Erratum* the entry for "Mirror Generic Pattern" in ISIX Cases 1 and 2 in Table 14 was "Yes", which was an incorrect setting for these cases. Appendix D corrects this inadvertent mistake and in Table 14, the entry for "Mirror Generic Pattern" in ISIX Cases 1 and 2 will be "No". *Expanding the Economic and Innovation Opportunities for Spectrum Through Incentive Auctions, Office of Engineering and Technology Releases and Seeks Comment on Updated OET-69 Software, Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Service*, GN Docket No. 12-268, ET Docket No. 13-26, ET Docket No.14-14, Second Erratum, 30 FCC Rcd 1255, 1256 (2015) (*ISIX Second Erratum*).

## B. Request for Additional Protection in the Repacking Process

76. As discussed below, we affirm our decision in the *ISIX R&O* declining to adopt an aggregate cap on new station-to-station interference in the repacking process. We also decline to establish a cap on population loss resulting from new channel assignments in the repacking process. We amend our rules, however, to provide that any station that is predicted to experience a loss in population served in excess of one percent as a result of the repacking process – either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both) – may file for an alternate channel or expanded facilities in a priority window.

### 1. Aggregate Cap on New Station-to-Station Interference

77. *Background.* Section 1452(b)(2) requires the Commission, in reorganizing or “repacking” the broadcast television bands, to “make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served” of eligible television stations.<sup>220</sup> Consistent with that requirement, the Commission in the *Incentive Auction R&O* adopted an approach to preserving population served under which “no individual channel reassignment, considered alone, will reduce another station’s population served . . . by more than 0.5 percent.”<sup>221</sup> Under this approach, the Commission will consider only station-to-station (or “pairwise”) interference when determining whether a particular channel assignment is permissible.<sup>222</sup>

78. In the *Incentive Auction R&O*, the Commission deferred consideration of whether to adopt a cap on the amount of total or aggregate new station-to-station interference that a broadcast station will be allowed to receive as a result of the repacking process.<sup>223</sup> The Commission resolved this issue in the *ISIX R&O*, declining to adopt a cap.<sup>224</sup> Relying on a staff study of the potential for aggregate interference in the repacking process,<sup>225</sup> the Commission concluded that the vast majority of stations were unlikely to experience aggregate new interference of more than one percent.<sup>226</sup> The Commission nonetheless adopted measures to address exceptional cases where a station is predicted to receive aggregate new interference in excess of one percent: (1) optimization techniques that seek to reduce aggregate interference in the final channel assignments;<sup>227</sup> and (2) the opportunity to file an application proposing an alternate channel or expanded facilities in a priority filing window.<sup>228</sup> In addition to explaining why an aggregate cap on new station-to-station interference was unnecessary, the Commission also explained that the proposed cap was not practical or realistic, because even if a means had been

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<sup>220</sup> 47 U.S.C. § 1452(b)(2).

<sup>221</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6649-50, para. 179. The Commission’s rules treat 0.5 percent interference or less as *de minimis* or no new interference, as this amount rounds to zero at integer precision. *Id.* at 6649, para. 178 n.598.

<sup>222</sup> See *id.* at 6649-51, paras. 179-82.

<sup>223</sup> See *id.* at 6651, para. 182.

<sup>224</sup> See *ISIX R&O*, 29 FCC Rcd at 13073-83, paras. 2-22.

<sup>225</sup> See *Incentive Auction Task Force Releases Updated Constraint File Data Using Actual Channels and Staff Analysis Regarding Pairwise Approach to Preserving Population Served*, GN Docket No. 12-268, ET Docket No. 13-26, Public Notice, 29 FCC Rcd 5687 (June 2, 2014) (*Aggregate Interference PN*).

<sup>226</sup> See *ISIX R&O*, 29 FCC Rcd at 13075-79, paras. 6-13 (explaining that the staff analysis applying the repacking approach adopted in the *Incentive Auction R&O* predicted that the overwhelming majority of stations (approximately 99 percent) will not experience new interference above one percent).

<sup>227</sup> See *id.* at 13079-80, paras. 14-15.

<sup>228</sup> See *id.* at 13079-80, para. 15.

identified for implementing it, an aggregate interference cap would deprive the reverse auction bidding process of its speed and, therefore, compromise the success of the incentive auction.<sup>229</sup>

79. CDE and NAB seek reconsideration of our decision declining to adopt an aggregate cap on new station-to-station interference.<sup>230</sup> NAB claims that post-auction optimization techniques are unlikely to address its concerns because such measures are used only after the initial repacking channel plan is determined.<sup>231</sup> Both NAB and CDE claim that the Commission did not adequately explain why an aggregate interference cap is complex or would slow down the auction process.<sup>232</sup>

80. *Discussion.* We deny the CDE and NAB petitions for reconsideration and affirm our decision in the *ISIX R&O* declining to adopt an aggregate cap on new station-to-station interference in the repacking process. We concluded in the *ISIX R&O* that the “vast majority” of stations were unlikely to experience aggregate new interference of more than one percent.<sup>233</sup> CDE contends that we did not define “vast majority.”<sup>234</sup> In fact, our use of the phrase “vast majority” was based on the staff study relied on in the *ISIX R&O*, which concluded that approximately 99 percent of stations will not experience new interference above one percent.<sup>235</sup> Neither CDE nor NAB challenge the staff study or otherwise dispute our conclusion that stations are unlikely to be experience significant new interference as a result of the repacking process. Moreover, in the *Bidding Procedures PN*, we adopted optimization techniques to reduce the maximum amount of aggregate new interference any single station could receive in the final channel assignments.<sup>236</sup> To be sure, optimization techniques are not guaranteed to prevent aggregate new interference over one percent because they are not used until the set of stations that will remain on the air after the auction is fixed.<sup>237</sup> Nonetheless, we believe they will serve as a useful “safety valve” for the small number of stations that face a disproportionately high amount of aggregate new interference, together with the opportunity to file an application proposing an alternate channel or expanded facilities in a priority filing window.<sup>238</sup>

81. Both CDE and NAB question our conclusion that a cap on new station-to-station interference in the repacking process will complicate and slow down the auction.<sup>239</sup> We explained in detail in the *ISIX R&O* how an aggregate interference cap would deprive the repacking feasibility checker of its speed.<sup>240</sup> CDE and NAB do not offer any reason to dispute this conclusion, nor do they propose a means of implementing an aggregate interference cap without compromising the speed of the bidding

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<sup>229</sup> See *id.* at 13080-81, paras. 16-19.

<sup>230</sup> See CDE Petition at 2-3; NAB Petition at 1-6.

<sup>231</sup> See NAB Petition at 4.

<sup>232</sup> See CDE Petition at 2-3; NAB Petition at 3-6.

<sup>233</sup> *ISIX R&O*, 29 FCC Rcd at 13075, para. 6.

<sup>234</sup> CDE Petition at 3.

<sup>235</sup> *ISIX R&O*, 29 FCC Rcd at 13075, para. 6 (citing *Aggregate Interference PN*, 29 FCC Rcd at 5706-08, Appendix).

<sup>236</sup> See *Bidding Procedures PN*, 30 FCC Rcd at 9103, para. 277. NAB did not submit comments in response to the *Comment PN* on how best to implement optimization techniques to address aggregate new interference. See *Comment PN*, 29 FCC Rcd at 15792-95, paras. 129-134, 15869, App. E.

<sup>237</sup> See *ISIX R&O*, 29 FCC Rcd at 13079-80, para. 15.

<sup>238</sup> In their Petitions, neither CDE nor NAB disputes the efficacy of the opportunity to file an application proposing an alternate channel or expanded facilities in a priority filing window. *ISIX R&O*, 29 FCC Rcd at 13079-80, para. 15. See also *infra* n.265.

<sup>239</sup> See CDE Petition at 2-3; NAB Petition at 4-6.

<sup>240</sup> See *ISIX R&O*, 29 FCC Rcd at 13080-81, paras. 16-19.

process. NAB, however, disputes the need for speed, asserting that broadcasters will not “drop out of the auction” in the event of delay.<sup>241</sup> NAB provides no basis for this assertion. Auction participation may require a significant amount of resources for some broadcasters. Devoting such resources over the course of weeks or months may not be feasible for such broadcasters, and may be very disruptive for others, potentially causing them to drop out of the auction if it takes too long. In addition, as we explained in the *Incentive Auction R&O*, speed is critical not only to prevent broadcasters from dropping out of the auction, but also to avoid dissuading broadcasters from participating in the first place.<sup>242</sup> Moreover, speed is critical not only for broadcaster participation, but also for forward auction participation, which NAB does not dispute.<sup>243</sup> NAB claims that we are concerned with speed and complexity only when considering measures that would increase protection for broadcast services, but have abandoned such concerns in accommodating market variation, which requires consideration of inter-service interference during the auction.<sup>244</sup> As we explained in the *ISIX R&O*, the required computations to assess inter-service interference during the auction will mostly be completed prior to the auction, and thus will not impact our ability to conduct the incentive auction bidding process with the speed necessary for the auction’s success.<sup>245</sup> NAB does not challenge this conclusion. Conversely, as explained in the *ISIX R&O*, assessing aggregate station-to-station interference would require a possibly exponential number of feasibility checks for each round of the auction based on provisional channel assignments, thereby depriving the repacking feasibility checker of its speed and threatening the success of the incentive auction.<sup>246</sup>

## 2. Population Loss Resulting from New Channel Assignments

82. *Background.* Shortly before adoption of the *ISIX R&O*, NAB in *ex parte* filings argued for the first time that, in addition to the potential for stations to lose viewers because of new station-to-station interference resulting from the repacking process, the Commission should also address the potential for stations to lose viewers because of new channel assignments.<sup>247</sup> Because radio signals propagate differently on different frequencies, the signal of a station reassigned to a different channel will generally not be receivable in precisely the same locations within a station’s contour as it was in its original channel.<sup>248</sup> Instead, there may be signal losses due to terrain in different areas within the

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<sup>241</sup> NAB Petition at 5.

<sup>242</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6618, para. 111. See also *ISIX R&O*, 29 FCC Rcd at 13080, para. 16.

<sup>243</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6618, para. 111 n.362 (“Because closing the incentive auction requires completion of the final stage of both the forward and the reverse auction, the possibility of significant delay in the latter could discourage participation in the forward auction . . .”).

<sup>244</sup> See NAB Petition at 4-5. While NAB also mentions complexity involving implementation of Dynamic Reserve Pricing (“DRP”), we decided in the *Auction Procedures PN* not to use DRP. See *Auction Procedures PN* at paras. 120-21.

<sup>245</sup> See *ISIX R&O*, 29 FCC Rcd at 13092, para. 41 n.143.

<sup>246</sup> See *id.* at 13080-81, para. 17 (“This iterative process would have to be repeated until either a provisional channel assignment were found that satisfies the cap or all possible assignments were eliminated. The same analysis would need to be performed repeatedly for *each station* that continues to participate in the bidding process.”) (emphasis in original).

<sup>247</sup> See Letter from Rick Kaplan, Executive Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26, at 2 (filed September 24, 2014) (NAB Sept. 24, 2014 Ex Parte); Letter from Rick Kaplan, Executive Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26; Letter from Patrick McFadden, Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26 (filed October 9, 2014) (NAB Oct. 9, 2014 Ex Parte).

<sup>248</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6646, para. 170.

contour.<sup>249</sup> In its *ex parte* filings, NAB asked the Commission to address both station-to-station interference and population loss resulting for new channel assignments by adopting a cap on “aggregate population loss.”<sup>250</sup> The Commission declined to do so in the *ISIX R&O* on procedural grounds, explaining that no commenter had previously advocated a cap on population loss resulting from new channel assignments and that this request was outside the scope of the item.<sup>251</sup> While the Commission declined to adopt NAB’s newly requested cap, it decided to use optimization techniques to seek to avoid final channel assignments that would result in significant viewer losses because of terrain.<sup>252</sup>

83. NAB seeks reconsideration of our decision declining to adopt a cap on population loss resulting from new channel assignments in the repacking process.<sup>253</sup> NAB argues that, in order to “make all reasonable efforts” to preserve service to viewers, the Commission must take steps to limit lost viewers resulting from a station’s assignment to a new channel.<sup>254</sup> NAB contends that the Commission failed to address its proposed approaches for incorporating its suggested cap into the repacking process.<sup>255</sup> Moreover, NAB argues that post-auction optimization techniques are unlikely to address its concerns regarding terrain loss.<sup>256</sup>

84. We note that NAB raised similar concerns regarding lost viewers resulting from a station’s assignment to a new channel in its appeal of the *Incentive Auction R&O* before the United States Court of Appeals for the District of Columbia Circuit (“D.C. Circuit”).<sup>257</sup> The court rejected NAB’s arguments, explaining that, under the “all reasonable efforts” standard in Section 1452(b)(2), it was “entirely permissible for the Commission to take into account the Spectrum Act’s overarching objective of repurposing broadcast spectrum,” and that the Commission “reasonably exercised its discretion in concluding that a prohibition against any reassignments carrying a risk of terrain loss would unduly limit its flexibility in connection with the reverse auction and repacking process.”<sup>258</sup> Thus, fact that some

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<sup>249</sup> *See id.*

<sup>250</sup> *See* NAB Sept. 24, 2014 Ex Parte at 2.

<sup>251</sup> *See ISIX R&O*, 29 FCC Rcd at 13082, para. 21.

<sup>252</sup> *See id.* at 13082-83, para. 22. The Commission did not adopt a specific optimization technique in the *ISIX R&O* to carry out this objective, explaining that it would seek further comment in the *Comment PN* on optimization factors for the final channel assignment scheme. *See id.* *See also Comment PN*, 29 FCC Rcd at 15792-95, paras. 129-134 (seeking comment on appropriate objectives in optimizing the final television channel assignment plan and on how to prioritize those objectives). In August 2015, the Commission adopted such optimization factors in the *Procedures PN*. *See Auction Procedures PN* at paras. 120-21 (explaining that the first objective of the final television channel assignment plan selection procedure will be to maximize the number of stations assigned to their pre-auction channels which will, among other things, avoid terrain losses that could result from channel changes due to signal propagation differences on different frequencies).

<sup>253</sup> *See* NAB Petition at 2-6.

<sup>254</sup> *See id.* at 3 (citing 47 U.S.C. § 1452(b)(2)).

<sup>255</sup> *See id.* 2-3.

<sup>256</sup> *See id.* at 4.

<sup>257</sup> *See* Joint Opening Brief for Petitioners National Association of Broadcasters and Sinclair Broadcast Group, Inc., Case No. 14-1154 (Nov. 7, 2014), at 58-59 (“[W]hile the FCC adopted a benchmark for population lost due to new interference, it did not consider establishing a similar benchmark for protecting viewers against terrain loss on a licensee’s new channel. The FCC also never considered calculating population served for each licensee on each channel as of February 22, 2012, and then simply excluding those channel reassignments that would result in more than a specified percentage change in a given licensee’s population served. The Commission simply ignored terrain losses and made no effort to compensate for them.”).

<sup>258</sup> *See National Ass’n of Broadcasters, v. FCC*, 789 F.3d 165, 178 (D.C. Cir. 2015).

stations may experience a change in their coverage area or population served at their new channel assignments does not violate our mandate under Section 1452(b)(2).<sup>259</sup>

85. *Discussion.* We grant in part and deny in part NAB's petition for reconsideration requesting that we adopt a cap on population loss resulting from new channel assignments in the repacking process. As an initial matter, we conclude that NAB's concerns about lost viewers due to new channel assignments are overstated. As explained in the *Incentive Auction R&O*, under the 600 MHz Band Plan the Commission will be seeking to repurpose UHF spectrum contiguously from channel 51 down, meaning that stations being reassigned to new channels within the UHF band generally will be assigned to channels lower in the band.<sup>260</sup> Because of the superior propagation characteristics on lower frequencies, such stations are likely to experience *decreases* rather than increases in coverage lost to terrain within their contours.<sup>261</sup> As a result, we expect most stations will not lose viewers as a result of terrain loss resulting from new channel assignments. Even if some stations are predicted to lose viewers as a result of terrain loss resulting from new channel assignments, our final television channel assignment plan selection procedure includes optimization techniques to address this concern.<sup>262</sup> As explained in the *Bidding Procedures PN*, final channel assignments will be made applying optimization techniques that take into account certain objectives, with the first priority to maximize the number of stations assigned to their pre-auction channel.<sup>263</sup> Because a station that stays on the same channel will not experience terrain loss, this optimization technique will reduce the number of stations losing viewers as a result of terrain loss.

86. In the event some stations are predicted to lose viewers as a result of new channel assignments even after optimization techniques are applied, there will be post-auction solutions to address this situation. First, as adopted in the *Incentive Auction R&O*, a television station may request up to a one percent coverage contour increase as part of its initial post-auction construction permit application, subject to certain conditions.<sup>264</sup> Second, we amend our rules to provide that stations predicted to experience a loss in population served in excess of one percent as a result of the repacking process - either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both) - may file an application proposing an alternate channel or expanded facilities in a priority filing window, along with a limited number of other stations that have been assigned the same

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<sup>259</sup> See *id.* ("Congress's instruction to make 'all reasonable efforts' to preserve the service of existing stations did not constrain the Commission to accept nothing more than a *de minimis* change in coverage area or population served in the repacking process.").

<sup>260</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6648, para. 174.

<sup>261</sup> See *id.*

<sup>262</sup> In *ex parte* submissions before adoption of the *ISIX R&O*, NAB cited the repacking simulations underlying the *Aggregate Interference PN* as demonstrating that 3.1 percent of stations would experience a loss in population served in excess of one percent, either because of new station-to-station interference or terrain loss resulting from a new channel assignment or both. See NAB Sept. 24, 2014 Ex Parte, Attachment at 5; NAB Oct. 9, 2014 Ex Parte, Attachment at 5. These repacking simulations, however, did not employ optimization techniques designed to minimize the number of stations relocated.

<sup>263</sup> *Bidding Procedures PN*, 30 FCC Rcd at 9101-02, paras. 273-74.

