INTERFERENCE ON THE FM BAND

Doug Vernier

V-Soft Communications/Telecommunication Consultants

Cedar Falls, Iowa

As enter into the new millennium, we note that the FCC has several proposals before it that will affect the future of the FM band by raising the interference floor. Its plans to "streamline" the rules to allow interference signal contours to overlap protected signal contours by up to five percent and for interference to be bought and sold under "negotiation" and its plans to create a whole new service of low power FM stations without maintaining current 3^{rd} or 2^{nd} adjacent channel protections cause serious concerns. It is the purpose of this paper to review methods for predicting interference while examining some weaknesses and strengths and to review some recent receiver studies which will help us determine the ultimate impact of the proposed changes on modern FM radio listening.

Coverage:

The broadcast industry today is dependent upon reaching people. Quality coverage is a key ingredient. The better the signal the higher the likelihood people will listen. FM coverage is dependent on a station's radiated power level and its antenna height when considered in relationship to terrain averages. Noise and interference from other stations reduce coverage.

The FCC method of determining coverage involves calculating the effective antenna height of a given transmitter along a minimum of eight azimuths. At least fifty terrain elevation points from 3 to 16 kilometers from the transmitter must be evaluated on the eight azimuth radials. (See Figure #1) For many years topographic maps were used to derive the elevation points, but today nearly all such work is performed by computers using either the National Geophysical Data Center's 30 arc second digital terrain database or the United States Geological Survey's 03 arc second terrain database. The elevation points are averaged to produce an average elevation for the radial. This figure is then subtracted from the antenna's center of radiation above mean sea level to determine the "height above average terrain" along the radial. The distance to a signal contour is then calculated using the FCC's F(50-50) curves found under section 73.333. The FCC has published two sets of curves the F(50-50) for coverage and the F(50-10) for interference calculations. Today, nearly all signal calculations using the Commission's curves are done with computers.

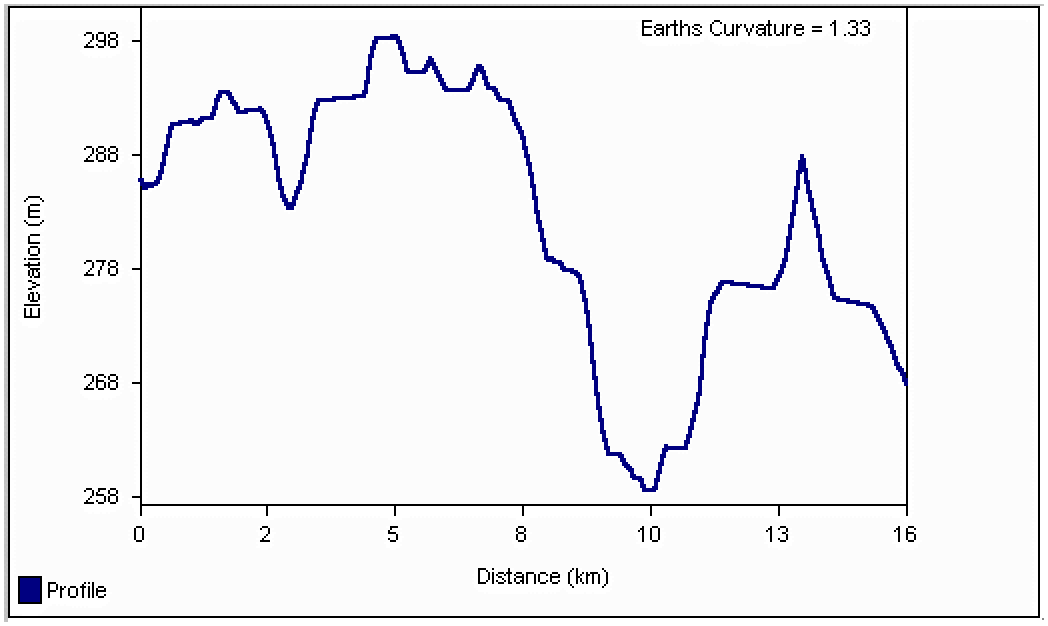


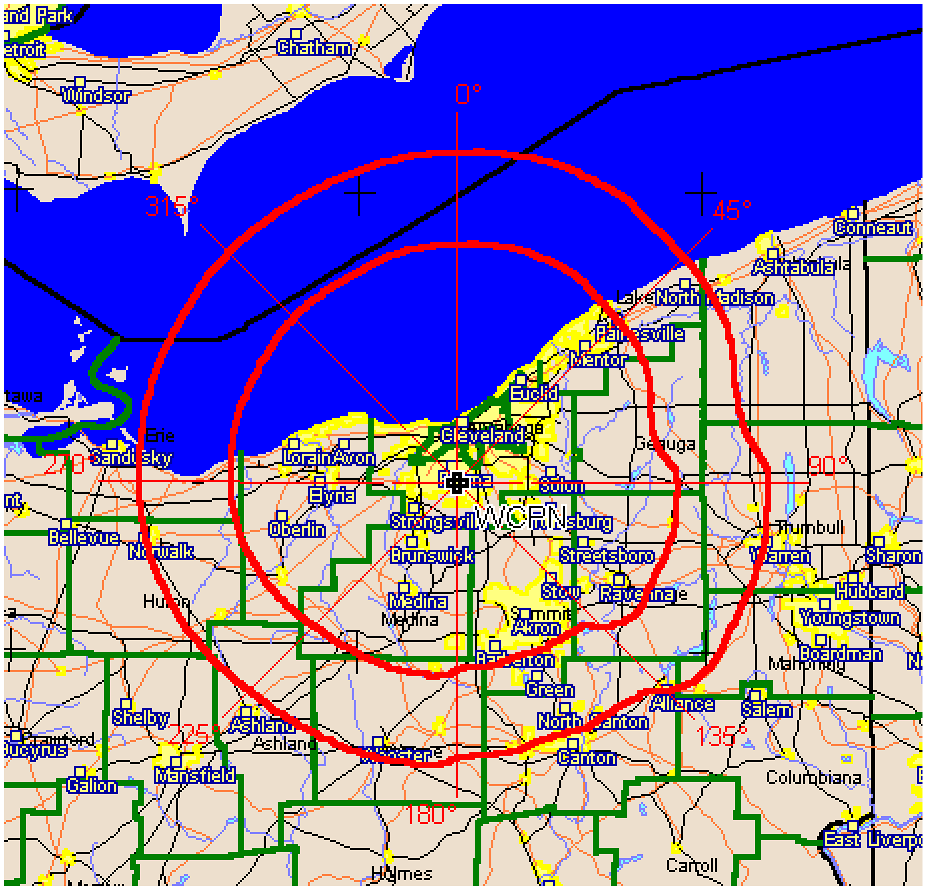
Figure 1 - Terrain Elevation Profile

A given station's coverage area is supposed to be protected from interference under the FCC's rules. As we shall see this is not always the case. The chart below lists the signal contours the FCC considers "protected" and within which interference should not be received.

