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

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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.[1] 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,[2] 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.[3] 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.[4] 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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1 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.

2 *See* 47 C.F.R. § 73.682(d).

3 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 Rcd 10732 (2011).

4 *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;[5] the rules also specify standards for determining interference to DTV service.[6] Because wireless services are expected to be noise-like and studies have shown that noise-like signals have interference potential nearly identical to DTV,[7] 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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5 *See* 47 C.F.R. §§ 73.622(e), 73.6010(c).

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

7 *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.[8] 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.[9]

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.[10]

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.[11] The Longley-Rice propagation model Version 1.2.2 is

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

9 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.

10 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.

11 See *TVStudy Manual* at 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^2 at the south edge to 3.94 km^2 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

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[12] 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.

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

12 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.

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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)	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.
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.		

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 + α – OFR, spectral overlap > 0 MHz
Adjacent channel Wireless-into-DTV D/U = -33, spectral overlap ≤ 0 MHz

Where:

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

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

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 / OFR (dB)	5	4	3	2	1	0 to -5 MHz
Downlink into DTV	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[13] using FCC's emission limits,[14] and DTV receiver performance standards published by ATSC for the first-adjacent channel.[15]

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 α 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 α factor as the desired signal approaches the minimum S/N, α is limited to a maximum value of 8 dB.

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13 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. 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 28-31at 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).

14 *See* 47 C.F.R. § 27.53(g).

15 *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 (last visited May 1, 2014).

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5[16]
Downlink into DTV D/U Required (dB)	16.0 + α	15.1 + α	13.8 + α	12.1 + α	9.3 + α	-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-dBµV/m)	K_d	-130.8
Dipole factor adjustment	K_a	see text
Thermal noise (dBm)	N_t	-106.2
Antenna gain (dBd)	G	10
Downlead line loss (dB)	L	4
System noise figure (dB)	N_s	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:

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

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.[17] 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

16 -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.

17 *See* OET Bulletin No. 69 at 9.

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,[18] 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.[19]

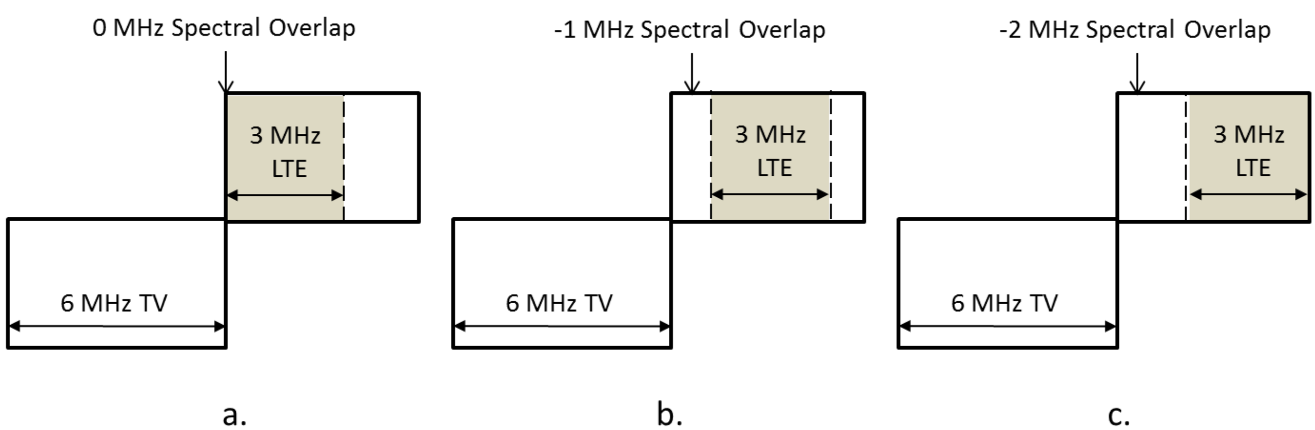

Figure 1. Examples of Spectral Overlap when LTE channel is using only a portion of 5 MHz channel

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[18] Approximately 41.5° at Low VHF, 45° at High VHF, and 48.1° and UHF.

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

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) + 17dBμV/m, for co-channel and 74 dBμV/m for adjacent channel} contour.

HAAT	ERP (kW)								
(m):	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 ≥ 5 MHz)

HAAT	ERP (kW)								
(m):	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	ERP (kW)								
(m):	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	ERP (kW)								
(m):	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	ERP (kW)								
(m):	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 ≤ 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.[20] The generic elevation pattern should, however, be offset by the amount of electrical beam tilt specified in the CDBS.

[20] 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).