<sup>264</sup> Specifically, we allow stations to propose transmission facilities in their initial construction permit applications that will increase their coverage contour if such facilities: (1) are necessary to achieve the coverage contour specified in the *Channel Reassignment PN* or to address loss of coverage area resulting from their new channel assignment; (2) will not extend a full power station's noise limited contour or a Class A station's protected contour by more than one percent in any direction; and (3) will not cause new interference, other than a rounding tolerance of 0.5 percent, to any other station. See 47 C.F.R. § 73.7300(b)(1)(i); *Incentive Auction R&O*, 29 FCC Rcd at 6648, para. 175 and 6791, 548.

priority.<sup>265</sup> Third, we proposed in the *LPTV Third FNPRM* to allow a full power station that is predicted to experience a loss in its pre-auction digital service area as a result of its new channel assignment to seek authority to deploy a digital-to-digital replacement translator (“DTDRT”) to serve the loss area.<sup>266</sup> We previously created a similar analog-to-digital replacement translator service in 2009, as full power stations were transitioning from analog to digital operation, to assist full power television stations to restore service to any loss areas that may have occurred as a result of the transition.<sup>267</sup> A DTDRT would serve the same purpose and directly addresses the concern raised by NAB: to fill in a loss area that may result from the transition to a new channel.<sup>268</sup> Taken together, the optimization techniques, post-assignment facilities modification process, and the proposed ability to deploy DTDRTs will provide a “safety valve” in the exceptional cases where stations are predicted to lose viewers as a result of terrain loss.<sup>269</sup>

87. In addition to being unnecessary for the reasons described above, a cap on population loss resulting from new channel assignments as proposed by NAB would compromise the central objective of a successful auction to allow market forces to repurpose spectrum.<sup>270</sup> While Section 1452(b)(2) requires that we “make all reasonable efforts to preserve” each station’s coverage area and population served, we explained in the *Incentive Auction R&O* that this requirement does not mandate

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<sup>265</sup> In the *Incentive Auction R&O*, we decided to allow stations to propose alternate channels and expanded facilities following the repacking process. See *Incentive Auction R&O*, 29 FCC Rcd at 6793, para. 553. We announced a filing priority for stations unable to construct facilities that meet the technical parameters specified for their new channel for reasons beyond their control. See 47 C.F.R. § 73.3700(b)(1)(iv); *Incentive Auction R&O*, 29 FCC Rcd at 6794, para. 554. We also explained that a station that is dissatisfied with its new channel assignment due to terrain losses could seek an alternate channel or expanded facilities, but we did not provide these stations with a filing priority. See *Incentive Auction R&O*, 29 FCC Rcd at 6648, para. 175. In the *ISIX R&O*, we allowed stations predicted to experience a loss in population served in excess of one percent as result of new station-to-station interference in the repacking process to file for an alternate channel or expanded facilities in a priority window. See *ISIX R&O*, 29 FCC Rcd at 13079-80, para. 15. We now expand the priority filing opportunity adopted in the *ISIX R&O* as provided above to include stations predicted to experience a loss in population served resulting from a new channel assignment.

<sup>266</sup> See *Amendment of Parts 73 and 74 of the Commission’s Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations*, MB Docket No. 03-185, Third Notice of Proposed Rulemaking, 29 FCC Rcd 12536, 12548-49, paras. 29-31 (2014) (*LPTV Third FNPRM*). A full power station’s “service area” is the area within its noise-limited F(50,90) contour where the signal strength is predicted to exceed the noise-limited service level. 47 C.F.R. § 73.622(e). We proposed that applications for DTDRTs will have processing priority over all LPTV and TV translator new, minor change, or displacement applications, even if the latter is filed first, and co-equal priority with displacement applications for existing analog-to-digital replacement translators filed on the same day. See *LPTV Third FNPRM*, 29 FCC Rcd at 12550, para. 35.

<sup>267</sup> See *LPTV Third FNPRM*, 29 FCC Rcd at 12548, para. 29 (citing *Amendment of Parts 73 and 74 of the Commission’s Rules to Establish Rules for Replacement Digital Low Power Television Translator Stations*, MB Docket No. 08-253, Report and Order, 24 FCC Rcd 5931, 5932, para. 3 (2009) (*DRT R&O*)).

<sup>268</sup> In addition to a DTDRT, concerns regarding terrain loss could also be addressed through a distributed transmission system (“DTS”) using multiple transmitters. See *Incentive Auction R&O*, 29 FCC Rcd at 6648, para. 175.

<sup>269</sup> Courts have repeatedly held that it is reasonable for the agency to rely on a waiver process to address any unforeseen shortcomings that might arise in specific instances. See *Vt. Pub. Serv. Bd. v. FCC*, 661 F.3d 54, 65 (D.C. Cir. 2011) (finding a waiver process provided a reasonable means to update stale line count data used in a model for determining universal service support); *Rural Cellular Association v. FCC*, 588 F.3d 1095, 1104 (D.C. Cir. 2009) (discussing, with approval, a waiver process used to provide certain wireless carriers additional support should an interim cap render support insufficient); *Alenco Comm. Inc. v. FCC*, 201 F.3d 608, 622 (5th Cir. 2000) (finding a single carrier’s reduced rate of return under an operating expenses cap “at most . . . presents an anomaly that can be addressed by a request for a waiver”).

<sup>270</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6570, para. 2.

sacrificing the auction's central objective.<sup>271</sup> In upholding the *Incentive Auction R&O*, the D.C. Circuit agreed that, "[i]n deciding which preservation efforts would be 'reasonable,' it was entirely permissible for the Commission to take into account the Spectrum Act's overarching objective of repurposing broadcast spectrum."<sup>272</sup> As discussed below, NAB's proposed approach for incorporating its cap on population loss into the repacking process involves certain elements that are either infeasible or meaningless and, on the whole, would impede our ability to conduct a successful auction and thereby sacrifice the goal of repurposing spectrum.

88. First, NAB argues that we could "pre-calculat[e] the population of every station on every channel, identifying channel assignments that result in population losses over a cap, and augmenting the domain file to prohibit assignments to those channels."<sup>273</sup> In order to implement this approach, however, for each station we will protect in the repacking process, we would have to eliminate certain channels from consideration in determining a feasible channel reassignment for a station if assignment to those channels would cause the station to exceed the cap. Specifically, we would remove otherwise feasible channel assignments from a station's domain file, thereby increasing the number of fixed constraints in the repacking process.<sup>274</sup> Increasing the number of fixed constraints in the repacking process, however, makes it more difficult to repack television spectrum and increases the potential costs of the clearing spectrum through the reverse auction, thereby jeopardizing our ability to carry out a successful auction and undermining our goal of using market forces to repurpose spectrum for flexible use. Indeed, removing otherwise feasible channel assignments could result in reduce the number of feasible repacking solutions. For example, if due to other fixed constraints, a particular station has only five feasible channel assignments (which is common in border-restricted markets like Los Angeles, San Diego, Yuma, and Laredo), removing two channels due to terrain loss concerns would reduce the number of potential channel assignments to three, a reduction of forty percent. That, in turn, could require the selection of a lower clearing target at the outset of the auction. Rather than adopting additional constraints in the repacking process, we believe that the optimization techniques adopted in the *Bidding Procedures PN* will allow us to minimize viewers lost because of new channel assignments without jeopardizing a successful auction. Moreover, as discussed above, in the event some stations are predicted to lose viewers as a result of terrain loss even after optimization techniques are applied, such stations will have other means to address this situation.<sup>275</sup>

89. Second, NAB argues that, after pre-calculating the population of every station on every channel and determining the population lost due to new channel assignments, we can then create a new "combinatorial interference constraint file" by also considering aggregate station-to-station interference.<sup>276</sup> This approach would require that we account for aggregate station-to-station interference

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<sup>271</sup> See *id.* at 6622-23, para. 122.

<sup>272</sup> *National Ass'n of Broadcasters*, 789 F.3d at 178.

<sup>273</sup> NAB Petition at 2, 4.

<sup>274</sup> As explained previously, the staff will develop "constraint files" for each station to be protected in the repacking process, which will be used to check the feasibility of assigning permissible channels to stations that will remain on the air. See *Incentive Auction R&O*, 29 FCC Rcd at 6619-20, para. 114. One file, the "interference-paired" file, lists all stations that could not be assigned to operate on the same or on an adjacent channel with a particular station (because the stations' interference relationship would violate the 0.5 percent new pairwise interference threshold). See *Incentive Auction R&O*, 29 FCC Rcd at 6619-20, para. 114; *ISIX R&O*, 29 FCC Rcd at 13076, para. 8. The other file, the "domain" file, includes a list of all the channels to which the station could be assigned considering fixed constraints, that is, incumbents in the bands other than domestic television stations that are entitled to interference protection at fixed geographic locations and on specific channels. See *Incentive Auction R&O*, 29 FCC Rcd at 6619-20, para. 114; *ISIX R&O*, 29 FCC Rcd at 13076, para. 8.

<sup>275</sup> See *supra* para. 86 (discussing the post-assignment facilities modification process and the ability to deploy DTDRTs).

<sup>276</sup> NAB Petition at 2.

in the repacking process. As we explained in the *ISIX R&O*, and affirm above, doing so would deprive the reverse auction bidding process of its speed and compromise the success of the incentive auction.<sup>277</sup>

90. Third, NAB argues that we could “conduct[] a mid-auction optimization to identify and mitigate instances where repacking results in population losses over a cap for any reason.”<sup>278</sup> A mid-auction optimization, however, would not accomplish NAB’s objective. All channel assignments in the remaining TV bands are provisional and subject to change until the final TV channel assignment plan is established, which will not occur until after the bidding is complete and the identity of the stations that have to be assigned channels in the remaining TV bands is fixed. Thus, a mid-auction optimization would accomplish nothing because the provisional channel assignments are subject to change, and would add unnecessary delay in the completion of the reverse auction.

### C. Use of TVStudy to Determine Coverage Area and Population Served by Television Stations

91. We deny Petitions for Reconsideration of the *Incentive Auction R&O* filed by the Affiliates Associations and CDE<sup>279</sup> challenging our decision to use *TVStudy* software and certain inputs in applying the methodology described in OET-69 to determine the coverage area and population served by television stations.<sup>280</sup> While the Affiliates Associations claim that any changes to the software or inputs used to determine coverage area and population served alter the “methodology described in OET Bulletin 69,”<sup>281</sup> we specifically explained in the *Incentive Auction R&O* why the software and inputs are distinct from the methodology.<sup>282</sup> Our reasoning was affirmed by the D.C. Circuit, which agreed that “[d]istinguishing between a ‘methodology’ and the ‘software’ and ‘inputs’ used for applying that methodology’ is ‘consistent with the ordinary meaning’ of each of those terms. . . . [W]hile ‘the methodology described in OET-69 requires a computer program and data inputs,’ those are ‘tools for applying’ the methodology, not the methodology itself.”<sup>283</sup> Affiliates Associations offer no basis to revisit this conclusion.

92. Affiliates Associations and CDE note that the *TVStudy* software using the updated inputs produce different results in coverage area and population served than older software used to implement OET-69 using outdated inputs,<sup>284</sup> but as we explained in the *Incentive Auction R&O*, using *TVStudy* with

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<sup>277</sup> See *supra* para. 81. See also *ISIX R&O*, 29 FCC Rcd at 13080-81, paras. 16-19.

<sup>278</sup> NAB Petition at 2.

<sup>279</sup> See ABC Television Affiliates Association, CBS Television Network Affiliates Association, FBC Television Affiliates Association, and NBC Television Affiliates (“Affiliates Associations”), Petition for Reconsideration, GN Docket No. 12-268 (Sept. 15, 2014); Cohen, Dippell, and Everist, P.C., Petition for Reconsideration, GN Docket No. 12-268 (Sept. 15, 2014). We addressed the other arguments in the Petitions filed by the Affiliates Associations and CDE in the *Second Order on Reconsideration*, 30 FCC Rcd 6746.

<sup>280</sup> Section 1452(b)(2) requires the Commission, in “making any reassignments or reallocations,” to “make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served of each broadcast television licensee, as determined using the methodology described in OET Bulletin 69 . . . .” 47 U.S.C. § 1452(b)(2). In the *Incentive Auction R&O*, we decided to use new software developed by OET, *TVStudy*, to implement the methodology of OET-69. See *Incentive Auction R&O*, 29 FCC Rcd at 6625-36, paras. 127-47. We also updated certain input values to implement OET-69. See *id.* at 6636-42, paras. 148-61.

<sup>281</sup> See Affiliates Associations Petition at 21.

<sup>282</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6628-32, paras. 134-39.

<sup>283</sup> *National Ass’n of Broadcasters*, 789 F.3d at 173 (quoting *Incentive Auction R&O*, 29 FCC Rcd at 6628-29, para. 134).

<sup>284</sup> See Affiliates Associations Petition at 21-22; CDE Petition at 4-5.

the updated inputs results in greater utility and accuracy.<sup>285</sup> We note that using *TVStudy* with the updated inputs would result in a population increase for 88 percent of full power stations, and a decrease for only 12 percent.<sup>286</sup> Nonetheless, Affiliates Associations argue that a reduction in population for any stations is inconsistent with the requirements of the Spectrum Act.<sup>287</sup> We disagree. As we explained previously, and as affirmed by the D.C. Circuit, the “all reasonable efforts” mandate “necessitates the use of updated software and inputs with greater utility and accuracy.”<sup>288</sup> Affiliates Associations and CDE take issue with the fact that, using identical inputs, *TVStudy* produces different results than previous versions of the software used to implement OET-69.<sup>289</sup> We acknowledged that *TVStudy* is not designed to produce the identical results produced by earlier software, even when the input parameters are set consistently,<sup>290</sup> but Affiliates Associations contend that the *Incentive Auction R&O* did not explain how use of software that produces different results is consistent with Congressional intent.<sup>291</sup> As discussed above, the Spectrum Act mandates that we use the “methodology described in OET Bulletin 69,” not particular software to implement that methodology or arrive at a pre-determined result. Our decision to use software that is “user-friendly and better adapted to handle the kinds of computations the Commission will need to conduct in the reverse auction and repacking process called for by the Spectrum Act” is fully consistent with Congressional intent.<sup>292</sup>

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<sup>285</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6626, para. 130 (“*TVStudy*’s capability to create and use a uniform nationwide grid for analysis of coverage area and population served is essential to the repacking process. In addition, the software previously used to implement OET-69 cannot support the incentive auction because it cannot undertake, in a timely fashion, the volume of interference calculations necessary to ensure that all stations that will remain on the air following the auction are assigned channels in accordance with the provisions of the Spectrum Act. Further, the proposed updates to the input values used in applying the OET-69 methodology allow for a more accurate analysis of each station’s coverage area and population served as of the date of the enactment of the Spectrum Act and eliminate the use of input values that are now obsolete.”).

<sup>286</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6632-33, para. 140.

<sup>287</sup> See Affiliates Association Petition at 22.

<sup>288</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6631, para. 137 (“We cannot conclude that Congress intended to require us to maintain and somehow adapt an obsolete computer program that relies on inaccurate data—particularly given the threat that doing so could leave some viewers without television service.”); *id.* at 6631-32, para. 138 (“We cannot fulfill the statutory mandate using outdated data.”). See also *National Ass’n of Broadcasters*, 789 F.3d at 176 (“It is self-evident that the accuracy of the Commission’s determinations would be improved by its use of more recent population data, more precise terrain calculations, and more exact technical information. . . . The Spectrum Act aims to enhance the technological capacity of the United States by requiring the Commission to conduct an incentive auction that is ‘the first such auction ever attempted worldwide.’ The Commission understandably declined to fulfill that forward-looking mandate by using obsolete software and inaccurate data. Petitioners’ insistence that the Commission do so runs counter to the statute’s basic objectives.”) (citations omitted).

<sup>289</sup> See Affiliates Association Petition at 22-23; CDE Petition at 4-5.

<sup>290</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6641-42, para. 161 (“*TVStudy* is not designed to produce the identical results produced by earlier software, although it does produce very similar results. *TVStudy* is configured differently from earlier software so that it can support the repacking process using the most up-to-date and accurate information and technical evaluation capabilities and, therefore, necessarily does not produce exactly the same results.”); *id.* at 6642, para. 161 n.541 (“There are differences between *TVStudy* and FLR that would be expected to produce different results even when the input parameters are set consistently. For example, *TVStudy* automatically corrects for obvious errors in the license data base; the FLR and Media Bureau software has no such capability. The terrain grid sizes can be set to be identical, but the programs use different compilations of the underlying 3 arc-second terrain data.”).

<sup>291</sup> See Affiliates Associations Petition at 23.

<sup>292</sup> *National Ass’n of Broadcasters*, 789 F.3d at 175.

93. Affiliates Associations also claim that the *Incentive Auction R&O* “fail[ed] to address” losses in “coverage area.”<sup>293</sup> In fact, we explained that we fulfill the statutory obligation to “preserve” a station’s coverage area in our repacking process by ensuring that they can continue to operate at technical parameters sufficient to maintain their coverage areas as of February 22, 2012.<sup>294</sup> We also clarified that we would not provide interference protection to unpopulated areas because it would depart from OET-69 and the Commission’s rules; the processing software currently used by the Media Bureau to evaluate applications for and modifications to television facilities does not routinely provide an indication of interference to unpopulated areas; and the Media Bureau does not consider interference in unpopulated areas in making licensing decisions.<sup>295</sup> Our decision pertaining to preservation of “coverage area” was affirmed by the D.C. Circuit.<sup>296</sup> Affiliates Associations offers no basis to revisit our approach to preserving “coverage area.”

#### IV. PROCEDURAL MATTERS

##### A. Final Regulatory Flexibility Analysis

94. As required by section 604 of the Regulatory Flexibility Act of 1980 (RFA), 5 U.S.C. § 604, the Commission has prepared a Final Regulatory Flexibility Analysis of the possible economic impact on small entities of the policies and rules adopted in this *Third Report and Order and First Order on Reconsideration*. This Final Regulatory Flexibility Analysis is set forth in Appendix E.

##### B. Paperwork Reduction Act

95. This *Third Report and Order and First Order on Reconsideration* 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 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.

96. We have assessed the effects of the policies adopted in this *Third Report and Order and First 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 protecting them from interference. In addition, we have described impacts that might affect small businesses, which

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<sup>293</sup> See Affiliates Associations Petition at 22. We interpreted “coverage area,” consistent with the definition of “service area” in OET-69 and 47 C.F.R. § 73.622(e) as the area within a full power station’s noise-limited F(50,90) contour where the signal strength is predicted to exceed the noise-limited service level, and as the area within a Class A station’s protected contour. *Incentive Auction R&O*, 29 FCC Rcd at 6643, paras. 164-65.

<sup>294</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6644-45, para. 166 (“In preserving a station’s coverage area, we will replicate that station’s contour on its new channel. . . . [W]e adopt the ‘equal area’ approach for replicating the area within the station’s existing contour as closely as possible using the station’s existing antenna pattern. Assuming a station maintains its other existing technical parameters, *i.e.*, location, antenna height and antenna pattern, we will permit the station to adjust its power on the new channel until the geographic area within the station’s noise-limited or protected contour (depending on whether the station is full power or Class A) is equal to the area within the station’s original contour on its pre-auction channel.”) (footnotes omitted).

<sup>295</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Declaratory Ruling, 29 FCC Rcd 12240, 12242, para. 6, 12242-43, para. 8 (2014).