Station Class	*Protected Contour in dBu*
A	60
C3	60
C2	60
C1	60
C	60
B1	57
B	54

Figure 2 shows the 60 and 50 dBu signal contours of a typical station.

Figure 2 - Typical F(50-50) Coverage Contours



Channel assignment procedures:

To simplify the process of assigning new channels in the commercial band the FCC has created a set of distance tables that define the minimum distance one station must be removed from another. These tables consider the class of stations involved and the channel relationship. As an example, Table A shows the minimum spacings between a class A station and stations of other classes.

Table A - Minimum Distance Separation

(Requirements in Kilometers)

	Co	*1st*	*2nd*	*3rd*	*IF*
A to A	115	72	31	10	
A to B1	143	96	48	12	
A to B	178	113	69	15	

A to C3	142	89	42	12
A to C2	166	106	55	15
A to C1	200	133	75	22
A to C	226	165	95	29

The basis for these minimum spacings are the F(50-50) and F(50-10) curves. In each relationship the Commission has calculated the average F(50-50) distance to the protected signal contour at the maximum power and antenna height for the class and then calculated the average F(50-10) interference distance for the other station. Although some adjustments to the tables have been made, generally when these two figures are added together it produces the minimum spacing distances used in the tables.

Stations operating in the non-commercial educational portion of the FM band operate under a different allocation system. Except for when the channels interface with the commercial band (channels 218-220), a non-commercial station must not cause its interference signal contour to overlap the 60 dBu protected contour of any other non-commercial station. The value of the interference contour will vary depending on the channel relationship.

The following chart defines the Undesired to Desired relationships the FCC uses for both non-commercial and commercial FM signal relationships:

Channel Relationship	***U/D Ratio***
Co-channel	-20 dB
1st adjacent	-6 dB
2nd adjacent	+40, NCE +20 dB
3rd adjacent	+40 dB

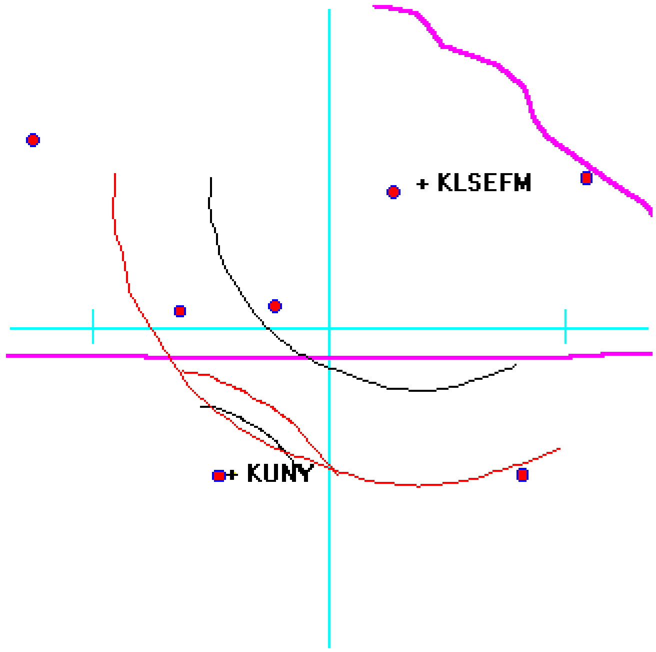


Figure 3 - Protected and Interfering Signal Contours

In the example shown in Figure 3, the 1st adjacent interference 54 dBu F(50-10) interference contour of KLSE overlaps the protected 60 dBu F(50-50) contour of KUNY causing the station to receive interference. The reverse contours are also shown however, KUNY's interference signal does not overlap KLSE's protected 60 dBu contour.

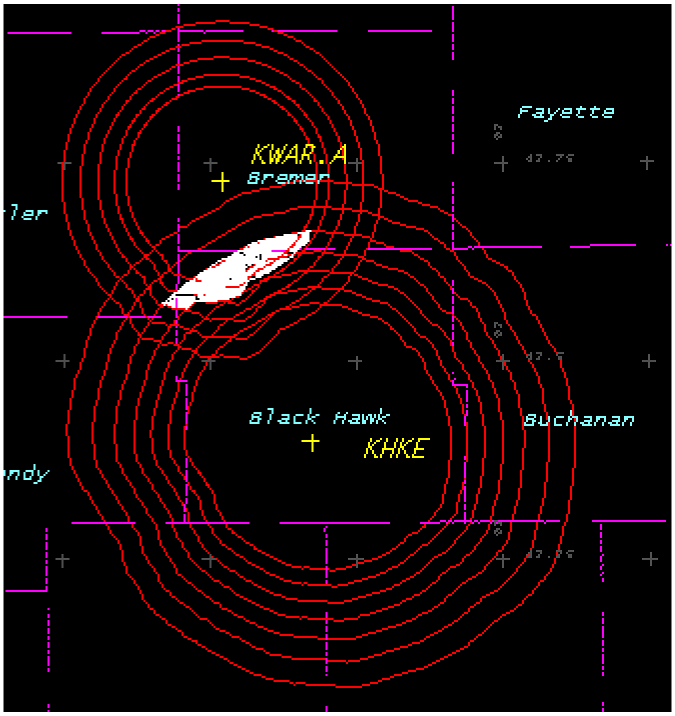


Figure 4 - U/D method

In the example shown below the U/D relationships detailed above are used to determine an actual area of interference (the white area). This procedure is more accurate than the simple overlapping contour method shown in Figure #3 because the U/D relationship can be applied at each level of a protected station's contour rather that just at the 60 dBu. Since the signal value increases above 60 dBu as one moves closer to the protected station's transmitter, this method, called the "U/D method", will define a smaller area of interference than the simple overlapping contour method. The Commission has proposed to allow the use of the U/D method rather then the overlapping contour method to define interference under it's streamlining procedures.

Where did the U/D ratios come from?

Project #22231. In 1947, the FCC "Laboratory Division" conducted tests on FM Radios and published reports on "Characteristics of Commercial FM Broadcast Receivers".

Included in the project were tests concerning the interference rejection ratios on both co-channel and adjacent channels. These measurements were the basis for the interference ratios used in the FM rules (first adopted in 1951.)

Alternative methods of signal prediction:

The point-to-point method:

Since the entire path between a transmitter and receiver has an effect on the signal, using only a portion of the path between 3 and 16 kilometers will produce errors that will result in overstating both coverage and interference distances. Using the standard FCC method, a large hill or mountain beyond 16 kilometers will be completely missed. Under its "streamlining" proposal in Docket 99-93 the Commission has proposed the use of a new method developed by FCC engineer Harry Wong called point-to-point or "PTP" for short.