<sup>296</sup> See *National Ass’n of Broadcasters*, 789 F.3d at 179 (“Insofar as a possibility of signal interference exists, the Commission reasonably decided against insulating an area from interference if it is unpopulated—*i.e.*, if there are no viewers affected by the interference. . . . [W]e find that the Commission permissibly considered the Spectrum Act’s overall goals in deciding how to exercise its ‘reasonable efforts’ mandate.”).

includes most businesses with fewer than 25 employees, in the Final Regulatory Flexibility Analysis in Appendix E.

**C. Congressional Review Act**

97. The Commission will send a copy of the *Third Report and Order and First Order on Reconsideration* to Congress and the Government Accountability Office pursuant to the Congressional Review Act.<sup>297</sup>

**D. Contact Person**

98. For additional information, please contact Aspasia Paroutsas, Office of Engineering and Technology, at (202) 418-7285 or [Aspasia.Paroutsas@fcc.gov](mailto:Aspasia.Paroutsas@fcc.gov).

**V. ORDERING CLAUSES**

99. **IT IS ORDERED**, that pursuant to the authority found in Sections 1, 4, 301, 303, 307, 308, 309, 316, 319, 332, and 403 of the Communications Act of 1934, as amended, and sections 6402 and 6403 of Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, 47 U.S.C. §§ 151, 154, 301, 303, 307, 308, 309, 316, 319, 332, 403, 1452, and 1454, the *Third Report and Order and First Order on Reconsideration* **IS ADOPTED**. **IT IS FURTHER ORDERED** that the Commission's rules **ARE HEREBY AMENDED** as set forth in Appendix B.

100. **IT IS FURTHER ORDERED** that the rules adopted herein **WILL BECOME EFFECTIVE** 30 days after the date of publication in the *Federal Register*, except for Sections 27.1310 and 73.3700(b)(1)(iv)(B) of the rules which contain new or modified information collection requirements subject to the Paperwork Reduction Act of 1995, Public Law 104-13, that are not effective until approved by the Office of Management and Budget (OMB). The Federal Communications Commission will publish a document in the Federal Register announcing OMB approval and the effective date of this rule.

101. **IT IS FURTHER ORDERED** that, pursuant to Section 405 of the Communications Act of 1934, as amended, 47 U.S.C. § 405, and section 1.429 of the Commission's rules, 47 C.F.R. § 1.429, the Petitions for Reconsideration of the Second Report and Order in GN Docket No. 12-268, ET Docket No. 13-26, and ET Docket No. 14-14 filed by Cohen, Dippell, and Everist, P.C. and by Sprint Corporation **ARE DENIED** to the extent described herein.

102. **IT IS FURTHER ORDERED** that, pursuant to Section 405 of the Communications Act of 1934, as amended, 47 U.S.C. § 405, and section 1.429 of the Commission's rules, 47 C.F.R. § 1.429, the Petition for Reconsideration of the Second Report and Order in GN Docket No. 12-268, ET Docket No. 13-26, and ET Docket No. 14-14 filed by the National Association of Broadcasters **IS GRANTED IN PART AND DENIED IN PART** to the extent described herein.

103. **IT IS FURTHER ORDERED** that, pursuant to Section 405 of the Communications Act of 1934, as amended, 47 U.S.C. § 405, and section 1.429 of the Commission's rules, 47 C.F.R. § 1.429, the Petitions for Reconsideration of the Report and Order in GN Docket No. 12-268 filed by ABC Television Affiliates Association, CBS Television Network Affiliates Association, FBC Television Affiliates Association, and NBC Television Affiliates and by Cohen, Dippell, and Everist, P.C. **ARE DENIED** to the extent described herein.

104. **IT IS FURTHER ORDERED** that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, **SHALL SEND** a copy of this *Third Report and Order and First Order on Reconsideration* in GN Docket No. 12-268, ET Docket No. 13-26, and ET Docket No. 14-14, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

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<sup>297</sup> See 5 U.S.C. § 801(a)(1)(A).

105. **IT IS FURTHER ORDERED** that the Commission **SHALL SEND** a copy of this *Third Report and Order* and *First Order on Reconsideration* in GN Docket No. 12-268, ET Docket No. 13-26, and ET Docket No. 14-14 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

## LIST OF COMMENTERS

Further Notice of Proposed Rulemaking – Comments and Reply Comments***Comments to Further Notice of Proposed Rulemaking***

Cohen, Dippell and Everist, P.C. (CDE)

Consumer Electronics Association (CEA)

CTIA – The Wireless Association (CTIA)

National Association of Broadcasters (NAB)

***Reply Comments to Further Notice of Proposed Rulemaking***

Block Communications, Inc., Lima Communications Corporation, Independence Television Company, Wand (TV) Partnership, Idaho Independent Television, Inc., and West Central Ohio Broadcasting, Inc. (Block Stations)

Cohen, Dippell and Everist, P.C. (CDE)

CTIA – The Wireless Association (CTIA)

National Association of Broadcasters (NAB)

Second Report and Order – Petitions for Reconsideration, Opposition/Reply to Petitions for Reconsideration, and Replies to Opposition/Reply***Petitions for Reconsideration of Second Report and Order***

Cohen, Dippell and Everist, P.C. (CDE)

National Association of Broadcasters (NAB)

Sprint Corporation (Sprint)

***Opposition to NAB Petition for Reconsideration and Reply to Sprint Petition for Reconsideration***

CTIA – The Wireless Association (CTIA)

***Replies to CTIA Opposition/Reply***

Competitive Carriers Association (CCA)

National Association of Broadcasters (NAB)

**APPENDIX B  
FINAL RULES**

For the reasons discussed above, the Federal Communications Commission amends 47 CFR parts 27 and 73 as follows:

**PART 27 – MISCELLANEOUS WIRELESS COMMUNICATIONS SERVICES**

1. The authority citation of Part 27 continues to read as follows:

**Authority:** 47 U.S.C. 154, 301, 302(a), 303, 307, 309, 332, 336, 337, 1403, 1404 and 1451  
unless otherwise noted.

2. Subpart N is amended by adding an undesignated center heading that precedes §27.1310 as follows:

**Protection of Other Services**

3. Section 27.1310 is added to read as follows:

**§ 27.1310 Protection of Broadcast Television Service in the 600 MHz Band from Wireless Operations.**

(a) Licensees authorized to operate wireless services in the 600 MHz band must cause no harmful interference to public reception of the signals of broadcast television stations transmitting co-channel or on an adjacent channel. (1) Such wireless operations must comply with the D/U ratios in Table 5 in OET Bulletin No. 74, Methodology for Predicting Inter-Service Interference to Broadcast Television from Mobile Wireless Broadband Services in the UHF Band ([DATE]) (“*OET Bulletin No. 74*”). Copies of *OET Bulletin No. 74* may be inspected during normal business hours at the Federal Communications Commission, 445 12<sup>th</sup> St., SW, Dockets Branch (Room CY A09257), Washington, DC 20554. This document is also available through the Internet on the *FCC Home Page* at <http://www.fcc.gov>.

(2) If a 600 MHz band licensee causes harmful interference within the noise-limited contour or protected contour of a broadcast television station that is operating co-channel or on an adjacent channel, the 600 MHz band licensee must eliminate the harmful interference.

(b) A licensee authorized to operate wireless services in the 600 MHz downlink band:

(1) is not permitted to deploy wireless base stations within the noise-limited contour or protected contour of a broadcast television station licensed on a co-channel or adjacent channel in the 600 MHz downlink band;

(2) is required to perform an interference study using the methodology in *OET Bulletin No. 74* before deploying or operating wireless base stations within the culling distances specified in Tables 7-12 of *OET Bulletin No. 74* from the noise-limited contour or protected contour of such a broadcast television station;

(3) is required to perform an interference study using the methodology in *OET Bulletin No. 74* when modifying a base station within the culling distances in Tables 7-12 of *OET Bulletin 74* that results in an increase in energy in the direction of co-channel or adjacent channel broadcast television station's contours;

(4) is required to maintain records of the latest *OET Bulletin No. 74* study for each base station and make them available for inspection to the Commission and, upon a claim of harmful interference, to the requesting broadcasting television station.

(c) A licensee authorized to operate wireless services in the 600 MHz uplink band must limit its service area so that mobile and portable devices do not transmit:

(1) co-channel or adjacent channel to a broadcast television station within that station's noise-limited contour or protected contour;

(2) co-channel to a broadcast television station within five kilometers of that station's noise-limited contour or protected contour; and

(3) adjacent channel to a broadcast television station within 500 meters of that station's noise-limited contour or protected contour.

(d) For purposes of this section, the following definitions apply:

(1) broadcast television station is defined pursuant to §73.3700(a)(1) of this chapter;

(2) noise-limited contour is defined to be the full power station's noise-limited contour pursuant to § 73.622(e);

(3) protected contour is defined to be a Class A television station's protected contour as specified in section 73.6010;

(4) co-channel operations in the 600 MHz band are defined as operations of broadcast television stations and wireless services where their assigned channels or frequencies spectrally overlap;

(5) adjacent channel operations are defined as operations of broadcast television stations and wireless services where their assigned channels or frequencies spectrally abut each other or are separated by up to 5 MHz.

#### **PART 73 – RADIO BROADCAST SERVICES**

4. The authority citation of Part 73 continues to read as follows:

**Authority:** 47 U.S.C. 154, 303, 334, 336, and 339 unless otherwise noted.

5. Sections 73.3700 is revised by amending paragraph (b) and adding paragraph (i) to read as follows:

#### **§ 73.3700 Post-Incentive Auction Licensing and Operation.**

\* \* \* \* \*

(b) Post-auction licensing—

(1) Construction permit applications.

\* \* \*

(iv) Priority filing window.

(A) \* \* \*

(B) The licensee of any broadcast television station that the Commission makes all reasonable efforts to

preserve pursuant to section 6403(b)(2) of the Spectrum Act that is predicted to experience a loss in population served in excess of one percent as a result of the repacking process, either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both), will be afforded an opportunity to submit an application for a construction permit pursuant to paragraph (b)(2)(i) or (ii) of this section in the priority filing window required by paragraph (b)(1)(iv)(A).

\* \* \* \* \*

(i) A broadcast television station licensed in the 600 MHz band, as that band is defined in section 27.5(l), (1) shall not be permitted to modify its facilities, except as provided in subparagraph (b)(1)(ii), if such modification will expand its noise limited service contour (in the case of a full power station) or protected contour (in the case of a Class A station) in such a way as to (i) increase the potential of harmful interference to a wireless licensee which is co-channel or adjacent channel to the broadcast television station or (ii) require such a wireless licensee to restrict its operations in order to avoid causing harmful interference to the broadcast television station's expanded noise limited service or protected contour;

(2) shall be permitted to modify its facilities, even when prohibited by subparagraph (i)(1), if all the wireless licensees in subparagraph (i)(1) who either will experience an increase in the potential for harmful interference or must restrict their operations in order to avoid causing interference agree to permit the modification and the modification otherwise meets all the requirements in Part 73;

(3) For purposes of this section, the following definitions apply:

(i) Co-channel operations in the 600 MHz band are defined as operations of broadcast television stations and wireless services where their assigned channels or frequencies spectrally overlap.

(ii) Adjacent channel operations are defined as operations of broadcast television stations and wireless services where their assigned channels or frequencies spectrally abut each other or are separated by up to 5 MHz.

APPENDIX C

OET BULLETIN No. 74

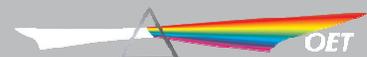
FCC/OET-74

# OET BULLETIN

OFFICE OF ENGINEERING AND TECHNOLOGY

FEDERAL COMMUNICATIONS COMMISSION

## Longley-Rice Methodology for Predicting Inter-Service Interference to Broadcast Television from Mobile Wireless Broadband Services in the UHF Band



XXXXXXXX XX, 20XX

**LONGLEY-RICE METHODOLOGY FOR  
PREDICTING INTER-SERVICE INTERFERENCE TO  
BROADCAST TELEVISION FROM MOBILE WIRELESS  
BROADBAND SERVICES IN THE UHF BAND**

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## I. INTRODUCTION

This Bulletin provides the methodology for prediction of interference from fixed wireless base stations in the 600 MHz downlink spectrum to the reception of signals from digital full power and Class A television service areas that operate co-channel or adjacent channel to mobile wireless broadband operations. The methodology provides guidance on the implementation and use of the NTIA Institute for Telecommunications Science's Longley-Rice radio propagation model for predicting inter-service interference (ISIX) to broadcast television receivers from mobile wireless broadband services.<sup>1</sup> Generally, co-channel interference between wireless services and broadcast television becomes unlikely if these services are geographically separated by a predetermined distance. Likewise, adjacent channel interference becomes unlikely at a lesser distance than the co-channel case, depending on the frequency separation between the TV channel and the wireless spectrum block. Similarly, the likelihood of interference at a particular location diminishes with lower height and/or power transmitters and increases with transmitters at a higher height and/or power. For broadcast television, this methodology assumes use of the Advanced Television Systems Committee's (ATSC) Digital Television (DTV) Standard,<sup>2</sup> although it is possible, especially across U.S. international borders, that the National Television Systems Committee (NTSC) analog Television (TV) standard may also be used.<sup>3</sup> Consideration of interference predictions from fixed wireless base stations to analog television service areas is outside of the scope of this Bulletin.

The methodology uses the Longley-Rice model for predicting field strength at receive points based on the elevation profile of terrain between the transmitter and each specific reception point. Predictions can be made either over a large area (described as a 2-kilometer grid of calculation cells) or at specific locations, depending upon whether the model is configured to use its broadcast (area) or individual location (point-to-point) mode. The methodology described in this Bulletin generates predictions over large areas using the broadcast mode.<sup>4</sup> For practical reasons, a computer is needed to make these predictions because of the large amount of data required for each calculation. Computer code for Version 1.2.2 of the Longley-Rice radio propagation model (Longley-Rice model) is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>.

Section II of this Bulletin provides a general descriptive outline of the methodology. Section III of this Bulletin provides detailed information on defining the DTV service areas subject to interference calculation. Section IV of this Bulletin provides detailed information on evaluating potential wireless interference within those areas.

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<sup>1</sup> Version 1.2.2 of the National Telecommunications and Information Administration (NTIA) Institute for Telecommunication Sciences (ITS) Irregular Terrain Model (ITM), known as the Longley-Rice model after Anita Longley and Phil Rice who developed the original version of the model, is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. The source code for this version of the Longley-Rice model, used by the Commission in several other contexts including OET Bulletin Nos. 69, 72 and 73, is available in FORTRAN, C++, and in algorithm form at the website cited above.

<sup>2</sup> See 47 C.F.R. § 73.682(d).

<sup>3</sup> For analog NTSC television transmission standards, *see, e.g.*, 28 FR 13676. Domestically, Class A television stations were required to cease analog operations by September 1, 2015. See Amendment of Parts 73 and 74 of the Commission's Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations and to Amend Rules for Digital Class A Television Stations, *Second Report and Order*, 26 FCC Red 10732 (2011).

<sup>4</sup> See NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. The broadcast (area) prediction mode is described in this report as best suited to determine the proper co-channel spacing of broadcast stations and/or wireless base stations.

## II. OUTLINE OF EVALUATION PROCEDURE

The examination of each station proceeds as follows:

- 1) The contour defining the DTV service area subject to interference calculation is determined based on the method and service thresholds provided in Section III.
- 2) The area within a station's contour is divided into cells based on a global 2-kilometer grid.
- 3) The calculation point for each cell is then determined based on the centroid of population that falls within each cell, or if the cell does not cover any population, the point is determined based on the geometric center of the cell.
- 4) The wireless base stations outside of the distance defined in Table 7 through Table 12 of Section IV are culled from the interference analysis, based on their geographic coordinates, effective radiated power (ERP) and antenna height above average terrain (HAAT).
- 5) The Longley-Rice propagation model is then applied as in Section III, Evaluation of Service, and Section IV, Evaluation of Interference.
- 6) Desired-to-undesired (D/U) ratios are determined at each cell on the global 2-kilometer grid based on the ratio of the desired TV station's predicted field strength to the root-sum-square of the predicted interfering field strengths from the wireless base stations within the culling distances.
- 7) Finally, the predicted interference at each cell in the desired station's coverage area is examined to determine if interference is predicted from any of the fixed wireless base stations within the culling distances. The appropriate minimum D/U ratio threshold for interference corresponding with the spectral overlap between the TV channel and wireless block is found in Table 5. Interference is considered harmful if any of the D/U ratios determined by the previous step are less than the appropriate minimum D/U ratio threshold in any of the populated cells on the global 2-kilometer grid within the TV station's service area.

## III. EVALUATION OF SERVICE

### A. DTV Service Area Subject to Interference Calculations

The service areas subject to interference calculation are defined in the FCC rules for both digital full power and Class A television stations;<sup>5</sup> the rules also specify standards for determining interference to DTV service.<sup>6</sup> Because wireless services are expected to be noise-like and studies have shown that noise-like signals have interference potential nearly identical to DTV,<sup>7</sup> interference protection criteria similar to those currently used for DTV-to-DTV can generally be applied with some adjustments as discussed below.

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<sup>5</sup> See 47 C.F.R. §§ 73.622(e), 73.6010(c).

<sup>6</sup> See 47 C.F.R. § 73.623(c). See also OET Bulletin No. 69, Table 5A.

<sup>7</sup> See Stephen R. Martin, "Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006," FCC/OET Report 07-TR-1003, March 30, 2007. See also, "Tests of ATSC 8-VSB Reception Performance of Consumer Digital Television Receivers Available in 2005," FCC/OET Report TR-05-1017 November 2, 2005.

Under the FCC's rules, a TV station's service area is limited to the areas within certain specific field strength contours where the station's field strength exceeds a threshold value. As a result of the DTV transition, domestic full power TV stations transmit only in digital (ATSC). As of the date of this Bulletin, Class A TV stations can be either analog or digital. However, all analog Class A facilities are currently required to cease operation by September 1, 2015.<sup>8</sup> Prediction of interference to analog television facilities is beyond the scope of this Bulletin.

For digital full power television stations, service is evaluated inside the noise-limited contour defined in 47 C.F.R. § 73.622(e) with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus, the area subject to interference calculation for digital full power TV stations consists of the area within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of the time by FCC curves is at least as great as the values given in Table 1 below.<sup>9</sup>

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$41 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 1. Field strengths defining the area subject to calculation for UHF digital full power TV stations

For digital Class A TV stations, service is protected only inside the "protected contour" defined in 47 C.F.R. § 73.6010(c), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus, the area subject to interference calculation for digital Class A TV stations consists of the area within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of time by FCC curves is at least as great as the values given in Table 2 below.<sup>10</sup>

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$51 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 2. Field strengths defining the area subject to calculation for UHF digital Class A TV stations

## B. Application of the Longley-Rice Model to Define DTV Service Area

The service area subject to interference calculation is divided into trapezoidal cells approximately 2 kilometers on a side across a global grid.<sup>11</sup> The Longley-Rice propagation model Version 1.2.2 is

<sup>8</sup> See <http://www.fcc.gov/guides/dtv-transition-and-lptv-class-translator-stations>.