This method uses Fresnel zone calculations that include the impact of defraction losses and knife-edge effects to calculate the effect of terrain on a signal from the transmitter to the point of reference even when the point is beyond 16 kilometers. Mr. Wong has devised a computer program which first produces an array of signal levels at constant intervals along a given azimuth and then calculates a matched distance to a given signal level. At this point, use of the PTP method is only a proposal and there are concerns that while the method works nicely to calculate an array of signals along a given azimuth it fails to adequately interpolate a given signal distance from the array. The problem stems from the difficulty of determining exactly where a contour line falls when in fact the signal from a given transmitter may rise and fall above and below a given signal level numerous times along the path.

In testing the method, we have found several instances where the interference signal contour is actually predicted to travel farther for a lower effective radiated power (or ERP) than a higher ERP with the antenna height and path being held constant. In examining the code we find that the problem stems from the curve fitting routine, because the program attempts to fit the entire curve and not a pertinent window along the radial. We have also found circumstances where the change in power of a watt or two results in a change in the predicted signal contour change of ten or twenty kilometers. While this may be consistent with a curve fitting and point extraction methodology, it is not consistent with reality.

The PTP method suffers with the same fundamental problem of the standard FCC prediction method in that it attempts to calculate the location of a single contour value along a radial from a transmitter where the signal level may rapidly vary.

Longley-Rice methodology:

Calculating the location of a single contour level is only efficient from an administrative standpoint. It is easy to say that these signal contours overlap, however applying such a procedure overly simplifies interference calculations and leads to error. A better solution is the use of Longley-Rice methods integrated with population extractions so that one can determine the real impact of an interfering signal as it rises and falls in relationship to a desired signal. While Longley-Rice uses methods of predicting signal that are similar to those used in the PTP method the use of an integrated population database lends a new dimension. Pools of coverage can be predicted and the population within those pooled areas can be calculated. By using the Commission's U/D ratios the locations of the pools of a given station's F(50-10) interference signal can be calculated and can be compared with a desired station's pools of F(50-50) coverage to ultimately identify areas of interference and the population within those areas.

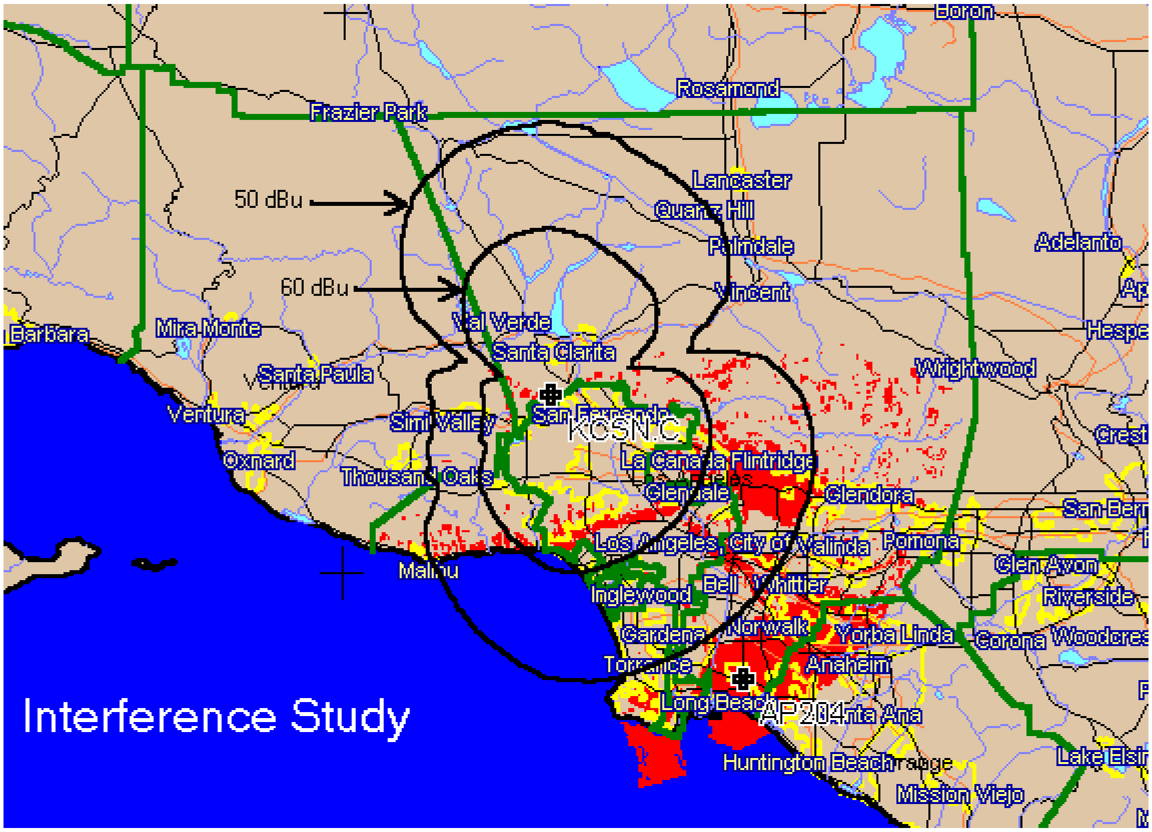


Figure 5 – Longley-Rice Interference Map

The map shown above demonstrates the use of Longley-Rice interference analysis. It shows the FCC standard contours of the desired station and the location of interference pools (in red) caused by the proposed 1st adjacent translator. Note that the proposed translator though legally licensable will cause significant widespread interference within the protected station's 60 dBu signal contour. This depiction of interference more accurately reflects reality than the overlapping contour method or the U/D method used by the Commission.

Other methods:

Longley-Rice is not the only alternative method. Other methods used FM for broadcast include a modified Longley-Rice method called the Terrain Irregular Rough Earth Model or TIREM, the Okamura (Hata) method and the Bullington method. It is the Longley-Rice method however, that has been adopted by the FCC for use in digital television allocation work and for use in conjunction with the Satellite Home Viewers Act. (ILLR method.) Under the Commission's DTV method, Longley-Rice analysis is used to calculate a given station's interference contribution. A station making a change to its DTV facilities may not increase the interference to the population of any other station by more than 2 percent and may not increase the interference to the noise limited population of any station that already receives more than ten percent. Interference caused to a given station which is "masked" by interference caused by other stations can be removed from the calculations.

The sophistication of the DTV allocation process can be applied to FM radio. Using the Longley-Rice methodology similar to that developed for DTV by the FCC's Office of

Engineering Technology would be a significant improvement over the existing system and a better choice than the PTP method.

The LPFM proposal:

Now that we have discussed how we can determine when and where interference exists we turn to Docket 99-25, the FCC's proposal to create a new low power FM service that if adopted as envisioned will basically fill in the spaces between our assigned 800 kHz spaced system:

The Commission proposes three station classes each having different powers and antenna height maximums.

Class	*Max Power (watts)*	*Max Antenna Height (meters)*
LP1000	1000	60
LP 100	100	30
LP 10	10	30

The Commission proposed to not require I.F. taboos for LP100 and LP10 stations and argues that 2^{nd} and 3^{rd} adjacent channel protections should be eliminated since there would be few channels available in many markets if these protections were not dropped. The Commission proposes to not protect existing licensed FM translator stations from LP1000 stations and possibly the other low power classes as well. The table in Figure #6 shows the proposed low power minimum spacings for a 100 watt LPFM station in relationship to a standard class station:

CLASS LP100

Assuming 100 watts effective radiated power (ERP)
at 30 meters antenna height above terrain (HAAT)
60 dBu F(50,50) protected contour extends 5.2 km
MINIMUM DISTANCE SEPARATION (KM) NECESSARY TO:
CAUSE NO OVERLAP/RECEIVE NO OVERLAP

Channel Class	co-	1st-	2nd-reserved band	2nd-/3rd-commercial band	IF
A	47/92	36/49	30/15	29/8	7
C3	58/119	47/66	41/19	40/10	9
B1	67/119	54/66	47/19	46/10	9
C2	71/143	60/84	54/26	53/12	12
B	92/143	77/84	68/26	67/12	12
C1	91/178	80/111	74/39	73/16	20
C	110/203	100/142	93/56	93/19	28
D	24/23	13/13	7/7	6/6	4
Other LP100	24	14			

Figure 6 – Proposed LPFM 100-Watt Separation Table

Under the co-channel, 1^{st}-, 2^{nd}-reserved band, 2nd-/3^{rd} commercial band columns the Commission places two numbers. The first is the minimum separation in kilometers necessary to keep the low power station from overlapping its interference signal contour with the protected contour of another station. When the distances between stations are at the minimum specified in the table the low power station will receive contour overlap over the majority, if not all, of its "protected" 60 dBu contour, however its interference signal contour will not overlap the other station's protected signal contour. If the second and larger set of numbers were used, the low power station would be free from contour overlap at the specified minimum distances.

We set about to determine where these minimum distances came from. The map below shows a 100-watt LPFM station located at the minimum distance from a co-channel class A station. The location selected was Florida since it is basically at sea level and the terrain has little affect on both the interfering and protected signal distances.

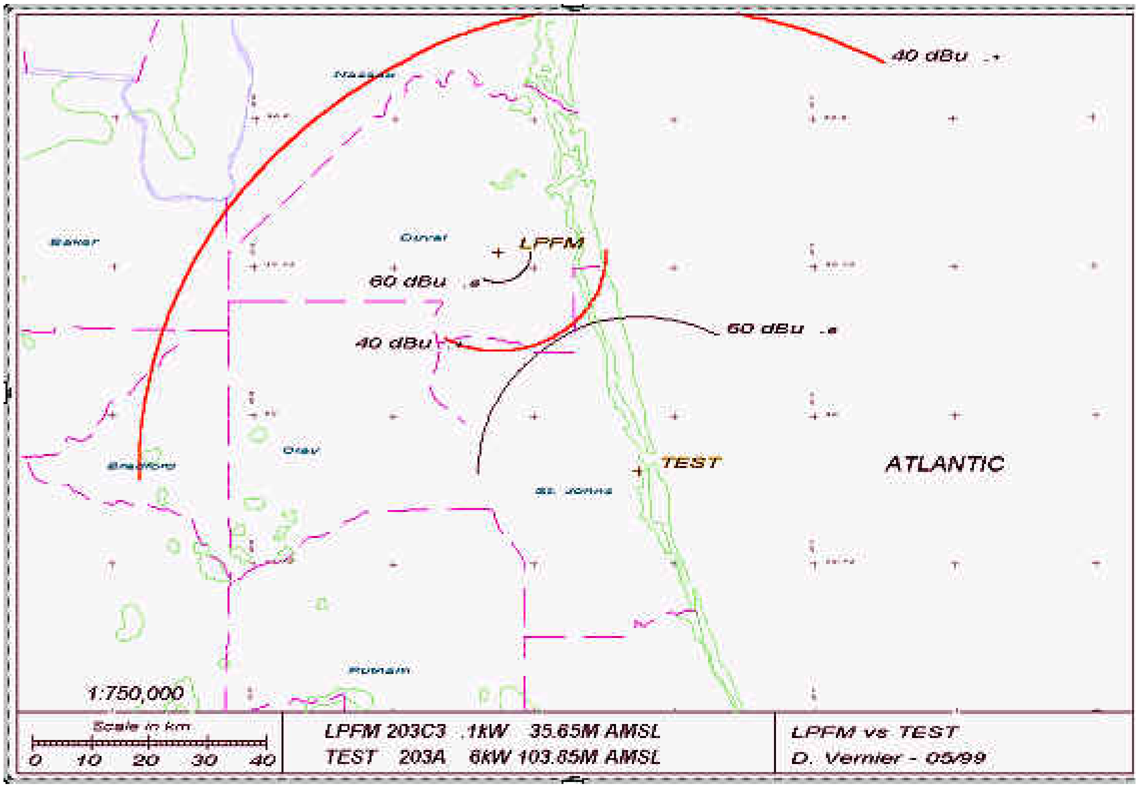


Figure 7 – LPFM and class A at minimum separation over flat land

The reader will notice that the minimum distance separation for the interference signal of the LPFM station just barely touches the protected 60 dBu signal of the class A co-channel station. However, these tables allow the interference signal contour of the class A station to completely overlap the LPFM's 60 dBu contour by nearly 50 kilometers. The impact of this minimum spacing distance is the sizable reduction of the interference free coverage area of the LPFM station to a little more than two kilometers.