<sup>9</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699. See 47 C.F.R. § 73.699.

<sup>10</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699. See 47 C.F.R. § 73.699.

<sup>11</sup> See *TVStudy Manual* at [http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr\\_TVStudyManual.pdf](http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr_TVStudyManual.pdf). The latitude size of cells is fixed for any grid type based on the specified cell size, but for a global grid the longitude size varies in steps according to latitude range (up to 75 degrees latitude). Breaks in latitude bands defining the northern and southern edges of cells are targeted to occur when the cell area changes by 2% across a band. However, incrementing the integer longitude size by a whole number of seconds will lead to an actual area change by more than 2%. For a 2-kilometer target cell size, the change in area is actually 3.25%, meaning the area of cells varies from 4.07 km<sup>2</sup> at the south edge to 3.94 km<sup>2</sup> at the north edge of a band. The actual area of each cell is to be used when cell areas are summed to determine a contour or service areas, so the changes in cell areas across a grid latitude band do not result in cumulative

(continued....)

applied between the DTV transmitter site and a point in each cell to determine whether the predicted desired field strength is above the value found in Table 1 or Table 2 for each digital full power or Class A TV station, respectively, based on the TV station's operating channel. For cells with population, the point chosen is the population centroid, as determined using the method implemented in the FCC's *TVStudy* software<sup>12</sup> implementing the Longley-Rice model – otherwise the point chosen is the geometric center of the cell and the point so determined represents the entire cell in all subsequent service and interference calculations. The station's directional transmitting antenna patterns (azimuth and elevation), if applicable, are taken into account in determining the effective radiated power (ERP) in the direction of each cell.

Those desiring to implement the Longley-Rice model in their own computer program to make these calculations should either download the source code available either through FCC's *TVStudy* software or through NTIA's website at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. However, the point chosen to determine field strength by other independent implementations of the Longley-Rice model must still be either the population centroid for cells with population or the geometric center for cells with no population. Longley-Rice parameter settings for the calculations specified in this Bulletin are shown in Table 3.

(Continued from previous page) \_\_\_\_\_

summation errors. Cells are referenced by their southeast corner, beginning with zero degrees latitude, zero degrees longitude.

<sup>12</sup> The FCC's *TVStudy* software provides analysis of coverage and interference of full-service digital and Class A television stations, with enhanced features and user functionality from previous versions of software implementing the Longley-Rice model. The FCC is using its *TVStudy* software in connection with the proposed broadcast television spectrum incentive auction. See <http://www.fcc.gov/document/oet-announces-release-updated-oet-69-software>. The Longley-Rice Fortran code implementing the Longley-Rice model is used in the FCC's *TVStudy* software. As the Longley-Rice Fortran code is complex, many of its options are configurable through the FCC's *TVStudy* software, available for download at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. The individual installing this should have computer programming skills and experience as a system administrator of the computer system on which it is to be installed.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOLE	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	See note	Height of the radiation center above ground.
HG(2) (m)	10	Height of DTV receiver above ground.
Time variability (desired signal)	90%	
Time variability (undesired signal)	10%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Code (KWX = 3)	Ignore	Accept the path loss value that is returned by Longley-Rice code.
<p>Note: HG(1) is the height of the wireless transmitting antenna radiation center above ground at its specific geographic coordinates, which may be determined by subtracting the ground elevation above mean sea level (AMSL) at the transmitter location from the height of the antenna radiation center AMSL. However, if ground elevation is retrieved from the terrain elevation database as a function of the transmitter site coordinates, then bilinear interpolation between the surrounding data points in the terrain database shall be used to determine the ground elevation. Care should be used to ensure that consistent horizontal and vertical datums are employed among all data sets.</p>		

Table 3. Longley-Rice parameter values

Terrain elevation values at uniformly spaced points between transmitter and receiver must be obtained in the manner used by *TVStudy*. That software uses a terrain elevation database with values approximately every 1 arc-second of latitude and longitude as an input. The program retrieves elevations from this database at regular intervals with a spacing increment which is chosen at the time the program is run. Based upon analysis of the effect of the terrain extraction interval on predicted field strength values compared with measured median field strength values, 0.1-kilometer spacing is to be used for terrain extraction intervals. The elevation of a point of interest is determined by bilinear interpolation of the values retrieved for the corners of the coordinate rectangle in which the point of interest lies.

#### IV. EVALUATION OF INTERFERENCE

##### A. Application of the Longley-Rice Model to Determine Interfering Signal Strength

The presence or absence of interference in each grid cell of the area subject to calculation is determined by further application of the Longley-Rice model. Radio paths between undesired transmitters and each global 2-kilometer grid point inside the service area are examined. The undesired transmitters included in the analysis of each cell are those which are possible sources of interference at that cell, considering their distance from the cell and frequency relationships. For each such radio path, the Longley-Rice model is applied for median situations (that is, confidence 50%), for 50% of locations, 10% of the time for the prediction of potential interference to TV receivers. In those cases that error code 3 occurs ( $KWX = 3$ ), the predicted interfering field strength nevertheless is to be accepted in determining whether there is interference at that location.

##### B. Areas of Potential Interference

To determine whether the placement of a wireless base station at a particular location would cause interference to TV receivers, information about each site in a planned wireless base station deployment is required. Specifically, actual values are required for:

- effective radiated power (ERP),
- geographic location, and
- antenna height above average terrain (HAAT)

The wireless transmit antennas may conservatively be assumed to be non-directional in both the azimuth and elevation directions, as these may be simpler to implement. However, actual antenna azimuth and elevation patterns for each planned wireless base station site may be used for increased accuracy by importing these patterns into the software implementing the Longley-Rice model and setting the azimuth orientation (N ° E, T) on a site-by-site basis.

The interference analysis for TV reception examines only those cells across the global 2-kilometer grid within the area subject to calculation that have already been determined to have a desired field strength above the threshold for reception given in Table 1 or Table 2 as appropriate. A cell on the global 2-kilometer grid is counted as receiving interference to TV if the ratio of the desired field to that of the square root of the sum of the squares (root-sum-square, or RSS) of all of an individual wireless licensee's undesired wireless interference sources within the appropriate culling distances, defined below, is less than the minimum D/U threshold value for the corresponding spectral overlap between the TV and wireless channels. The comparison is made after applying the discrimination effect of the receiving TV antenna.

##### C. DTV D/U Ratios for Co-Channel and Adjacent Channel Operations

Thresholds of interference using the ratio of desired to undesired field strength to protect DTV reception from wireless co-channel interference are computed from the following formula:

Co-channel Wireless-into-DTV D/U =  $16 + \alpha - \text{OFR}$ , spectral overlap  $> 0$  MHz  
 Adjacent channel Wireless-into-DTV D/U =  $-33$ , spectral overlap  $\leq 0$  MHz

Where:

$$\alpha = \text{minimum} \left( 10 \log_{10} \left[ \frac{1}{(1 - 10^{-x/10})} \right], 8 \right) \quad (\text{Eq. 1})$$

$$x = \text{S/N} - 15.19 \text{ dB} \quad (\text{Eq. 2})$$

OFR = Off-frequency rejection (see Table 4)

The quantity  $x$  in Equation 1 is the amount by which the actual desired S/N, computed using Equation 2 below, exceeds the minimum required for DTV reception. As the desired DTV signal level approaches the minimum level for reception, the D/U ratio will increase exponentially.

Because a 5 MHz wireless channel and a 6 MHz DTV channel may not always fully overlap, the total wireless power in the TV channel is a function of the degree of spectral overlap, expressed in integer megahertz (MHz). In Table 4, a fully co-channel scenario would correspond to 5 MHz of transmitter/receiver overlap, while a first-adjacent situation would correspond to 0 MHz of overlap. Partial co-channel overlaps correspond to values of 1, 2, 3, and 4 MHz. Negative overlap values define the amount of frequency separation between channel edges in the adjacent channel cases. The co-channel values at 5 MHz may be used where there is more than 5 MHz of overlap. Wireless operations with frequency separations more than 5 MHz between channel edges or distance separations greater than the culling distances beyond a DTV station's noise-limited or protected contour, for full power and Class A stations, respectively, are not evaluated for interference because the probability of interference beyond those values for each height and/or power combination specified in Table 7 through Table 12 below is unlikely.

Overlap in MHz	5	4	3	2	1	0 to -5 MHz
OFR (dB)	0	0.9	2.2	3.9	6.7	Not applicable

Table 4. Calculated off-frequency rejection (OFR) values for wireless base station into DTV

The values for off-frequency rejection (OFR) were derived using NTIA's MSAM FDR computer program<sup>13</sup> using FCC's emission limits,<sup>14</sup> and DTV receiver performance standards published by ATSC

<sup>13</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook, <http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28-31 (last visited Apr. 17, 2014); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5-8, 5-9 (last visited Apr. 17, 2014); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Apr. 17, 2014).

<sup>14</sup> See 47 C.F.R. § 27.53(g).

for the first-adjacent channel.<sup>15</sup>

To protect DTV reception from wireless downlink interference at various degrees of spectral overlap, the minimum threshold D/U ratios are shown in Table 5. These were derived using Equation 1 and the OFR values from Table 4. Values of  $\alpha$  vary for each cell and are determined by the predicted desired field strength in each cell, the DTV planning factors of Table 6, and the S/N of Equation 2. To avoid exponential increases of the  $\alpha$  factor as the desired signal approaches the minimum S/N,  $\alpha$  is limited to a maximum value of 8 dB.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5 <sup>16</sup>
Downlink into DTV D/U Required (dB)	16.0 + $\alpha$	15.1 + $\alpha$	13.8 + $\alpha$	12.1 + $\alpha$	9.3 + $\alpha$	-33	-33

Table 5. Threshold interfering D/U ratios for wireless base station into DTV

#### D. DTV Planning Factors

The field strength values in Table 1 and Table 2 define the area subject to interference calculations for full power and Class A UHF DTV stations, respectively. These field strengths are based on the DTV planning factors for UHF shown in Table 6. These planning factors are assumed to characterize the equipment, including antenna systems, used for consumer reception at fixed locations. They determine the minimum field strength for DTV reception in the UHF band.

Planning Factor	Symbol	UHF Ch 14-51
Geometric mean frequency (MHz)	F	615
Dipole factor (dBm-dB $\mu$ V/m)	K <sub>d</sub>	-130.8
Dipole factor adjustment	K <sub>a</sub>	see text
Thermal noise (dBm)	N <sub>t</sub>	-106.2
Antenna gain (dBd)	G	10
Downlead line loss (dB)	L	4
System noise figure (dB)	N <sub>s</sub>	7
Required signal-to-Noise ratio (dB)	S/N	15

Table 6. Planning factors for UHF

For UHF, the dipole adjustment factor,  $K_a = 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$ , is added to  $K_d$  in each case to account for the fact that field strength requirements are greater for UHF channels above the geometric mean frequency of the historically defined UHF TV band (*i.e.*, channels 14-69) and smaller for UHF channels below that mean frequency. The geometric mean frequency, 615 MHz, is approximately the mid-frequency of TV channel 38. By applying the planning factors in Table 6 and using the Longley-Rice model to predict the desired field strength “E,” the predicted signal-to-noise ratio (S/N) is then calculated from the formula:

<sup>15</sup> See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.2, Adjacent Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

<sup>16</sup> -33 dB adjacent channel rejection is used for the DTV receiver and 43+10logP in a 100 kHz bandwidth attenuation is used for the wireless emission mask. These flat response curves lead to a constant OFR at spectral overlaps less than 0 MHz.

$$S/N = E + K_d + K_a + G - L - N_t - N_s \quad (\text{Eq. 3})$$

The predicted S/N value associated with the field strength of the desired signal in each cell is used, based on the TV station's operating channel, to determine the applicable interference threshold using Equation 1 and Table 5 above.

#### **E. DTV Receiving Antenna Pattern**

The TV receiving antenna is assumed to have a directional gain pattern which tends to discriminate against off-axis undesired stations. This pattern is a planning factor affecting the receiver's susceptibility to interference.<sup>17</sup> A working group of the FCC Advisory Committee for Advanced Television Service chose the specific form of this pattern. The discrimination, in relative field, provided by the assumed TV receiving pattern is a fourth-power cosine function of the angle between the lines joining the desired and undesired stations to the reception point. One of these lines goes directly to the desired station, the other goes to the undesired station. The discrimination is calculated as the fourth power of the cosine of the angle between these lines but never more than represented by the front-to-back ratio of 14 dB for UHF. When both desired and undesired stations are on the receive antenna's boresight, the angle is 0.0 giving a cosine of unity so that there is no discrimination. When the undesired station is somewhat off-axis, the cosine will be slightly less than unity and the resulting interference field strength is reduced accordingly by this value (while the desired field strength remains unchanged); when the undesired station is far off-axis,<sup>18</sup> the maximum discrimination given by the 14 dB front-to-back ratio is attained, and the resulting interference field strength is reduced by 14 (while the desired field strength still remains unchanged).

#### **F. Identification of Potentially Interfering Stations**

Potential sources of interference are identified as a function of distance for the given ERP, HAAT, and frequency relationship in terms of spectral overlap of each site in a planned wireless deployment. Spectral overlap is defined as the frequency separation between channel edges of a wireless block and DTV channel. For wireless bandwidths 5 MHz or smaller, interference evaluations need only consider the separation between the occupied portions of the nearest 5 MHz block. For example, as shown in Figure 1, for a first-adjacent wireless block/TV channel relationship (otherwise there is 0 MHz spectral overlap for the 5 MHz case) if a 3 MHz LTE signal is being deployed in a 5 MHz block, then the spectral overlap would depend on its position within the 5 MHz block (e.g., 0 MHz if in the 3 MHz nearest to TV (Figure 1a); -1 MHz if centered in the 5 MHz block (Figure 1b); or -2 MHz if furthest from TV (Figure 1c)), and the ERP would be the total. If two or more blocks are to be used contiguously and the overlap between the wireless signal and the DTV channel is 5 MHz or less, the analysis should only consider the 5 MHz block with the highest spectral overlap, and the ERP should be determined by the power in that 5 MHz block. When the contiguous blocks completely overlap the DTV channel, the analysis should be done using a spectral overlap of 5 MHz and an ERP that is the power in the wireless signal that overlaps the television channel (*i.e.* the power over the 6 MHz DTV channel). When the wireless signal is adjacent to the DTV channel (*i.e.* no overlap between the wireless signal and DTV channel), the analysis should be conducted using the 5 MHz block that is closest to the DTV channel. If a wireless licensee operates on non-contiguous blocks, separate analyses would be required.<sup>19</sup>

<sup>17</sup> See OET Bulletin No. 69 at 9.

<sup>18</sup> Approximately 41.5° at Low VHF, 45° at High VHF, and 48.1° and UHF.

<sup>19</sup> When a wireless licensee is adjacent or co-channel to multiple DTV stations, separate interference analyses are required for each of those DTV stations.

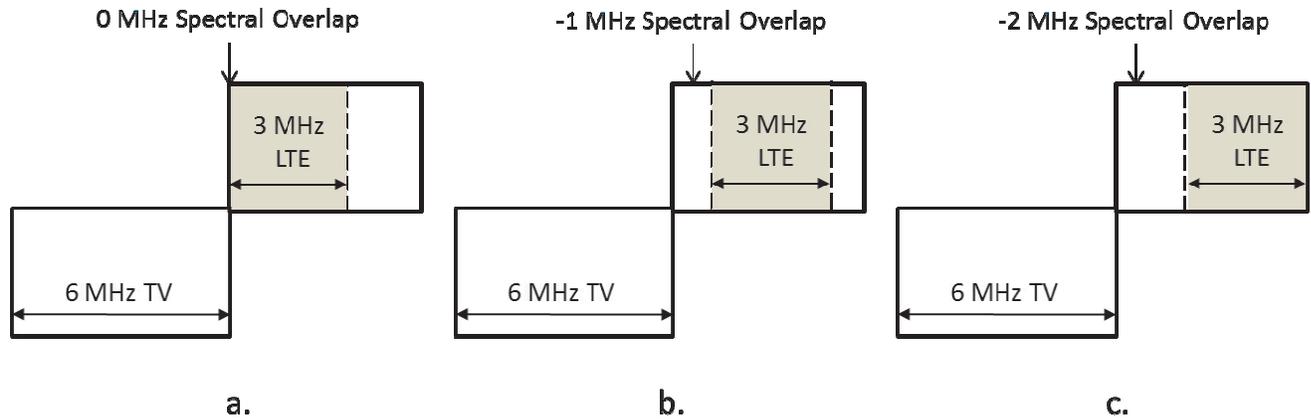


Figure 1. Examples of Spectral Overlap when LTE channel is using only a portion of 5 MHz channel

The interference analysis is performed independently for each cell in the DTV service area subject to calculation. Only those wireless base stations with transmitter sites at distances less than the culling distance (corresponding to the wireless base station ERP, HAAT, and spectral overlap) from the edge of a DTV station noise-limited or protected contour are to be considered in the interference analysis. Table 7 through Table 12 specify these culling distances, which were derived based on the distance to the UHF F(50,10) {OFR (dB) + 17dB $\mu$ V/m, for co-channel and 74 dB $\mu$ V/m for adjacent channel} contour.

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	215	209	202	192	174	168	159	142	120
200	204	197	189	179	163	157	147	130	109
150	196	190	183	173	157	150	141	124	104
100	189	184	176	166	150	143	132	117	96
80	185	180	172	162	146	139	129	113	91
65	182	176	169	159	143	136	126	109	88
50	178	173	165	155	139	132	122	106	85
35	174	168	161	151	134	128	118	102	81

Table 7. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap  $\geq$  5 MHz)

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	210	205	198	187	170	164	154	137	116
200	198	192	185	175	159	152	142	126	105
150	191	186	179	169	153	146	136	120	99
100	185	179	172	162	145	138	128	112	92
80	181	175	168	158	141	134	124	108	87
65	177	172	164	154	138	131	121	105	84
50	174	168	160	151	134	128	118	101	81
35	169	164	156	147	130	123	114	98	77

Table 8. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 4 MHz)

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	202	197	190	179	164	157	146	130	109
200	189	184	177	167	151	144	135	119	98
150	183	178	171	162	145	138	129	113	92
100	177	171	164	154	137	130	121	105	84
80	172	167	159	150	133	126	117	101	80
65	169	163	156	147	130	123	114	97	77
50	165	160	153	144	127	120	110	94	74
35	161	156	149	139	123	116	106	90	71

Table 9. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 3 MHz)

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	193	187	180	170	154	147	137	121	102
200	180	175	168	159	142	136	126	110	90
150	174	169	163	153	136	129	120	105	85
100	167	162	155	145	128	121	113	97	77
80	163	158	151	142	124	118	108	92	73
65	160	154	148	138	121	114	105	89	70
50	156	151	145	135	118	111	101	86	67
35	152	147	140	130	114	107	98	82	63

Table 10. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 2 MHz)

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	176	171	165	155	138	131	122	106	90
200	165	160	153	143	127	120	111	95	78
150	159	154	147	137	121	114	105	90	72
100	151	146	139	128	113	106	97	82	66
80	148	142	135	125	109	102	93	78	63
65	145	139	132	122	106	99	90	75	60
50	141	135	128	118	102	95	86	72	57
35	136	131	124	115	98	92	83	68	54

Table 11. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 1 MHz)

HAAT (m):	ERP (kW)								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	23	22	20	18	14	13	12	10	8
200	18	17	16	14	11	11	10	8	6
150	15	14	13	12	10	9	8	7	6
100	12	11	11	10	8	8	7	6	5
80	11	10	10	9	7	7	6	5	4
65	10	9	9	8	7	6	6	5	4
50	9	8	8	7	6	6	5	4	3
35	7	7	6	6	5	5	4	3	3

Table 12. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap  $\leq 0$  MHz)

### G. Engineering Databases

*DTV Engineering Data.* Engineering data for TV stations in the U.S. (including full power DTV and Class A) is available from the FCC. Data for individual stations can be found at <http://www.fcc.gov/mb/video/tvq.html>, and consolidated data for all authorized stations can be found at <ftp://ftp.fcc.gov/pub/Bureaus/MB/Databases/cdbs/>. Where more than one authorization exists for a particular station, the record associated with the facility actually operating shall be used. Where specific elevation pattern data are not provided in the engineering data, a generic elevation pattern may be used as described generally in OET Bulletin No. 69 or in the rules.<sup>20</sup> The generic elevation pattern should, however, be offset by the amount of electrical beam tilt specified in the CDBS.

<sup>20</sup> For full power UHF DTV stations, see Table 8 of OET Bulletin No. 69. However, for Class A UHF DTV stations, see 47 C. F. R. § 74.793(d).

## APPENDIX D

**UPDATED METHODOLOGY FOR IDENTIFYING IMPAIRED LOCATIONS  
IN 600 MHz WIRELESS LICENSE AREAS DURING THE  
BROADCAST TELEVISION INCENTIVE AUCTION**

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**I. INTRODUCTION**

1. This appendix sets forth the updated methodology for predicting interference between broadcast television and wireless services when co-channel or adjacent-channel to the 600 MHz Band (“ISIX Methodology”) that was initially adopted in the *Incentive Auction Second Report and Order* (“ISIX R&O”).<sup>1</sup> The ISIX Methodology will be used to identify the locations within a wireless 600 MHz Band license area that either experience interference from DTV or cause interference to DTV. The modifications made to the ISIX Methodology reflect the modifications made in the underlying interference thresholds in the *First Order on Reconsideration* and are the same as those adopted in OET Bulletin No. 74, to be used following the auction.

2. The ISIX methodology uses the NTIA Institute of Telecommunications Science’s Irregular Terrain Model (Longley-Rice model) for predicting radio signal propagation losses, established planning factors and industry standards to define thresholds of coverage and interference, and typical technical specifications in the absence of industry standards. It also generally applies commonly used protocols, databases, and propagation models to describe a predictive methodology that can be run on a computer. For broadcast television, it assumes use of the Advanced Television Systems Committee’s (ATSC) Digital Television (DTV) Standard,<sup>2</sup> although it is possible, especially across international

<sup>1</sup> *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, ET Docket No. 13-26, ET Docket No. 14-14, Second Report and Order and Further Notice of Proposed Rulemaking, 29 FCC Rcd 13071 (2014) (*ISIX R&O*).

<sup>2</sup> See 47 C.F.R. § 73.682(d).

borders, that the National Television Systems Committee (NTSC) analog Television (TV) standard may also be used.<sup>3</sup> For wireless operations, it assumes use of the 3<sup>rd</sup> Generation Partnership Project (3GPP) Long-Term Evolution (LTE) standard.<sup>4</sup>

3. The ISIX Methodology uses the Longley-Rice radio propagation model, which predicts field strength at receive points based on the elevation profile of terrain between the transmitter and each specific reception point.<sup>5</sup> Predictions are made over a large area (described as a 2-kilometer global grid of calculation cells).<sup>6</sup> Predictions of interference for the purpose of determining impairment locations during the incentive auction will be made using the FCC's *TVStudy* software and relevant TV station engineering data from the FCC's Consolidated Database System (CDBS).<sup>7</sup>

## II. OVERVIEW OF METHODOLOGY

4. To determine potential wireless license impairments, we first define the area subject to calculation. For interference to wireless, the area subject to calculation is defined as each wireless Partial

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<sup>3</sup> For analog NTSC television transmission standards, *see, e.g.*, 28 FR 13676. Domestically, low-power television stations, including Class A and television translators, are the only remaining over-the-air broadcast television service permitted to transmit analog signals. All Class A television stations are required to terminate all analog operations by 11:59 pm local time on September 1, 2015. *See* 47 C.F.R. § 74.788. For LPTV and TV translator stations other than Class A, the digital transition deadline has been suspended pending final action in the rulemaking proceeding in MB Docket No. 03-185. *See Suspension of September 1, 2015 Digital Transition Date for Low Power Television and TV Translator Stations*, MB Docket No. 03-185, Public Notice, 30 FCC Red 3741 (MB, 2015).

<sup>4</sup> Specifically, we reference the radio access layer of the 3GPP LTE technical specification, Release 10. *See* Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36104.htm>, Version 10.11.0. *See also* Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36101.htm>, Version 10.12.0.

<sup>5</sup> Version 1.2.2 of the National Telecommunications and Information Administration (NTIA) Institute for Telecommunication Sciences (ITS) Irregular Terrain Model (ITM), known as the Longley-Rice model after Anita Longley and Phil Rice who developed the original version of the model, is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. The source code for this version of the Longley-Rice model, used by the Commission in several other contexts including OET Bulletin Nos. 69, 72 and 73, is available in FORTRAN, C++, and in algorithm form at the website cited above.

<sup>6</sup> *See TVStudy Manual* available at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. The latitude size of cells is fixed for any grid type based on the specified cell size, but for a global grid the longitude size varies in steps according to latitude range (up to 75 degrees latitude). Breaks in latitude bands defining the northern and southern edges of cells are targeted to occur when the cell area changes by 2% across a band. However, incrementing the integer longitude size by a whole number of seconds will lead to an actual area change by more than 2%. For a 2-kilometer target cell size, the change in area is actually 3.25%, meaning the area of cells varies from 4.07 km<sup>2</sup> at the south edge to 3.94 km<sup>2</sup> at the north edge of a band. The actual area of each cell is to be used when cell areas are summed to determine a contour or service areas, so the changes in cell areas across a grid latitude band do not result in cumulative summation errors. Cells are referenced by their southeast corner, beginning with zero degrees latitude, zero degrees longitude.

<sup>7</sup> The FCC's *TVStudy* software provides analysis of coverage and interference of full-service digital and Class A television stations, with enhanced features and user functionality from previous versions of software implementing the Longley-Rice model. The FCC is using its *TVStudy* software in connection with the proposed broadcast television spectrum incentive auction. *See* <http://www.fcc.gov/document/oet-announces-release-updated-oet-69-software>. The Longley-Rice Fortran code implementing the Longley-Rice model is used in the FCC's *TVStudy* software. As the Longley-Rice Fortran code is complex, many of its options are configurable through the FCC's *TVStudy* software, available for download at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. Parties installing this software should have computer programming skills and experience as a system administrator of the computer system on which it is to be installed.

Economic Area (PEA).<sup>8</sup> For interference to TV, the area subject to calculation is the area inside of the noise-limited contour defined in 47 C.F.R. § 73.625(a) for full power DTV stations and the area within the protected contour defined in 47 C.F.R. § 73.6010 for digital Class A TV stations.<sup>9</sup>

5. There are four scenarios, or cases, of potential interference that may be experienced as a result of market variation. When broadcast television operations and wireless operations are co-channel or adjacent-channel in nearby markets, interference may be predicted in the following four cases: (1) DTV transmitter-into-wireless base station; (2) DTV transmitter into wireless user equipment; (3) Wireless base station-into-DTV receivers; and (4) Wireless user equipment-into-DTV receivers. These cases are shown graphically in Figure 1 below:

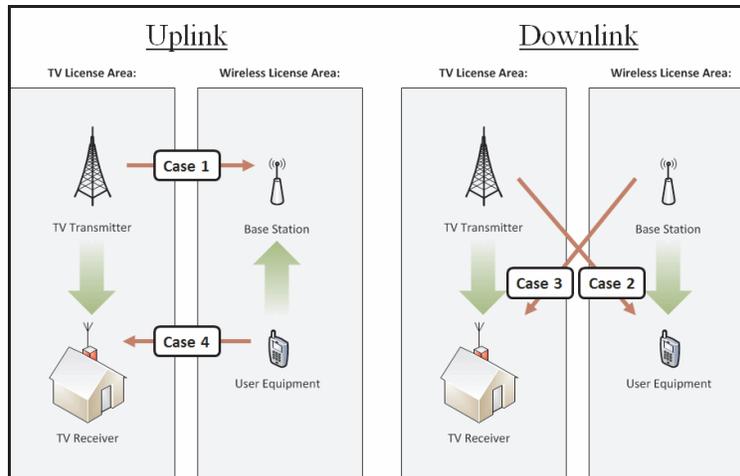


Figure 1. Four interference scenarios

6. Depending on the interference scenario being examined, the methodology evaluates interference using either field strength limits at the wireless receive antenna, or D/U ratios at the DTV receive antenna, as a function of the amount of spectral overlap between the DTV and wireless channel. Potential interference is then defined to occur at a specified location when the predicted interfering field strength or D/U ratio fails to meet the applicable threshold. Locations where interference occurs to or originates from the wireless network are collectively the impaired locations which will be used as a basis for determination of impairments within each wireless license area during the auction.

7. Because the near-national band plan will not be known until the level of broadcaster participation in the auction is determined, the alignment of the wireless blocks to repacked DTV stations who are assigned channels in the repurposed 600 MHz spectrum is also unknown. For this reason, all interference thresholds are specified in terms of spectral overlap. Spectral overlap refers to the degree of wireless spectrum block to TV channel overlap and is an integer number between +5 MHz and -5 MHz, in 1 MHz increments. When the wireless block completely overlaps the TV channel the spectral overlap is equal to +5 MHz, and when there is 5 MHz of separation between the wireless block edge and the TV channel the spectral overlap is equal to -5 MHz. Co-channel interference refers to the instances when the wireless block overlaps the TV channel by 5 to 1 MHz (spectral overlap = +5 to 1 MHz) and adjacent-channel interference refers to instances when the wireless block edge and TV channel edge are separated by 0 to 5 MHz (spectral overlap = 0 MHz to -5 MHz).

<sup>8</sup> There are 416 PEAs that will be licensed. Each PEA is comprised by one or more US counties. See <http://transition.fcc.gov/oet/info/maps/areas/>

<sup>9</sup> The term “contour”, unless otherwise noted, refers to either the noise-limited or protected contour of a full power or Class A TV station, respectively.

### III. PREDICTING INTERFERENCE FROM DTV TO WIRELESS (CASES 1 AND 2)

8. Cases 1 and 2 involve interference caused by a co- or adjacent-channel DTV transmitter to a wireless base station (BS) or user equipment (UE), respectively. To determine areas of possible interference to wireless (wireless service impairments, or “infringed” portions of a wireless license area) we divide the wireless license area into a 2-kilometer global grid and calculate field strength levels at the population centroid of each grid point for each DTV facility within approximately 500 km of the wireless license boundary.<sup>10</sup> Every DTV station is replicated onto channel 38<sup>11</sup> and the predicted F(50,50) field strength<sup>12</sup> at each grid point is then compared to the appropriate interference field strength threshold for each spectral overlap. Since we cannot consider actual 600 MHz wireless deployments, all field strength thresholds for Cases 1 and 2 are based on the assumption that the desired wireless signal is always at the edge of coverage and operating at or near the receiver sensitivity threshold. Additionally, the wireless base station receiver assumptions do not consider antenna discrimination or other techniques to mitigate interference. Thus, impaired locations due to either Case 1 or Case 2 tend to be conservatively large.

9. Figure 2 illustrates how the spectral overlaps and field strength thresholds are used during the auction to identify impaired locations within each wireless market.

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<sup>10</sup> *TVStudy* only calculates field strength within a DTV station’s service contour, therefore for Cases 1 or 2 we set the service contour threshold to 0 dB $\mu$ V/m, use the F(50,10) curves and a minimum HAAT of 50 meters to achieve the largest calculation area possible. This generally equates to a maximum distance of about 500 km but varies based on the terrain near the DTV facility (contours only consider terrain elevations between 2 and 10 miles from the DTV facility), and DTV facility parameters, such as ERP and HAAT.

<sup>11</sup> Channel 38 is selected as the proxy channel because it is approximately in the middle of where a repacked DTV station may potentially be in the 600 MHz Band. This channel will be used in estimating the contours of DTV stations when determining impairments to wireless licenses. We note that the use of a proxy channel in this ISIX methodology differs from the approach adopted by the Commission in the Incentive Auction R&O for determining TV-to-TV interference, where the coverage area and interference between stations is calculated on every possible channel that could be assigned during the repacking process. See *Incentive Auction R&O*, 29 FCC Rcd at 6620, para. 115. A different approach is used in the ISIX Methodology for two reasons. Any potential improvement in the accuracy of estimating wireless license impairments obtained by using actual channels would be limited by the fact that we are calculating interference in Cases 1 and 2 with the assumption that the wireless base station or user equipment is operating at or near receiver sensitivity (non-optimal configurations) and in Case 3 we are using hypothetical base station locations and configurations. Second, the definition of license categories in the forward auction makes more precise calculations unnecessary since impairments are grouped together into just two categories. See *Bidding Procedures PN*, 30 FCC Rcd at 9047, para. 144. Post-auction interference predictions will use actual channels as described in OET Bulletin No. 74. Once the final channel assignments are determined post-auction, using actual channels will be feasible because the specific DTV station and the location and configurations of the actual (as opposed to hypothetical) base stations will be known.

<sup>12</sup> All field strength predictions for Cases 1 or 2 are median situations which means that Longley-Rice statistical parameters are set for median situations (50% confidence), for 50% of the locations, 50% of the time (i.e. F(50,50))

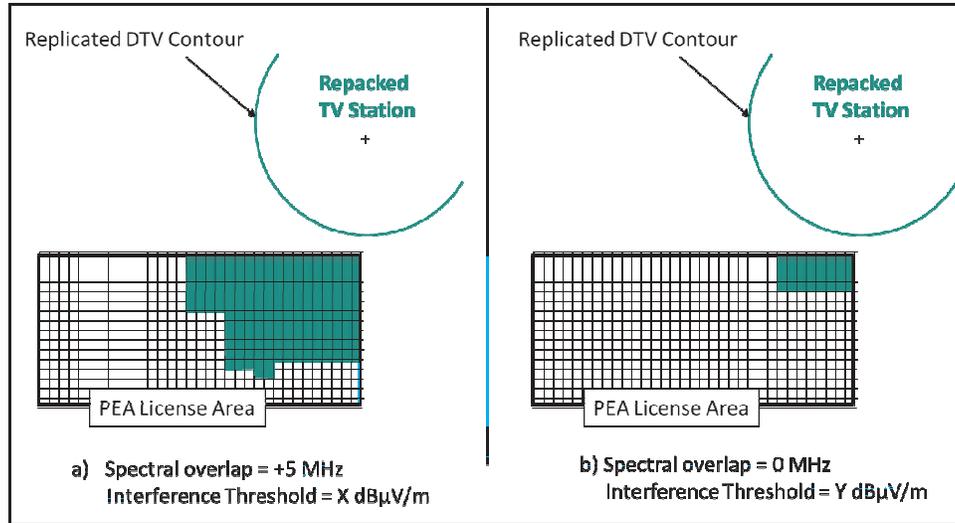


Figure 2. Illustration of interference prediction from DTV to wireless license area

10. Figure 2a shows the impaired locations within the PEA license area if the spectral overlap between the wireless channel and TV channel were +5 MHz. The green grid cells in Figure 2a are the locations where the predicted field strength from the DTV station exceeds the interference threshold, X. Similarly, Figure 2b shows the impaired locations within the same PEA license area if the spectral overlap were 0 MHz. The green grid cells in Figure 2b show the locations where the predicted field strength from the DTV station exceeds the interference threshold, Y. For Case 1 or Case 2, this interference would occur in a base station receiver or UE receiver, respectively, and the field strength limit is derived accordingly considering typical assumptions in either case. These calculations are performed for each DTV station and each spectral overlap value to develop a complete list of Case 1 or 2 impairment locations for use during the incentive auction.

**A. Threshold Values for Interference from Digital Full Power and Class A TV Stations into Wireless Uplink (Case 1)**

11. The field strength interference limits for interference from full power DTV and digital Class A sources into the wireless uplink (base station receive) are shown in Table 1<sup>13</sup>.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Uplink (dBµV/m)	17.3	18.2	19.5	21.2	24.0	34.4	61.4	62.5	63.7	65.5	68.6

Table 1. Interference field strength values for DTV into wireless uplink

The assumptions for typical base station height, antenna pattern, antenna gain and receiver sensitivity used to determine these limits are provided in Table 3 below.

<sup>13</sup> Threshold values for interference from US DTV stations to Canadian wireless base stations:

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Uplink (dBµV/m)	11.3	12.2	13.5	15.2	18.0	28.4	55.4	56.5	57.7	59.5	62.6

The threshold values for Interference from US DTV stations to Mexican wireless base stations are the same as those applied in the U.S. and shown in Table 1.

**B. Threshold Values for Interference from Digital Full Power and Class A TV Stations into Wireless Downlink (Case 2)**

12. The field strength interference limits for interference from full power DTV and digital Class A sources into the wireless downlink (UE receive) as shown in Table 2<sup>14</sup>.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Downlink (dB $\mu$ V/m)	33.8	34.7	36.0	37.6	40.4	50.7	65.8	66.6	67.6	68.9	70.8

Table 2. Interference field strength values for DTV into wireless downlink

Table 4 below provides details on the assumptions for typical user equipment height, antenna pattern, antenna gain and receiver sensitivity used to determine these limits.