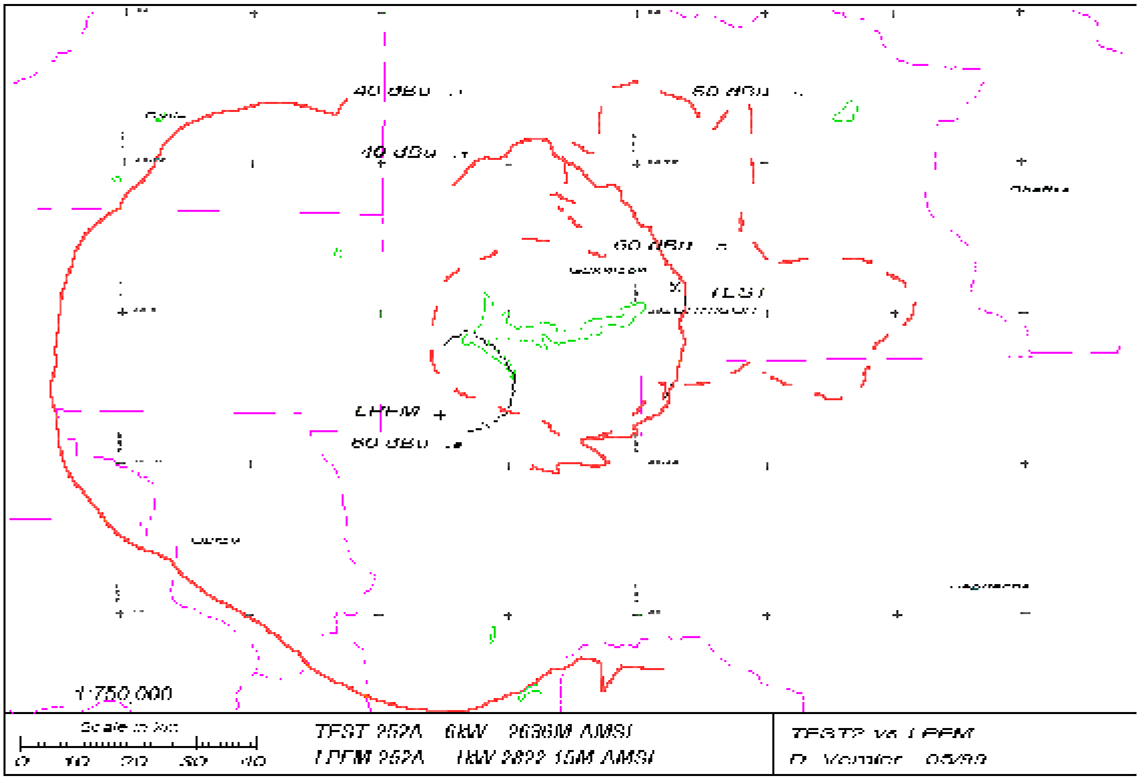


Figure 8 – LPFM Overlaps Class A Protected Contour in Hilly Terrain

In hilly terrain the proposed LPFM spacings could actually cause interference to the class A station's protected 60 dBu under circumstances where the average antenna height of the LPFM's eight cardinal radials is below that height along the direct radial toward the class A station. Additional interference will result if the class A station has a high radial height toward the LPFM station. The map shown below depicts what can happen under such circumstances. It shows a co-channel LPFM station and a standard class A station, "TEST". The elevations involved cause a significant interference contour overlap with the class A's protected 60 dBu signal contour.

The Commission argues that it can't make lower power FM work if the present interference standards are kept, therefore it proposes to drop either the 3rd adjacent or both the 2nd and 3rd adjacent protections for LPFM stations. Its own studies showed no channel would be available in New York or Los Angles without making such interference concessions. Our own studies confirmed this. We studied numerous markets and found that without dropping both the 2nd and 3rd adjacent protections nearly all the major markets would not be able to support new LPFM stations. The table below shows our findings in the Milwaukee market:

LPFM - Milwaukee, Wisconsin – Number of channels found:

LPFM Class	***NCE Current Spacings***	***Drop 3rd***	***Drop 2nd&3rd***
LP1000	0	0	3
LP 100	0	0	3
LP 10	0	1	4

LPFM Class Commerical	***Current Spacings***	***Drop 3rd***	***Drop 2nd&3rd***
LP1000	0	4	7
LP 100	3	7	14
LP 10	4	8	15

Receiver Studies:

Both opponents and proponents of LPFM filed comments during the comment period. At issue is the Commission's surmise that receivers have improved since the original U/D standard was set up in the late forties. Suddenly, fifty some years after the original standards were established, new data has now become available. Though each of the studies we will review stand on solid methodology their interpretation is controversial.

The NAB Receiver Procedure summary:

The National Association of Broadcasters (NAB) used the lab work of the Carl Jones Corporation, which used methods basically established by the International Telecommunications Union – ITU. A total of 28 radios were studied. The desired signal was modulation at 100% with a 1 kHz tone at a deviation of +-75 kHz. The receiver under test was then measured for its base characteristic signal to noise (S/N). The undesired signal was then modulated with white noise and its level was increased until the S/N was reduced by 5 dB. The level of the undesired signal was then recorded as the identified receiver's desired to undesired signal ratio (D/U).

Tests were performed at three desired levels, -45, -55 and -65 dBm. (or 60, 70 and 80 dBu.)

NAB results summary:

The NAB developed the tables shown in Figure #9 from its public submission to the FCC. The table is for the -65 dBm (60 dBu) desired signal level. It should be noted that automobile and component receivers fared better in the NAB tests than clock, personal and portable radios many of which do not meet the FCC's current D/U interference ratios.

Figures #10 and #11 show the median of the receiver performance of all the types NAB tested for 2nd and 3rd adjacent channel relationships. A surprise finding from the NAB studies was the trend of increasing D/U ratios with increasing signal strength for all categories of receivers except for automobile receivers. In other words, the majority of the receivers it tested fared worse at points where the desired signal was higher than it did at lower level signal points. This fact ran contrary to the FCC's speculation that the greatest impact of undesired signals would fall at the periphery of a station's protected coverage.

To compare an aspect of the results of the NAB study with the current FCC U/D ratio we carried out four Longley-Rice interference studies. **Appendix A** shows the results of these studies.

Page # 1 of the appendix shows the interference caused by a 2nd adjacent LPFM spaced at the FCC's proposed minimum distance from the protected station. The reader can see significant interference caused by the LPFM within the protected station's 60 dBu service contour. The second map on this page shows the interference when the median D/U ratio of clock radios is used. The interference caused is over a greater area and the population within the interference area increases by 13,156 or 43.8 percent.

Page # 2 shows a third adjacent LPFM relationship with the protected station. The first map plots the area of interference caused to the protected station using the FCC's standard U/D ratios, while the second map shows the same relationship using the NAB derived D/U values for the median clock radio. While the third adjacent interference is not as great, the NAB tables show interference is caused to nearly five times as many people.

The FCC's Office of Engineering Technology receiver studies:

Procedural Summary:

A total of 21 radios were tested by modulating the desired signal with a 1 kHz tone at 97.5 MHz. The sample varied from small moderate cost receivers with antenna connections to automobile and component system radios. No small inexpensive radios with integral antennas were tested due to the "difficulty of providing test signals at accurately controlled levels." Using the selected sample each radio's baseline distortion was measured with a desired signal of 330 microvolts (equivalent to 60 dBu) and at a level that would represent the signal level at the noise limited contour.

An undesired signal was introduced on the 2nd & 3rd adjacent channels and modulated with clipped pink noise using equal left and right (no pilot) and then left channel only was used to "fully exercise the baseband and to maximize the energy of L-R." Then the undersired signal level was increased until the radio's distortion increased by one and three percent over the baseline measurement. The U/D ratio was then computed for +- 50 & +- 75 kHz deviation.

OET Results Summary:

The OET cautions the reader about making sweeping generalizations from the figures it produced due to the small sample size. At the 3% distortion level all receivers tested (except two) met the Sec 73.215, 2nd adjacent, +40 dB requirement and exceeded the +40 dB 3rd adjacent by a substantial margin

For 3rd adjacent channel relationships that margin was similar for most of the receivers at noise limited and 60 dBu contours. OET found that the receivers in their sample had substantially greater U/D ratios than the FCC's U/D ratio for 3rd adjacent interference - about 10 dB better. Operating with a deviation of +-50 kHz gave a several dB improvement in U/D - however the amount of improvement varied widely over the sample. The OET noted that automobile receivers had the best interference rejection capabilities of all the receivers tested.