**C. Technical Specifications**

13. *Field Strength Limits for DTV Interference to Wireless.* The values shown in Table 1 and Table 2 are derived from the technical specifications and assumptions given in Table 3, Table 4, and Table 5 and using the formula below.

$$\text{Field Strength Limit (dB}\mu\text{V/m)} = P_{\text{REFSENS}} - K_d - G + L + \text{OTR} + \text{OFR}$$

Where:

$P_{\text{REFSENS}}$ (dBm)	= victim receiver reference sensitivity level
$K_d$ (dBm-dB $\mu$ V/m)	= dipole factor at 615 MHz <sup>15</sup>
G (dBd)	= antenna gain
L (dB)	= line loss
OTR (dB)	= receiver on-tune rejection (dB)
OFR (dB)	= off-frequency rejection (dB) as a function of spectral overlap

<sup>14</sup> Threshold values for interference from US DTV stations to Canadian user equipment:

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Downlink (dB $\mu$ V/m)	27.6	28.5	29.8	31.4	34.2	44.5	59.6	60.4	61.4	62.7	64.6

The threshold values for Interference from US DTV stations to Mexican user equipment are the same as those applied in the U.S. and shown in Table 2.

<sup>15</sup> See OET Bulletin No. 69, Table 3. The adjustment,  $K_a = 20 \log[615/(\text{channel mid-frequency in MHz})]$ , is added to  $K_d$  to account for the fact that field strength requirements are greater for UHF channels above the geometric mean frequency of the UHF band and smaller for UHF channels below that frequency. The geometric mean frequency, 615 MHz, is approximately the mid-frequency of channel 38.

Parameter	Value	Comment
$P_{\text{REFSENS}}$ (dBm)	-101.5	Reference sensitivity level, per 3GPP Technical Specification 36.104 § 7.2.
$K_d$ (dBm-dB $\mu$ V/m)	-130.8	Dipole Factor, OET Bulletin No. 69, Table 3.
G (dBd)	13.8	$G$ (dBd) = 12.8 dBd + $G_{\text{div}}$ - $G_{\text{horiz}}$ . $G_{\text{div}}$ is receive antenna diversity gain, assumed to be 3 dB, and $G_{\text{horiz}}$ is additional antenna discrimination due to downtilt below the radio horizon, assumed to be 2 dB.
Antenna Pattern	Non-directional	
L (dB)	1	Assumed line loss.
Receiver BW (MHz)	5	For bandwidths (BW) $\geq$ 5 MHz, the reference sensitivity level is measured in accord with the 3GPP Technical Specification 36.104 using 25 consecutive resource blocks, corresponding to a channel bandwidth of 4.5 MHz.
Thermal noise, $N_t$ (dBm)	-107.5	= -174 (dBm/Hz) + $10\log_{10}(4.5 \text{ MHz})$ .
Effective noise figure, $N_e$ (dB)	6	
OTR (dB)	0.8	For TV into wireless, OTR = $10\log_{10}(6/5) = 0.8$ dB. Using typical 3 dB transmit signal bandwidths, $10\log_{10}(5.38/4.5)$ is also approximately 0.8 dB.
OFR (dB)	Varies	See Table 5
HG(2) (m AGL)	30	Assumed receive antenna height for wireless base stations.

Table 3. Wireless base station receiver technical parameters

Parameter	Value	Comment
$P_{\text{REFSENS}}$ (dBm)	-100	Reference sensitivity level, per 3GPP Technical Specification 36.101 § 7.3.
$K_d$ (dBm-dB $\mu$ V/m)	-130.8	Dipole Factor, OET Bulletin No. 69, Table 3.
G (dBd)	-2.2	Assumes 0 dBi - 2.2 (approximate dipole gain).
Antenna Pattern	Non-directional	
L (dB)	0	Assumed line loss.
Receiver BW (MHz)	5	For bandwidths (BW) $\geq$ 5 MHz, the reference sensitivity level is measured in accord with the 3GPP Technical Specification 36.104 using 25 consecutive resource blocks, corresponding to a channel bandwidth of 4.5 MHz.
Thermal noise, $N_t$ (dBm)	-107.5	= -174 (dBm/Hz) + $10\log_{10}(4.5 \text{ MHz})$ .
Effective noise figure, $N_e$ (dB)	7.5	
OTR (dB)	0.8	For TV into wireless, OTR = $10\log_{10}(6/5) = 0.8$ dB. Using typical 3 dB transmit signal bandwidths, $10\log_{10}(5.38/4.5)$ is also approximately 0.8 dB.
OFR (dB)	Varies	See Table 5
HG(2) (m AGL)	1.5	Assume 1.5 m height for user equipment receiver.

Table 4. Wireless user equipment receiver technical parameters

The values of OFR were derived using NTIA's MSAM FDR computer program,<sup>16</sup> with FCC's emission limits for DTV,<sup>17</sup> and wireless receiver performance standards published by 3GPP.<sup>18</sup> The results are provided in Table 5.

Overlap in MHz \ OFR (dB)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Uplink	0	0.9	2.2	3.9	6.7	17.1	44.1	45.2	46.4	48.2	51.3
DTV into Wireless Downlink	0	0.9	2.2	3.8	6.6	16.9	32	32.8	33.8	35.1	37

Table 5. Calculated off-frequency rejection (OFR) values for DTV into wireless

14. The values set in the Longley-Rice Fortran code implementing the Longley-Rice model accompanying the FCC's *TVStudy* software are provided in Table 6 below. As adopted in the *Second Report & Order*, we use F(50,50) propagation for Cases 1 and 2 and in those cases where error code 3 occurs (KWX = 3), the predicted field strength is to be accepted as indicative of the interfering field strength at that location.<sup>19</sup>

<sup>16</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook, <http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28–31 (last visited Apr. 17, 2014); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5–8, 5–9 (last visited Apr. 17, 2014); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Apr. 17, 2014).

<sup>17</sup> See 47 C.F.R. §§ 73.622(h).

<sup>18</sup> Specifically, we reference the radio access layer of the 3GPP LTE technical specification, Release 10. See Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36104.htm>, Version 10.11.0. See also Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36101.htm>, Version 10.12.0.

<sup>19</sup> See *ISIX R&O*, 29 FCC Rcd at 13090, 13100-01, paras. 37, 54.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOL	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	See note	Height of the radiation center above ground.
HG(2) (m)	30 1.5	Height of hypothetical base station antenna above ground (Table 3). Height of hypothetical user equipment above ground (Table 4).
Time variability	50%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Flag	Ignore	Accept pathloss value that is returned by Longley-Rice code
<p><b>Note 1.</b> HG(1) is the height of the transmitting antenna radiation center above ground. For TV, it is determined by subtracting the ground elevation above mean sea level (AMSL) at the transmitter location from the height of the radiation center AMSL. The latter value is contained in the FCC's CDBS, and may be found by query at <a href="http://www.fcc.gov/mb/video/tvq.html">http://www.fcc.gov/mb/video/tvq.html</a>. The former is retrieved from the terrain elevation database as a function of the transmitter site coordinates also found in CDBS. Bilinear interpolation between the surrounding data points in the terrain database is used to determine the ground elevation. Care should be used to ensure that consistent horizontal and vertical datums are employed among all data sets.</p>		

Table 6. Longley-Rice parameter values for ISIX Cases 1 and 2

#### IV. PREDICTING INTERFERENCE FROM WIRELESS TO DTV (CASES 3 AND 4)

15. Cases 3 and 4 involve interference caused by a co- or adjacent-channel base station or UE transmitter to a DTV receiver, respectively. Evaluations of interference from wireless base stations to DTV receivers (Case 3) are to be performed during the broadcast television incentive auction using a methodology that examines the desired-to-undesired (D/U) field strength ratio between a desired DTV transmitter and a series of uniformly distributed hypothetical base station transmitters operating with typical parameters. Case 3 impaired locations (“restricted” portions of a wireless license area) are then defined by the county boundaries<sup>20</sup> from within which at least one hypothetical base station transmitter is predicted to cause interference based on specified D/U threshold values. In the case of UE interference to DTV receivers (Case 4) impaired locations are defined by the collection of all the 2-kilometer grid points that fall inside the DTV station’s protected contour or noise-limited contour and within a specified separation distance outside the DTV station’s contour.

16. Case 3. The DTV station is replicated onto TV channel 38<sup>21</sup> and its contour is calculated.

<sup>20</sup> We use the county boundary files from the 2010 US Census available at <ftp://ftp2.census.gov/geo/tiger/TIGER2010/COUNTY/2010/>

<sup>21</sup> Because impaired locations are a result of TV stations in the 600 MHz Band, we can assume that the TV channel for which we want to predict wireless license impairments is at least above TV channel 26, which corresponds with the largest clearing target in the *Incentive Auctions R&O*. See *Incentive Auctions R&O*, 29 FCC Rcd at 7018, App.

(continued...)

The area within DTV station's contour is then divided into 2-kilometer grid cells and the desired DTV field strength at the population centroid of the grid cell is calculated. In cases where the grid cell does not contain population, the geometric center of the grid cell is selected as the calculation point. To calculate the undesired field strength, we sample the surrounding license areas by placing uniformly spaced hypothetical wireless base stations every 10 kilometers<sup>22</sup> with transmitting antennas at 30 meters above average terrain.<sup>23</sup> Each hypothetical base station is set up to transmit on the TV channel 38 center frequency. We limit the number of hypothetical base stations considered to those that fall within 500 kilometers of the DTV facility.

17. The undesired field strength from each hypothetical base station within 300 kilometers of a 2-kilometer grid cell is then predicted and a D/U ratio is determined. The interference analysis for TV reception examines only those cells across the global 2-kilometer grid that have already been determined to have a desired field strength above the field strength threshold for DTV reception given in Table 9 or Table 10, as appropriate. A cell on the global 2-kilometer grid is counted as receiving interference to TV if the ratio of the desired field strength to that of any one of the possible undesired wireless interference sources is less than the applicable threshold value specified in Table 7. The comparison is made after the discrimination effect of the receiving TV antenna is applied to the undesired field strength for a given cell. The assumed parameters of the hypothetical base stations are provided in Table 13.

18. Each grid point inside the DTV station's contour where the predicted D/U ratio falls below the appropriate threshold value is noted along with the corresponding hypothetical base station location causing the predicted interference. All county areas corresponding with a 10-kilometer square grid area from which a hypothetical base station causes interference to DTV service are then noted as impaired locations, resulting in restrictions in wireless license areas.

19. Figure 3 illustrates how the how spectral overlaps and D/U threshold values are to be used for a Case 3 ISIX analysis. In the figure, the sample locations of the hypothetical base stations are shown as "+". The hypothetical base stations that cause interference to any 2-kilometer grid cell within the repacked TV station's contour are shown as ⊕.

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C, Technical Appendix. Impaired locations could be anywhere in the re-purposed wireless spectrum, especially with respect to cases caused by international TV stations. We will use TV channel 38 to replicate all DTV stations for purposes of estimating their contours after repacking and potential wireless license impairments during the auction.

<sup>22</sup> The 3GPP LTE standard supports a maximum cell radius of 100 kilometers. In practice, however, cell radii vary from fraction of a kilometer in dense urban environments to tens of kilometers in sparsely populated rural areas. See Commerce Spectrum Management Advisory Committee (CSMAC), Final Report, Working Group 1 – 1695-1710 MHz Meteorological-Satellite, Rev. 1, July 23, 2013, Appendix 3. The uniform 10-kilometer spacing for base station transmitting sites we describe in this appendix approaches a practical limit on computation. The area surrounding each 10-kilometer base station can be thought of as a square with dimensions approximately 10 kilometers on each side, for a total area of 100 square kilometers associated with each hypothetical wireless site.

<sup>23</sup> The antenna height above average terrain (HAAT) is determined by the average elevation of between 3.2-16.1 kilometers (2-10 miles) from an antenna site for 8 radials at each 45 degrees of azimuth starting with the True North, using a terrain sampling interval of 0.1 kilometer along each radial.

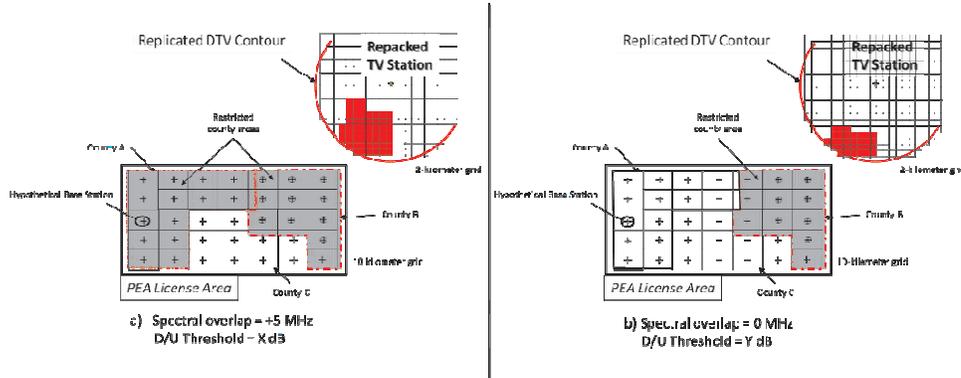


Figure 3. Illustration of Case 3 Impaired Locations (restricted operating areas)

20. Interference is considered to occur at 2-kilometer grid points where the calculated D/U ratio from any hypothetical base station exceeds the specified limit based on spectral overlap. Figure 3a shows several hypothetical base stations as causing interference (shown as “⊕”) to at least one 2-kilometer grid cell of the repacked TV station based on a spectral overlap of +5 MHz and a corresponding D/U threshold of X dB. County areas A and B are both marked as impaired locations within the PEA license area because their areas both intersect with at least one 10-kilometer grid area containing an interference causing hypothetical base station. In Figure 3b, only County B area is marked as an impaired location. This is because with the spectral overlap = 0 MHz the D/U threshold is now Y dB and several of the hypothetical base stations no longer cause interference, County A area no longer intersects with any 10-kilometer grid areas containing interference-causing hypothetical base stations. These calculations are performed for each DTV station and each spectral overlap value to develop a complete list of Case 3 impairment locations for use during the incentive auction.

21. **Case 4.** The area within a specified separation distance from the outer edge of the DTV station’s contour and including all area inside of the contour is divided into 2-kilometer grid cells. Each grid cell that falls within this area is noted and marked as impaired. The totality of these marked grid cells within any particular wireless license area becomes the restricted area of the wireless license. Determination of whether a grid cell is inside or outside of the specified separation distance is based on the point defined by the population centroid of the 2-kilometer grid cell or by the geometric center of the grid cell, when no population is present. Specified separation distances are based on wireless to DTV channel spectral overlap and are given in Table 8.

**A. Threshold Values for Interference from Wireless Downlink into Digital Full Power and Class A TV Stations (Case 3)**

22. The threshold D/U ratios for interference to DTV service from wireless downlink operations for the varying amounts of spectral overlap are shown in Table 7; a predicted D/U ratio lower than the applicable value in Table 7 indicates that interference is expected in cell. OTR is set to zero in this case because the DTV receiver bandwidth is assumed to be larger than the wireless emission.

Spectral Overlap (MHz)	5	4	3	2	1	0 to -5 <sup>24</sup>
Downlink to DTV D/U Required (dB)	16 + $\alpha$	15.1 + $\alpha$	13.8 + $\alpha$	12.1 + $\alpha$	9.3 + $\alpha$	-33

Table 7. Threshold Interfering D/U Ratios for Wireless Base Station into DTV

**B. Threshold Values for Interference from Wireless Uplink into Digital Full Power and Class A TV Stations (Case 4)**

23. Impairments caused to TV service by uplink full or partial co-channel (spectral overlaps of +5 to +1 MHz) wireless user equipment are to be determined based on a five kilometer distance restriction measured from the station's noise-limited or protected contour. Impairments due to full or partial first-adjacent-channel wireless user equipment (spectral overlaps of 0 to -5 MHz) are to be based on a 0.5 kilometer distance restriction measured from the station's noise-limited or protected contour.<sup>25</sup>

Spectral Overlap (MHz)	+5 to +1 MHz	0 to -5 MHz
Uplink to DTV Separation Requirement (km)	5	0.5

Table 8. Separation Distance requirements for Wireless UE to DTV

**C. Technical Specifications**

24. *Methodology to Define DTV Service Area.* For Case 3, service of digital full power television stations is evaluated inside the noise-limited contour defined in 47 C.F.R. § 73.622(e), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus the area subject to calculation for digital full power TV stations consists of that within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of the time by FCC curves is at least as great as the values given in Table 9 below.<sup>26</sup>

<sup>24</sup> We assume -33 dB adjacent channel rejection for the DTV receiver and  $43 + 10 \log(P)$  in a 100 kHz bandwidth attenuation for the wireless emission mask. These flat response curves lead to a constant OFR rejection at spectral overlaps less than 0 MHz.

<sup>25</sup> See Daniel, W. and Wong, H., "Propagation in Suburban Areas at Distances less than Ten Miles," FCC/OET TM 91-1, Federal Communications Commission, Office of Engineering and Technology, January 25, 1991." Assuming 18 dB $\mu$ V/m (41 dB $\mu$ V/m – 23 dB) as a sufficient field strength threshold to protect co-channel DTV and 51 dB $\mu$ V/m (41 dB $\mu$ V/m – 23 dB + 33 dB) as a sufficient field strength threshold to protect adjacent-channel DTV, as well as outdoor propagation from user equipment operating at 23 dBm (-9.2 dBW assuming a -2.2 dBd antenna gain), with a transmit height above ground of 1.5 meters and a receive antenna height above ground of 10 meters, the resulting separation distances from the 41 dB $\mu$ V/m DTV service contour are 2.8 kilometers for co-channel and 0.4 kilometers for adjacent-channel operation. While the user equipment could be higher above ground resulting in a larger separation distance, this simple analysis does not consider other factors such as building attenuation, clutter losses from other obstacles, transmit antenna inefficiencies, transmit power control, or receive antenna discrimination.

<sup>26</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699.

Channels	Defining Field Strength, dB $\mu$ V/m, to be predicted using F(50, 90) curves
14 - 51	$41 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 9. Field strength defining the area subject to ISIX calculations for UHF digital full power TV stations

25. For digital Class A TV stations, service is protected only inside the “protected contour” defined in 47 C.F.R. § 73.6010(c), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus the area subject to calculation for digital Class A TV stations consists of that within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of time by FCC curves is at least as great as the values given in Table 10 below.<sup>27</sup>

Channels	Defining Field Strength, dB $\mu$ V/m, to be predicted using F(50, 90) curves
14 - 51	$51 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 10. Field strength defining the area subject to ISIX calculations for UHF digital Class A TV stations

26. The values set in the Longley-Rice Fortran code implementing the Longley-Rice model accompanying the FCC’s *TVStudy* software are provided in Table 11 below. As adopted in the *ISIX R&O*,<sup>28</sup> in those cases that error code 3 occurs (KWX = 3), the predicted field strength is to be accepted as indicative of whether noise-limited field strength is available at that location.

<sup>27</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699.