Table 5 - D/U Ratio Required to Produce Interference

-65 dBm Desired Signal Level

Receiver Number	Receiver Category	3rd Adjacent	2nd Adjacent	1st Adjacent	Co-Channel
1	* Clock	-28.0	-17.2	1.8	12.3
2	* Clock	-39.4	-35.1	-2.1	27.6
3	* Clock	-30.1	-16.0	4.8	31.1
4	* Clock	-21.4	-14.3	-0.3	15.1
5	Personal	-45.6	-35.4	0.9	14.7
6	Personal	-36.0	-32.3	0.0	9.0
7	Personal	-42.3	-16.4	5.4	17.0
8	Personal	-44.7	-33.2	3.7	14.9
9	Personal	-40.8	-24.9	11.2	15.4
10	* Portable	-39.0	-27.6	0.2	16.2
11	Clock	-36.4	-19.1	17.5	26.6
12	* Portable	-36.5	-30.2	7.0	38.1
13	Portable	-22.2	-11.2	30.5	38.0
14	Portable	-45.1	-22.8	16.5	14.0
15	Portable	-18.3	-7.9	27.6	36.5
16	Component	-30.0	-25.4	-4.9	45.1
17	Component	-42.0	-39.1	4.0	38.2
18	Component	-38.2	-41.4	-1.5	37.3
19	Component	-39.3	-35.1	-7.0	31.8
20	Component	-55.6	-53.4	-9.3	46.5
21	Automobile	-40.4	-30.8	-3.2	38.0
22	Automobile	-34.0	-30.1	-9.4	38.3
23	Automobile	-67.0	-71.5	0.2	31.9
24	Automobile	-45.3	-61.3	-12.5	37.9
25	Automobile	-31.1	-26.0	18.1	40.2
26	Automobile	-63.8	-61.9	-10.2	35.6
27	Automobile	-59.1	-44.8	-9.2	38.5
28	Automobile	-39.9	-39.1	-5.8	40.2
Minimum		-67.0	-71.5	-12.5	9.0
Maximum		-18.3	-7.9	30.5	46.5
Median		-39.7	-30.5	0.2	33.8

Note: Asterisk denotes a monaural receiver

Figure 9 – NAB D/U Values for Receivers Tested

Table 7 - Median Receiver Performance by Category
2nd Adjacent Channel Interference

	- 45 dBm	- 55 dBm	- 65 dBm
Automobile	-44.8	-43.5	-41.9
Clock	-15.9	-16.7	-17.2
Component	-21.9	-31.4	-39.1
Personal	-15.8	-25.6	-32.3
Portable	-10.0	-16.7	-22.8

Figure 10 – NAB Median Receiver Performance - 2nd Adjacent

Table 6 - Median Receiver Performance by Category
3rd Adjacent Channel Interference

	- 45 dBm	- 55 dBm	- 65 dBm
Automobile	-50.6	-50.5	-42.9
Clock	-27.2	-29.5	-30.1
Component	-22.2	-31.9	-38.0
Personal	-25.0	-32.9	-42.3
Portable	-17.2	-28.0	-36.5

Figure 11 – NAB Median Receiver Performance - 3rd Adjacent

National Public Radio/Consumer Electronic Manufacturers Association/ Corporation for Public Broadcasting Receiver Studies: (RMC Technologies)

NPR,CEMA and CPB joined forces to do a set of their own studies. For these studies a signal to noise ratio of -45 dBu S/N (AM standard) was established as the minimum acceptable for a quality broadcast. The desired signal level was set at -50 dBm. The undesired signal was modulated with clipped pink noise.

The NPR/CEMA/CPB studies looked at interference, bandpass post noise, I.F. taboos, reduced undesired modulation, performance in an on-air environment and 800 kHz intermodulation. All tests were documented with audio recordings for the purpose of subjective evaluations.

Interference tests:

The impact on the receiver's signal to noise ratio of co-channel Interference was calculated using the FCC established +20 dB D/U. At this D/U average, the S/N measured 22 dB for 16 receivers. First adjacent tests showed the average receiver S/N at the 6 dB D/U contour was 35 dB while 2nd adjacent tests showed that at -20 dB D/U the S/N averaged 45 dB and with -40 dB D/U the S/N averaged 24 dB. The third adjacent tests showed that with a -30 dB D/U the S/N averaged 42 dB and with -50 dB D/U the S/N averaged 27 dB.

Post detection noise:

Changes in baseband noise were observed at the first adjacent channel with 6 dB D/U. The test showed that even within the 6 dB first adjacent channel protection contour, baseband noise is caused by the mixing of the audio of the first adjacent undesired signal and the desired signal. An especially significant result appeared as an increase in noise at subcarrier frequencies. This would affect the stereo signal and any subcarrier transmitter by a station.

I.F. and L.O. Taboo Studies:

I.F. Intermodulation is the condition where two signals of equal intensity are spaced at 10.6 or 10.8 MHz. Local Oscillator interference is caused by a single station operating at 10.6 or 10.8 MHz above the desired signal. The NPR/CEMA/CPB conclusions declared that interference can be controlled by adhering to IF protection requirements as per existing FCC rules.

Reduced Undesired Modulation:

Tests evaluated restricted FM modulation scenarios for 2nd & 3rd adjacent interference impact. In the presence of 2nd adjacent interference while using a -20 D/U, receivers were tested at +-75 kHz, 37.5 kHz and 82.5 deviations. (Stereo was used with a subcarrier.) The result obtained were highly receiver dependent. In general, it was shown that reduced deviation brings about a better S/N. The cost is reduced audio level. No S/N improvement was seen for 3rd adjacent channels when the smaller deviations were used.

Performance in on air environment:

Antenna signals were introduced into the lab-produced interference equation.

Nearly all receivers exhibited a reduction of S/N when additional signals were added. Omni antennas were worse than directional antennas.

R.F. Intermodulation with 800 kHz spacing:

Using the fact that the mixing of two or more undesired signals in a non-linear portion of an

FM receiver will generate spurs, NPR/CEMA/CPB tested the intermodulation effect. Two undesired signals were inserted at 800 kHz spacing and increased in level until the target of 45 dB S/N was hit. When both undesired signals exceeded the desired by 20 dB the S/N for 9 of the 16 receivers tested was found to be below 20 dB. The tests found that the majority of FM receivers are sensitive to RF intermodulation interference. NPR/CEMA/CPB declared that intermodulation interference could exist with other frequency spacings than those tested.

National Lawyers Guild Studies (Broadcast Signal Labs):

The National Lawyers Guild studies made no effort to establish undesired signal levels where interference begins because they felt interference was too subject and its detection by the listener varied too much with the program type that had a masking effect.