<sup>28</sup> See *ISIX R&O*, 29 FCC Rcd at 13100-01, para 54.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOLE	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	30	Height of the radiation center above ground.
HG(2) (m)	10	Height of DTV receiver above ground
Time variability (desired signal)	90%	
Time variability (undesired signal)	10%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Code	Ignore	Accept the path loss value that is returned by Longley-Rice code

Table 11. Longley-Rice parameter values for ISIX Case 3

27. *D/U Ratio Limits for Interference to DTV.* To predict impairments resulting from wireless interference to DTV service caused by wireless co-channel interference, the minimum D/U ratios are computed from the following formula:

$$\begin{aligned} \text{Wireless-into-DTV D/U Co-Channel} &= 16 + \alpha - \text{OFR} \\ \text{Wireless-into-DTV D/U Adjacent-Channel} &= -33 \end{aligned}$$

Where:

$$\alpha = \text{minimum} \left( 10 \log_{10} \left[ \frac{1}{(1 - 10^{-x/10})} \right], 8 \right)$$

$$x = \text{S/N} - 15.19 \text{ dB}$$

OFR = Off-frequency rejection (See Table 12)

The quantity x is the amount by which the actual desired S/N exceeds the minimum required for DTV reception. As the desired DTV signal level approaches the minimum level for reception, the D/U ratio will increase exponentially.

28. The D/U threshold for each spectral overlap is then adjusted by the OFR value based on the transmitter emission mask and receiver selectivity curves. The values for OFR were derived using the NTIA's MSAM FDR computer program,<sup>29</sup> using the FCC's emission limits for wireless,<sup>30</sup> and DTV

<sup>29</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook,

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receiver performance standards published by ATSC.<sup>31</sup> The results are provided in Table 12.

OFR (dB)	Overlap in MHz				
	5	4	3	2	1
Full Power and Class A stations	0	0.9	2.2	3.9	6.7

Table 12. Calculated Off-Frequency Rejection (OFR) values for Wireless into DTV

Parameter	Value	Comment
Emission BW (MHz)	5	
ERP (W)	720 <sup>32</sup>	Assumes 1.2 kW in 10 MHz channel with two 40 W power amplifiers.
ERP (dBm)	58.6	= $10\log_{10}(\text{ERP}) + 30$ .
G (dBd)	12.8	Assumes 15 dBi - 2.2 (approximate dipole gain).
Antenna Pattern	Non-directional	Hypothetical base station antennas are assumed to be non-directional in the azimuth direction and are assumed to have an elevation pattern similar to the generic pattern specified for UHF DTV in OET Bulletin No. 69, Table 8.
L (dB)	1	Line loss
HG(1) (m)	30	Antenna height above ground

Table 13. Assumed wireless base station transmitting specifications

29. We recognize that wireless downlink transmitters in multiple adjacent wireless spectrum blocks can increase the potential for interference to DTV service. To offset this, we assume base station ERP based on the power in a 6 MHz channel (see Table 13 and footnote 32) and separately evaluate each 5 MHz wireless channel.

30. *TV Receiving Antenna Pattern.* For Case 3, the TV receiving antenna is assumed to have a directional gain pattern which tends to discriminate against off-axis undesired stations. This pattern is a planning factor affecting interference.<sup>33</sup> A working group of the FCC Advisory Committee for Advanced Television Service selected the specific form of this pattern. The discrimination, in relative field, provided by the assumed TV receiving pattern is a function of the angle between the lines joining the desired and undesired stations to the reception point. One of these lines goes directly to the desired station, the other goes to the undesired station. The discrimination is calculated as the fourth power of the cosine of the angle between these lines but never more than represented by the front-to-back ratio of 14 dB for UHF. When both desired and undesired stations are on the receive antenna's boresight, the angle

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<http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28–31 (last visited Sept. 21, 2015); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5–8, 5–9 (last visited Sept. 21, 2015); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Sept. 21 2015).

<sup>30</sup> See 47 C.F.R. § 27.53(g).

<sup>31</sup> See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.2, Adjacent Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

<sup>32</sup> ERP of 720 W = 120 W/MHz x 6 MHz. This adds an additional 0.8 dB of interference power in the wireless block to simulate operations of wireless base stations transmitting across contiguous adjacent wireless blocks affecting one 6 MHz TV channel.

<sup>33</sup> See OET Bulletin No. 69 at 9.

is 0.0 giving a cosine of unity so that there is no discrimination. When the undesired station is somewhat off-axis, the cosine will be less than unity and the resulting interference field strength is reduced accordingly by this value (while the desired field strength remains unchanged); when the undesired station is far off axis,<sup>34</sup> the maximum discrimination given by the 14dB front-to-back ratio is attained, and the resulting interference field strength is reduced by 14 (while the desired field strength still remains unchanged).

31. *Base Station Transmitter Antenna Pattern.* For Case 3, the base station transmitter azimuth pattern is assumed to be non-directional. The base station elevation pattern is based on UHF DTV vertical pattern described in OET Bulletin No. 69, Table 8, however it is assumed to be symmetrical above and below the horizon.

## V. ENGINEERING DATABASES

32. *DTV Engineering Data.* Engineering data for TV stations in the U.S. (including full power DTV and Class A) is available from the FCC. Data for individual stations can be found at <http://www.fcc.gov/mb/video/tvq.html>, and consolidated data for all authorized stations can be found at <ftp://ftp.fcc.gov/pub/Bureaus/MB/Databases/cdbs/>. Where more than one authorization exists for a particular station, the record associated with the facility actually operating is used. Where specific elevation pattern data are not provided, a generic elevation pattern may be used as described in OET Bulletin No. 69. The generic elevation pattern should, however, be offset by the amount of electrical beam tilt specified in the CDBS. When performing inter-service interference calculations for the purpose of predicting impaired locations during the incentive auction, the CDBS dataset approved by the Commission for use in the auction will be used.

## VI. USING TVSTUDY TO RUN INTER-SERVICE INTERFERENCE ANALYSIS FOR PREDICTION OF WIRELESS MARKET IMPAIRMENTS

33. *TVStudy Parameter Settings.* *TVStudy* with parameter settings as discussed below is used to perform the inter-service interference analyses to determine impairment locations in each wireless market. The results of these analyses will be used by the auction design team to determine market impairments. The *TVStudy* settings for each ISIX case will be identical to those in the final incentive auction *TVStudy* template with the exceptions as shown in Table 14 below.

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<sup>34</sup> Approximately 41.5° at Low VHF, 45° at High VHF, and 48.1° and UHF.

<i>TVStudy Tab</i>	<i>Parameter Name</i>	<i>ISIX Case 1<sup>35</sup></i>	<i>ISIX Case 2<sup>36</sup></i>	<i>ISIX Case 3</i>
General	Pathloss Profile Resolution - US	10	10	10
General	Rule Limit Extra Distance			200
General	First TV Channel	14	14	14
Patterns	Digital receive antenna f/b, UHF	0	0	
Patterns	Analog receive antenna f/b, UHF	0	0	
Contours	Digital Full Service contour, UHF - US	0	0	
Contours	Digital Class A/LPTV, UHF - US	0	0	
Contours	Analog Full Service, UHF - US	0	0	
Contours	Analog Class A/LPTV, UHF - US	0	0	
Contours	Propagation Curve Set, digital - US	F(50,10)	F(50,10)	
Contours	Propagation Curve Set, analog - US	F(50,10)	F(50,10)	
Contours	Truncate DTS service Area	unchecked (false)	unchecked (false)	
Contours	Minimum HAAT - US	50	50	
Pathloss	Longley-Rice error Handling - US	Disregard	Disregard	Disregard
Pathloss	Receiver Height AGL	30	1.5	
Pathloss	Digital Desired % time	50	50	

Table 14. ISIX *TVStudy* Parameter Settings that vary from the Incentive Auction TV-to-TV Defaults

34. *TVStudy ISIX Scenarios.* Inter-service interference impairment scenarios are created in *TVStudy* using its XML scenario import feature.

35. *ISIX Case 1 & 2 Scenarios.* For Case 1 or Case 2 impairment determinations during the auction, all CDBS DTV stations will be added to a single ISIX Case 1 or Case 2 scenario. Alternatively, if a smaller scenario is desired, this can be accomplished by identifying all CDBS stations within 500 km of a license boundary by selecting sites from *TVStudy*'s MYSQL data base and using a GIS tool or the search on radius feature of *TVStudy* with a center point selected from the center of the license boundary. Include additional distance in the radius to account for the maximum distance from license center point to license boundary, *i.e.* include additional distance equal to that maximum distance.

36. All DTV sites are to be added as "Desired Only" and replicated on channel 38. An XML scenario for ISIX Case 1 or Case 2 will look like the example shown in Figure 6 below. Other attributes can be included if desired; see the *TVStudy* Manual for more information on XML scenario format and attributes.

<sup>35</sup> When studying interference from US DTV across the border into Canadian wireless base stations the pathloss parameters of receiver height and Digital Desired % time are set to 50 meters and 10, respectively.

<sup>36</sup> When studying interference from US DTV across the border into Canadian user equipment the pathloss parameter of Digital Desired % time is set to 10.

```

<SCENARIO NAME="ExampleScn">
  <DESCRIPTION>example scenario</DESCRIPTION>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1310956"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1250731"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1331145"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1179172"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1260424"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1450167"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1431623"/>
  .
  .
  .
</SCENARIO>

```

Figure 4. Example XML ISIX Case 1 or Case 2 scenario

37. *ISIX Case 3 Scenarios.* For Case 3 impairment determinations during the auction, scenarios are established for each license or a grouping of license areas. This is accomplished by identifying all CDBS stations within 500 km of a license boundary by using a GIS tool or by using *TVStudy*'s search on radius feature of with a center point selected from the center of the license boundary and including additional distance in the radius to account for the maximum distance from license center point to license boundary. Create an XML scenario including all the 10-kilometer-spaced hypothetical wireless base stations within a license area of interest. Attributes for the hypothetical base stations are set as follows:

Attribute	Setting
Desired	FALSE
Undesired	TRUE
Locked	FALSE
CDBS_ID	<any integer> Must be present but not used since LOCKED=FALSE. Can be set to same integer as Facility ID
ID	<any integer> This is treated as Facility ID and it is useful to set this to a value that can be used to identify the hypothetical point.
SERVICE	DT
CHANNEL	38
CALL_SIGN	<any value>
CITY	<any value>
STATE	<any 2 letter value>
STATUS	LIC
FILE_NUMBER	<any value>
LATITUDE/LONGITUDE	NAD27 coordinates of hypothetical point. Can be given in unsigned decimal degrees or DMS_H format.
HAMSL	-999 (to have <i>TVStudy</i> calculate this value from specified HAAT)
HAAT	30 <sup>37</sup>
ERP	0.72
HAS_APAT	FALSE

<sup>37</sup> When creating Case 3 XML scenarios for Canadian wireless base stations, the HAAT for Canadian wireless base station is set to 50 meters. The HAAT for Mexican base station is set to 30 meters.

HAS_EPAT	TRUE
EPAT_ETILT	0
EPAT_MTILT	0
EPAT_ORIENT	0
HAS_MPAT	FALSE
USE_GENERIC	TRUE

Table 15. ISIX Case 3 XML Scenario Hypothetical Transmitter Attribute Settings

38. The elevation pattern for each base station must be imported in the XML file. The values for the symmetrical generic pattern are as follows.

Elevation Angle	Relative Field Strength
-90	0.15
-8.5	0.15
-7.5	0.15
-6.5	0.15
-5.5	0.15
-4.5	0.15
-3.5	0.2
-2.5	0.21
-2	0.235
-1.5	0.26
-1	0.46
-0.5	0.69
0	0.88
0.75	1
1.5	0.88
2	0.69
2.5	0.46
3	0.26
3.5	0.235
4	0.21
5	0.2
6	0.15
7	0.15
8	0.15
9	0.15
10	0.15
90	0.15

Table 16. ISIX Base Station Elevation Pattern

39. The inter-service interference Case 3 XML scenario will look similar to the example shown in Figure 5 below. CDBS sites are listed as “desired” while all hypothetical base stations are listed as undesired only.

```

<TVSTUDY VERSION="103000">
<SCENARIO NAME="EA127">
<DESCRIPTION>ISIX Case 3 Test</DESCRIPTION>
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="60000080" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="60000580" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="60001120" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="60001270" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="60001560" />
<SOURCE DESIRED="FALSE" UNDESIRED="TRUE" LOCKED="FALSE" CDBS_ID="3008624" ID="3008624"
SERVICE="DT" COUNTRY="US" CHANNEL="38" CALL_SIGN="eNB-8624" CITY="EA127" STATE="EA"
STATUS="LIC" FILE_NUMBER="FCCFileNo_8624" LATITUDE="30.825" LONGITUDE="97.3393"
HAMSL="-999" HAAT="30" ERP="0.72" HAS_APAT="FALSE" HAS_EPAT="TRUE" EPAT_ETILT="0" EPAT_MTILT="0"
EPAT_ORIENT="0" HAS_MPAT="FALSE" USE_GENERIC="TRUE">
<EPAT>
-90,0.15
-8.5,0.15
-7.5,0.15
-6.5,0.15
.
.
.
8,0.15
9,0.15
10,0.15
90,0.15
</EPAT>
</SOURCE>
.
.
.
</SCENARIO>
</TVSTUDY>

```

Figure 5. Example ISIX Case 3 XML Scenario

## APPENDIX E

## FINAL REGULATORY FLEXIBILITY ANALYSIS

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),<sup>1</sup> an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rule Making* (NPRM).<sup>2</sup> The Commission sought written public comment on the proposals in the *NPRM*, including comment on the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.<sup>3</sup>

**A. Need for, and Objectives of the Rules**

2. In the *Incentive Auction R&O*, we adopted a flexible band plan framework that accommodates market variation.<sup>4</sup> Market variation occurs where broadcast stations remain on spectrum that is repurposed for wireless broadband under the 600 MHz Band Plan.<sup>5</sup> In this *Third Report and Order and First Order on Reconsideration*, we adopt the framework we proposed in the inter-service interference Further Notice (*ISIX Further Notice*) to govern the interference environment in the new 600 MHz Band due to market variation.<sup>6</sup>

3. We adopt a number of measures to protect television reception for those television stations that will remain in the 600 MHz Band after the incentive auction. We adopt a zero percent threshold for interference from wireless operations to the reception of signals from television broadcast stations in the 600 MHz Band, which will prohibit 600 MHz wireless licensees from causing harmful interference at any level within the contour of a broadcast station.<sup>7</sup> We also adopt OET-74, a methodology for predicting interference to television receivers from wireless base stations. However, we modify the D/U threshold used to determine if interference to television reception is occurring in OET-74 from what was proposed in the *ISIX Further Notice* so that the threshold does not become unrealistically large when the television signal is weak. Wireless licensees will be allowed to deploy base stations within a specified culling distance of co-channel or adjacent channel television stations only where they can demonstrate using OET-74 that they will not cause harmful interference to television reception within the stations' contours.<sup>8</sup> In addition, we prohibit the operation of wireless user equipment within five kilometers of the contours of co-channel television stations and one-half kilometer of adjacent channel television stations. We will require wireless licensees to eliminate any actual harmful interference to the reception of signals from television station in the 600 MHz Band, even if such interference was not predicted using OET-74.

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<sup>1</sup> See 5 U.S.C. § 603. The RFA, see 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

<sup>2</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, ET Docket No. 13-26, ET Docket No. 14-14, Second Report and Order and Further Notice of Proposed Rulemaking, 29 FCC Rcd 13071 (2014) (*ISIX R&O/FNPRM or ISIX R&O or ISIX Further Notice*).

<sup>3</sup> See 5 U.S.C. § 604.

<sup>4</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6605, para. 82 (discussing how the 600 MHz Band Plan can accommodate market variation to avoid restricting the amount of repurposed spectrum that is available in most areas nationwide).

<sup>5</sup> See *id.* at 6604-6607, paras. 81-87.

<sup>6</sup> See *ISIX Further Notice*.

<sup>7</sup> The term “contour” refers to either the “noise-limited contour” for full power television stations or “protected contour” for Class A television stations. See 47 C.F.R. §§ 73.622(e), 73.6010.

<sup>8</sup> Co-channel operations in the 600 MHz band are defined as operations of broadcast television stations and wireless services where their assigned channels spectrally overlap. Adjacent channel operations are defined as operations of broadcast television stations and wireless services where their assigned channels spectrally about each other or are separated by up to 5 MHz. 47 C.F.R. § 27.1310(d).

4. We also adopt measures to protect the future operations of 600 MHz Band wireless licensees from television stations that remain in the 600 MHz band. We will prohibit broadcast television licensees who operate in the 600 MHz Band from expanding their noise-limited or protected contours if doing so would increase the potential for interference to a wireless licensee's service area or would result in additional impairments to the wireless licenses because of the obligations of the wireless licensee to protect television reception.<sup>9</sup> We also adopt the use of the ISIX Methodology specified in the *ISIX R&O*,<sup>10</sup> as modified in the *First Order on Reconsideration*, for predicting when an LPTV or TV translator station will cause harmful interference to wireless operations.<sup>11</sup> For this purpose, the ISIX Methodology will use the same threshold values for the prediction of interference from full power television to wireless operations as specified in the *ISIX R&O* and will use the F(50,10) statistical measure to predict the strength of the LPTV or TV translator signal.

5. Under the rules we adopted in the *Incentive Auction R&O*, 600 MHz Band wireless licensees are required to meet interim and final build-out requirements, but the build-out requirements only apply to areas they are permitted to serve.<sup>12</sup> We will require 600 MHz wireless licensees to use the ISIX Methodology and/or OET-74 to demonstrate that they cannot meet build-out requirements for portions of the geographic area covered by their license.

6. U.S. television stations may cause interference to Canadian wireless operations after the incentive auction. For purposes of predicting these impairments during the incentive auction, we adopt the use of the ISIX Methodology with adjustments to reflect an agreement reached with Canada.

7. In the *First Order on Reconsideration* we consider a number of petitions for reconsideration filed in response to the *ISIX R&O*. We affirm our decision to use the ISIX Methodology to predict inter-service interference between television and wireless services during the incentive auction. We modify the ISIX Methodology adopted in the *ISIX R&O* by making the same adjustment to the D/U threshold used to determine if interference will occur to television reception as we did for OET-74. We also affirm our decisions declining to adopt a cap on the aggregate amount of new interference a broadcast television station may receive from other television stations in the repacking process and declining to adopt a cap on population loss that a television station may experience because of a new channel assignment in the repacking process. We amend our rules to provide that a television station that will experience a loss in population served in excess of one percent as a result of the repacking process -- either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both) -- may file an application proposing an alternate channel or expanded facilities in a priority filing window. In response to a petition for reconsideration of the *Incentive Auction R&O*, we affirm our decision to use the *TVStudy* software and certain inputs in applying the methodology described in OET-69 to determine the coverage area and population served by television stations when making new channel assignments during the incentive auction.