For these studies the desired signal was set to 60 dBu at 30 ft or about 316 microvolts at receiver terminals. The frequency used was a mid-band 97.7 MHz.

The studies employed a Faraday Cage to isolate the impact of local signal on those being tested. The "transition zone" before failure was analyzed by increasing the undesired signal until total failure to receive the desired signal occurred and then marking the D/U in relationship with FCC’s D/U.

Car and higher priced radios performed better than one would predict based on FCC interference ratios. Performance of lower priced radios tended to straddle the FCC ratio reference levels. Susceptibility did not decrease from second to third to fourth adjacent channels (some receivers were studied for forth-adjacent interference effects). The Lawyer’s Guild studies determined that there were similarities between 2nd, 3rd and 4th adjacent channel performances. Their tests demonstrated that even the best receivers showed measurable, often imperceptible increases in distortion in the presence of extremely low level undesired signals. Using "transition zone" testing the response of all radios tested for co and 1st adjacent channel interference matched or exceeded FCC ratios. Second adjacent performance varied the widest between radios. The poorest radios were susceptible to 2nd adjacent undesired signals as much as 50 dB lower than levels that affected best performers. Third adjacent channel interference was less severe than 2nd adjacent for most radios. Higher priced radios withstood interference from 2nd, 3rd and 4th adjacent channels better than lower priced radios. In some cases radios were more susceptible to interference from a higher adjacency than a lower one.

Some Observations:

In an increasingly congested R.F. spectrum the FCC allocation methods are clearly inadequate. Using a method such as Longley-Rice with integrated population calculation would make a much better interference modeling system.

The tests showed that car radios and the more expensive component systems perform better than the FCC’s U/D ratios would predict. Yet many clock radios, personal radios and portables do not.

The NPR/CEMA/CPB tests showed that interference could be manifested by factors other than direct channel relationships. These included studies of I.F.and local oscillators, post detection baseband noise, intermodulation effects and air-environment performance.

With the exception of the Lawyers Guild studies each of the receiver studies detailed above used a different method of determining the D/U ratios of the receivers tested. Without a common definition of the point where interference begins, it is difficult to compare the results of the receiver tests.

The fact remains that additional signals will bring about more interference particularly if the 2nd or 3rd channel adjacencies are dropped to accommodate new LPFM stations. The location of this interference is not always found immediately around the offending translator and under certain circumstances can be widely propagated.

In addition to the interference that could be caused under the FCC's LPFM plan, the Commission has proposed "Streamlining the Rules" to allow contour overlap that causes up to 5 percent interference. While some radios may do better than others under this new signal burden, we believe that the integrity of U.S. FM band broadcasting is in question, especially when one considers the unknown impact of new interference on the in-band digital modulation systems currently under consideration. While it may be difficult to quantify where interference begins and where it ends and every radio will be affected differently by interference, it is clear that under the current allocation scheme used in the FM band that more signals cannot be added without suffering more interference.

References:

FCC MM Docket 99-25 – Low Power FM - 1999:

www.fcc.gov/Bureaus/Mass_Media/Notices/1999/fcc99006.txt

FCC MM Docket 99-93 – Streamlining the Rules –Negotiated Interference -1998

www.fcc.gov/Bureaus/Mass_Media/Notices/1998/fcc98117/wp

FCC Code of Regulations, Title 47, Chapter I, Section 73, Radio Broadcast Services:
www.access.gpo.gov/nara/cfr/waisidx_98/47cfr73_98.html

National Associations of Broadcasters – Comments on Docket 99-25 – Aug. 1999 – *Receiver Tests* *

Laboratory Division, OET – Comments on Docket 99-25 – Aug. 1999 - *2nd and 3rd Adjacent Channel Interference Study of FM Broadcasting Receivers* *

National Public Radio/Consumer Electronics Manufacturer's Association/Corporation for Public Broadcasting – Comments on Docket 99-26, Aug. 1999, *FM Receiver Interference Tests* *

Committee on Democratic Communications, National Lawyers Guild – Comments on Docket 99-25 – Aug. 1999 – *Receiver Evaluation Project* *

FCC Propagations Model and Longley-Rice Implementation – V-Soft Communications – 1998-99:

www.v-soft.com/LRSMore.html

www.v-soft.com/Probe

www.v-soft.com/Terrain-3D

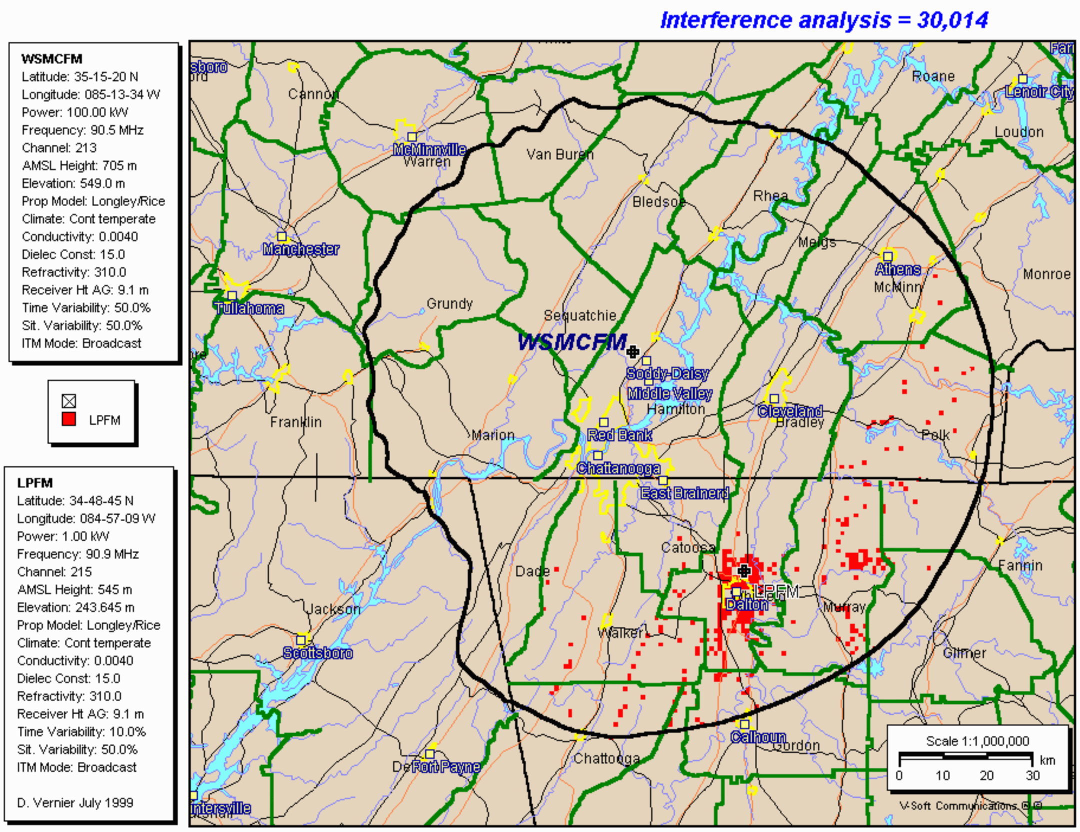
*Search FCC Electronic Comments Filing at URL:

https://gullfoss.fcc.gov/cgi-bin/ws.exe/prod/ecfs/comsrch_2.hts

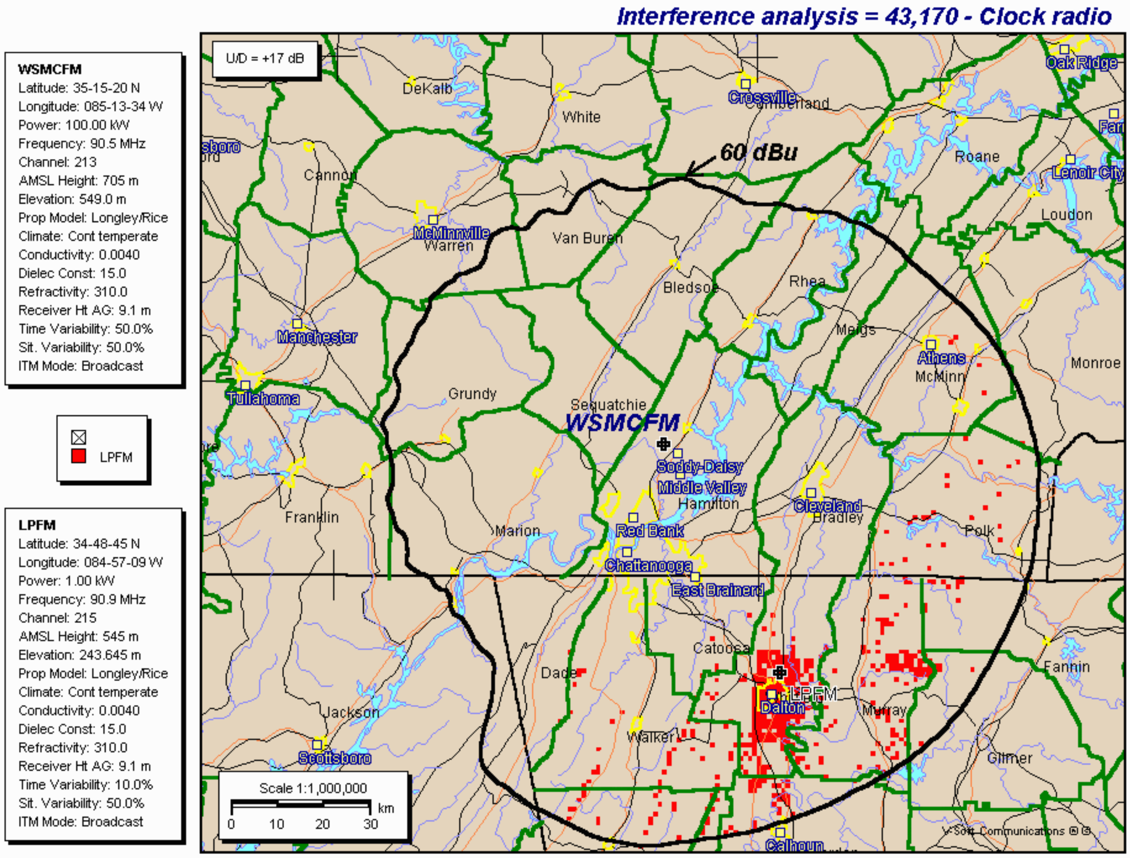
APPENDIX A:

Longley-Rice Interference Studies:

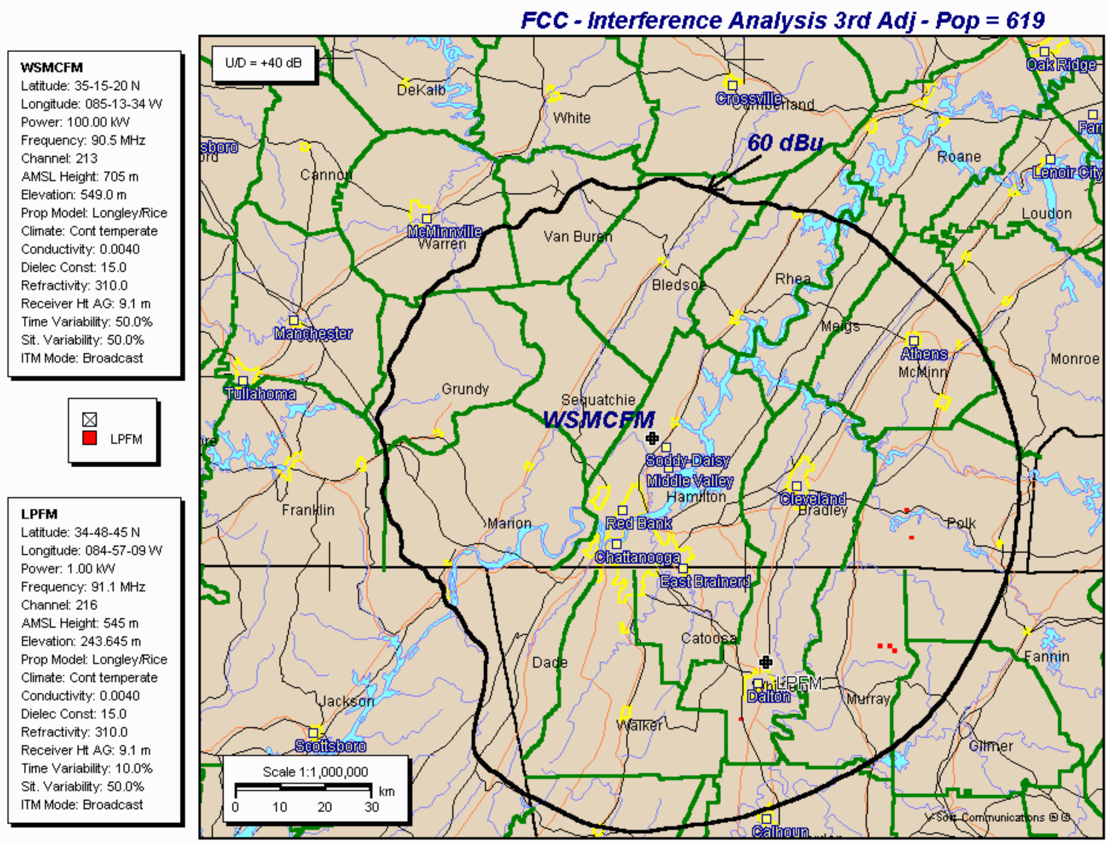
FCC Study – 2nd Adjacent LPFM at Minimum Spacing



NAB Study – 2nd adjacent Clock Radio



FCC analysis of 3rd Adjacent LPFM



NAB Analysis of 3rd Adjacent Interference – Clock Radio Median