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

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

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<sup>9</sup> For purposes of this rule, the contours of broadcast television stations are deemed to be those described in their initial post-auction construction permit for their new channel.

<sup>10</sup> *ISIX R&O*, 29 FCC Rcd at 13089-92, paras. 36-41.

<sup>11</sup> As set forth in the *Incentive Auction R&O*, LPTV and TV translators in the 600 MHz Band may continue operating indefinitely unless a 600 MHz licensee provides advance notice that it intends to commence operations and that the LPTV or TV translator is likely to cause harmful interference to the wireless operations. *Incentive Auction R&O*, 29 FCC Rcd at 6834-6835, 6839-6841, paras. 657, 668-671.

<sup>12</sup> *Id.* at 6606-07, para. 86.

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

9. 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**

10. 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>13</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>14</sup> In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.<sup>15</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 SBA.<sup>16</sup>

11. *Television Broadcasting.* This economic census category "comprises establishments primarily engaged in broadcasting images together with sound. These establishments operate television broadcasting studios and facilities for the programming and transmission of programs to the public."<sup>17</sup> The SBA has created the following small business size standard for Television Broadcasting firms: those having \$38.5 million or less in annual receipts.<sup>18</sup> The Commission has estimated the number of licensed commercial television stations to be 1,388.<sup>19</sup> In addition, according to Commission staff review of the BIA Advisory Services, LLC's *Media Access Pro Television Database* on March 28, 2012, about 950 of an estimated 1,300 commercial television stations (or approximately 73 percent) had revenues of \$38.5 million or less.<sup>20</sup> We therefore estimate that the majority of commercial television broadcasters are small entities.

12. We note, however, that in assessing whether a business concern qualifies as small under the above definition, business (control) affiliations must be included.<sup>21</sup> Our estimate, therefore, likely overstates the number of small entities that might be affected by our action because the revenue figure on

<sup>13</sup> 5 U.S.C. § 603(b)(3).

<sup>14</sup> 5 U.S.C. § 601(6).

<sup>15</sup> 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to the RFA, 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." 5 U.S.C. § 601(3).

<sup>16</sup> Small Business Act, 15 U.S.C. § 632 (1996).

<sup>17</sup> U.S. Census Bureau, *2012 NAICS Definitions: 515120 Television Broadcasting*, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=515120&search=2012> (last visited Mar. 6, 2014).

<sup>18</sup> 13 C.F.R. § 121.201 (NAICS code 515120) (updated for inflation in 2010).

<sup>19</sup> See FCC News Release, *Broadcast Station Totals as of December 31, 2013* (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>20</sup> We recognize that BIA's estimate differs slightly from the FCC total given the information provided above.

<sup>21</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. § 121.103(a)(1).

which it is based does not include or aggregate revenues from affiliated companies. In addition, an element of the definition of “small business” is that the 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 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 to that extent.

13. In addition, the Commission has estimated the number of licensed noncommercial educational (“NCE”) television stations to be 395.<sup>22</sup> These stations are non-profit, and therefore considered to be small entities.<sup>23</sup>

14. There are also 2,414 LPTV stations, including Class A stations, and 4,046 TV translator stations.<sup>24</sup> Given the nature of these services, we will presume that all of these entities qualify as small entities under the above SBA small business size standard.

15. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* The Census Bureau defines this category as follows: “This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.” The SBA has developed a small business size standard for Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing, which is: all such firms having 750 or fewer employees. According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 912 had less than 500 employees and 17 had more than 1000 employees. Thus, under that size standard, the majority of firms can be considered small.

16. *Audio and Video Equipment Manufacturing.* The SBA has classified the manufacturing of audio and video equipment under in NAICS Codes classification scheme as an industry in which a manufacturer is small if it has less than 750 employees. Data contained in the 2007 U.S. Census indicate that 492 establishments operated in that industry for all or part of that year. In that year, 488 establishments had fewer than 500 employees; and only 1 had more than 1000 employees. Thus, under the applicable size standard, a majority of manufacturers of audio and video equipment may be considered small.

17. *Wireless Telecommunications Carriers (except satellite).* The Census Bureau defines this category as follows: “This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves. Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular phone services, paging services, wireless Internet access, and wireless video services.”<sup>25</sup> The appropriate size standard under SBA rules is for the category Wireless Telecommunications Carriers (except Satellite). The size standard for that category is that a business is small if it has 1,500 or fewer employees.<sup>26</sup> For this

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<sup>22</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>23</sup> See generally 5 U.S.C. §§ 601(4), (6).

<sup>24</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. January 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>25</sup> U.S. Census Bureau, *2012 NAICS Definitions: 517210 Wireless Telecommunications Carriers (except Satellite)*, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=517210&search=2012> (last visited Mar. 6, 2014).

<sup>26</sup> 13 C.F.R. § 121.201 (NAICS code 517210).

category, census data for 2007 show that there were 1,383 firms that operated for the entire year.<sup>27</sup> Of this total, 1,368 firms had employment of 999 or fewer employees and 15 had employment of 1000 employees or more.<sup>28</sup> Similarly, according to Commission data, 413 carriers reported that they were engaged in the provision of wireless telephony, including cellular service, PCS, and Specialized Mobile Radio (“SMR”) Telephony services.<sup>29</sup> Of these, an estimated 261 have 1,500 or fewer employees and 152 have more than 1,500 employees.<sup>30</sup> Consequently, the Commission estimates that approximately half or more of these firms can be considered small. Thus, using available data, we estimate that the majority of wireless firms can be considered small.

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

18. Wireless licensees in the 600 MHz Band will be required to conduct an interference analysis using OET-74 before operating a base station within the culling distance of the contour of a co-channel or adjacent channel broadcast television station. They will also be required to conduct an OET-74 interference analysis when making a modification to such a base station that could result in an increase in energy in the direction of broadcast station’s contour. The wireless licensee will be required to retain the latest copy of their OET-74 analysis for each base station that is within the culling distance of a co-channel or adjacent channel broadcast station. The wireless licensee will be required to make this analysis available for inspection by the Commission at any time and to make this analysis available to a television station upon request when there are complaints of interference either from the subject television station or a station viewer. Wireless licensees and television stations will cooperate in good faith to resolve any disputes, as not to unreasonably frustrate wireless and broadcast operations. In the event the parties do not reach resolution, a broadcaster can submit a claim of harmful interference to the Commission.

19. Wireless licensees in the 600 MHz Band will be prohibited from operating a base station within the contour of a co-channel or adjacent channel broadcast station. Wireless licensees will also be required to limit their coverage areas so that mobile and portable devices maintain a minimum distance of five kilometers from a co-channel broadcast station’s contour and 500 meters from an adjacent channel broadcast station’s contour.

20. Wireless licensees will be required to eliminate any harmful interference that occurs to television reception within the contours of a co-channel or adjacent channel broadcast television station. This requirement to eliminate harmful interference applies even if the OET-74 analysis indicates that no harmful interference will occur.

21. A broadcast television station in the 600 MHz Band will not be allowed to expand its contour such that it would increase impairments to a wireless licensee either by causing additional interference to the wireless licensee’s service area or because of the obligations of the wireless licensee to protect television reception, unless an agreement is reached with the wireless licensee allowing the expansion.

22. A wireless licensee that intends to commence operations will be required to use the ISIX Methodology adopted in the *ISIX R&O*, as modified in the *First Order on Reconsideration*, to determine

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<sup>27</sup> U.S. Census Bureau, Table No. EC0751SSSZ5, *Information: Subject Series - Establishment and Firm Size: Employment Size of Firms for the United States: 2007* (NAICS code 517210), [http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2007\\_US\\_51SSSZ5](http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_51SSSZ5).

<sup>28</sup> *Id.* Available census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with 1000 employees or more.

<sup>29</sup> See *Trends in Telephone Service* at Table 5.3.

<sup>30</sup> See *id.*

if a LPTV or translator station will cause it harmful interference. The wireless licensee will then be able to send the required notification to the LPTV or translator station that will cause it harmful interference.<sup>31</sup>

23. Wireless licensees will use the ISIX Methodology or OET-74 to show that they are unable to operate in portions of their license area for purposes of satisfying their build-out requirements. They will use the ISIX Methodology for demonstrating harmful interference from co-channel and adjacent channel broadcast television stations to their base stations and user equipment as well as demonstrating harmful interference from wireless user equipment to television receivers. They will use OET-74 for demonstrating harmful interference from wireless base stations to television receivers.<sup>32</sup> If the impairing television station ceases to operate before the construction benchmarks, the wireless licensee will be permitted to use the entire license area, and will be obligated to serve the area that was previously restricted in demonstrating that it has met its build-out requirements.<sup>33</sup>

24. A television station that will experience a loss in population served in excess of one percent as a result of the repacking process -- either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both) -- may file an application proposing an alternate channel or expanded facilities in a priority filing window. Previously, our rules permitted a station to file an application in the priority filing window only when the greater than one percent loss in population served was from station-to-station interference.

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

25. The RFA requires an agency to describe any significant 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 or reporting requirements under the rule for 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 small entities.<sup>34</sup>

26. Many of the reporting, recordkeeping, and compliance requirements we adopt here are designed to protect television broadcast stations and 600 MHz Band wireless licensees from harmful interference. Because many of these television broadcast stations and wireless licensees are small entities, the rules will protect the economic interest of small entities. Consequently, the effect of these rules on small entities can be viewed as a tradeoff between the compliance burdens of the rules on some small entities balanced against the interference protections supplied by the rules to other small entities. We conclude that the benefits of these rules in protecting small entities from interference is stronger than the compliance burdens that the rules place on small entities.

27. For example, the adopted rules require wireless licensees to conduct an OET-74 interference analysis before locating a base station within the culling distance of a co-channel or adjacent channel television broadcast station. This rule will impact those wireless licensees that are small entities by requiring them to perform the OET-74 analysis and potentially preventing them from constructing base

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<sup>31</sup> The requirement that the LPTV or translator station that will cause a wireless licensee harmful interference cease operation within 120 days after receiving notification from a wireless licensee that is going to commence operations was adopted in the *Incentive Auction R&O*. *Incentive Auction R&O*, 29 FCC Rcd at 6834-6835, 6839-6841, paras. 657, 668-671.

<sup>32</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6883, 684, paras. 778, 781; 47 C.F.R. § 1.946(d). The construction notification will have to be filed within 15 days of the relevant milestone certifying that it has met the applicable performance benchmark within its permitted boundaries.

<sup>33</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 n. 277.

<sup>34</sup> See 5 U.S.C. § 603(c).

stations in portions of their licensed service areas. However, this requirement will help prevent harmful interference to the reception of signals from co-channel and adjacent channel television broadcast stations, many of whom are small entities. As an alternative to requiring an OET-74 analysis, we could have specified an exclusion zone around a broadcast television station's contour that wireless base stations could not be located within to prevent interference to television reception. However, this would have excluded the base stations from a much larger area than the adopted rules because it would not have taken into account the effects that terrain has on signal propagation and the characteristics of the base stations such as transmitted power and antenna height. Requiring an OET-74 analysis instead of relying on an exclusion zone thereby enables the wireless licensee to use a greater portion of its licensed service area, which is of significant economic benefit to the wireless licensee.

28. As another example, the adopted rules prohibit television broadcast stations in the 600 MHz Band from expanding their contours in a way that will impair a wireless license by causing interference to a wireless licensee or because of a wireless licensee's obligation to protect television reception. This rule will impact television broadcast stations in the 600 MHz Band by preventing them from expanding their contours in the future, but the rule will protect the interests of wireless licensees by preventing impairments of their licenses.

29. Some of the rules we are adopting here provide a means to implement rules we have previously adopted. For example, in the *Incentive Auction R&O*, we adopted rules requiring 600 MHz Band wireless licensees to meet build-out requirements.<sup>35</sup> While the previously adopted rules do not require wireless licensees to build-out their networks in areas that are impaired by either receiving interference from television broadcasters remaining in the band or because they will cause interference to television reception, the rules do not specify how the wireless licensee will show what areas are impaired. For purposes of demonstrating impairments for the build-out requirements, the *Third Report and Order* will require 600 MHz wireless licensees to use the ISIX Methodology for showing interference from television broadcasters to wireless operations and for interference from wireless user equipment to television receivers and will require wireless licenses to use OET-74 to demonstrate interference to television receivers. This requirement will benefit 600 MHz Band wireless licensees by enabling them to exclude impaired locations of their licensed areas from the build-out requirements.

30. In the *Incentive Auction R&O*, we specified that LPTV and TV translator station in the 600 MHz band could continue to operate until a wireless licensee provided advance notice that it intends to commence operations and the LPTV or TV translator is likely to cause harmful interference. For purposes of providing this displacement notice, in the *Third Report and Order* we specify that wireless licensees will use the ISIX Methodology to determine if the LPTV or TV translator stations will cause them interference for purposes of notifying the LPTV or TV translator stations. While this requirement will burden 600 MHz Band wireless licensees by requiring them to perform an ISIX Methodology interference study, it will benefit LPTV and TV translator licensees by allowing them to continue operating until their spectrum is actually needed by the wireless licensees. Consequently, this requirement represents a reasonable balancing between the interest of LPTV and translators, many of whom are small businesses, and 600 MHz Band wireless licensees, many of whom are also small licensees.

31. To minimize the burdens on small businesses that are required by the rules we are adopting that require OET-74 and ISIX Methodology interference analyses, we intend to make a version of our *TVStudy* software available that can perform these analyses. The software can be used on a computer that costs less than \$2000 and is available free online at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. Because we are making this software available, licensees will not need to develop their own software or contract with an engineering consultant to perform these interference analyses. To further reduce the compliance burden on 600 MHz Band wireless licensees, we will not require them to

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<sup>35</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6877-78, para 764.

share their OET-74 interference analysis with television broadcasters unless there is an actual interference complaint. The wireless licensee will be able to store the OET-74 analysis electronically, which will reduce the record keeping and compliance cost to the wireless licensee.

32. Television stations that are relocated during the incentive auction may experience a change in coverage area due to terrain loss because of the different propagation characteristics at their new frequency. Television stations that experience a loss in population served in excess of one percent as a result of the repacking process -- either because of new station-to-station interference or terrain loss resulting from a new channel assignment (or a combination of both) -- will now be permitted to file an application proposing an alternate channel or expanded facilities in a priority filing window. This will benefit television stations that experience such a loss of population serviced.

Report to Congress: The Commission will send a copy of the Third Report and Order and First Order on Reconsideration, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.<sup>36</sup> In addition, the Commission will send a copy of the Third Report and Order and First Order on Reconsideration, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Third Report and Order and First Order on Reconsideration and FRFA (or summaries thereof) will also be published in the Federal Register.<sup>37</sup>

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<sup>36</sup> See 5 U.S.C. § 801(a)(1)(A).

<sup>37</sup> See 5 U.S.C. § 604(b).

**STATEMENT OF  
COMMISSIONER AJIT PAI  
APPROVING IN PART AND CONCURRING IN PART**

Re: *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268; *Office of Engineering Technology Releases and Seeks Comment on OET-69 Software*, ET Docket No. 13-26; *Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services*, ET Docket No. 14-14.

Much of this item is an attempt to make the best of a bad situation. In its post-auction 600 MHz band plan, the Commission chose to place too many broadcast television stations in the wireless portion of the band. That decision, in turn, was an attempt to mask other mistakes that the Commission had made designing the incentive auction and thus to salvage the Commission's chances of holding a successful incentive auction. But the Commission's gambit came at a cost. In order to obtain short-term gain, the Commission was willing to inflict long-term pain in the form of post-auction inter-service interference in the 600 MHz band.

Here, the Commission finalizes rules and procedures designed to minimize such interference between broadcast television and wireless services. And for the most part, I agree with the determinations set forth in this item. I do, however, question a couple of them.

First, I believe that commenters made a strong case for using the F(50,10) statistical measure for predicting inter-service interference caused by DTV signals to wireless operations rather than the less conservative F(50,50) measure adopted by the Commission. The F(50,10) standard was endorsed by trade associations representing both wireless carriers (CTIA and CCA) and broadcasters (NAB), the stakeholders who will be impacted by this interference. Moreover, the Commission has agreed to use the F(50,10) measure when predicting interference from U.S. DTV signals to Canadian wireless operations. And I have not seen any evidence that Canadians are less tolerant of dropped calls and interrupted downloads than are Americans.

I do appreciate, however, that the Commission will be providing sufficient information to allow wireless carriers to conduct interference analyses using the F(50,10) standard prior to the auction. Carriers should then be able to use this information in formulating their bidding strategies. I hope that it will be easy for carriers to conduct these analyses and that the Commission will provide any necessary assistance, particularly with respect to small carriers.

Second, I wish that this item did more to minimize the population loss that any television station will experience when it is given a new channel assignment during the repacking process. While much attention focused early in this proceeding on population loss caused by interference between television stations, the change in a station's coverage area due to a channel change was more of a sleeper issue. On that issue, the Commission does provide some relief here. Specifically, this item allows stations that are predicted to experience a loss in population served in excess of one percent as a result of the repacking process to file an application proposing an alternate channel or expanded facilities in a priority filing window after the auction. While this step will not completely solve the problem, it is a step in the right direction.

**STATEMENT OF  
COMMISSIONER MICHAEL O'RIELLY  
CONCURRING**

*Re: Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, GN Docket No. 12-268; Office of Engineering and Technology Releases and Seeks Comment on Updated OET-69 Software, ET Docket No. 13-26; Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services, ET Docket No. 14-14.*

Today's order demonstrates the complexities that arise when trying to accommodate two distinct services in the same band. I applaud the efforts of the Office of Engineering and Technology for coming up with a means that should allow wireless providers and broadcasters to operate in close proximity to one another without causing harmful interference. It is disappointing, however, that such analyses will likely have to be conducted in more markets than absolutely necessary.

Despite considerable opposition, the Commission previously adopted auction and band plan designs that could result in a number of broadcast stations being placed in the 600 MHz uplink, downlink and duplex gap. While the placement of a few broadcasters in the new wireless band was an unfortunate necessity to prevent interference with stations located in Canada and Mexico, the Commission should have ensured that market variation was as limited as possible and only occurred to prevent cross-border interference. Instead, the Commission adopted a structure that would allow a graduated percentage of impairments to account for broadcasters repacked into the 600 MHz Band. For example, if the Commission sets an 84 megahertz clearing target, the impairment rate will be 14 percent (by weighted pops). As I have said before, such a ridiculously high percentage of impairment is unnecessary, especially in light of deals reached with Canada and Mexico to limit cross-border interference.

Instead of minimizing market variation and the number of impaired licenses, the Commission is inclined to place more broadcasters in the 600 MHz Band in order to increase the number of licenses that can be auctioned, even if these licenses are not "clean." Because I remain unable to support the impairment level, I concur to today's item.