IV. The MITRE Report Is Replete With Major Technical Flaws.

A. MITRE's "Sample of One" Listening Test Was Not Scientifically Valid.

Rather than rely on established norms for determining objectionable or harmful interference via properly designed subjective listening tests, MITRE simply instructed a *single* field engineer to make a Yes ("Y," *i.e.*, interference was present) or No ("N," *i.e.*, interference was absent) notation.[24] The field engineer's determination was final – the *Report* makes clear that any decisions by the field engineer regarding cases where either no interference was detected (both before and after the LPFM interferer was introduced) or interference *was* detected both before and after the LPFM interferer was introduced, were never reviewed or questioned.[25]

The flaws in this scenario are numerous. In particular, the listening was done inside the field test vehicle (and, as discussed in Section IV.C., not in a characterized, controlled environment suitable for audio listening tests). Also, the person making decisions on the audio quality was aware *a priori* as to whether or not the LPFM interferer was present, thus clouding the audio quality judgments with an irremovable bias. A scientifically valid audio listening test is always conducted in a "blind" fashion such that listeners are unaware of the details of any

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aspect of the problem." *Motor Vehicle Manufacturers Assn v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983).

[24] *Report*, Vol. 1 at 2-6. An additional, "hearing-tested" MITRE engineer did listen to those audio recordings where the field engineer first denoted N and with the LPFM transmitter powered, then noted a Y. *Report*, Vol. 1 at 2-7. However, MITRE states that this step is merely to "refine," not replace, the listening test. *Id.*, Vol. 1 at 2-9.

[25] *Id.*, Vol. 1 at 2-7, in which MITRE states that "[a]fter receiving the recorded audio samples from the subcontractor, a hearing-tested MITRE engineer listened to the recordings associated with the N>Y transitions."

particular audio cut.[26] The *Report* does not meet accepted scientific standards for a subjective listening test and thus fails to satisfy the statutory standard.

Just as disturbing as the non-scientific manner in which determination of audio interference was made is the way this information was put to use. MITRE establishes what it calls "Reception Degradation Thresholds" as a means of translating the observed audio interference behavior of each receiver (based on the judgment of MITRE's single listener) to corresponding threshold desired-to-undesired ("D/U") ratios (which then form the basis for its proposed allocation rules).[27] Ultimately each receiver is assigned a threshold, based on the data collected in this study, identifying where that receiver will experience interference due to an upper third adjacent channel LPFM interferer. The thresholds established by MITRE are listed in Table 1. Note that better performance (*i.e.*, a greater immunity to interference) is indicated by a more negative number. Hence, the auto receiver is estimated as being most immune to interference and the Reading Services for the Visually Impaired ("RSVI") receiver the least. MITRE's interpretation of these thresholds is that a given receiver will experience audio interference due to a third adjacent channel LPFM interferer if the D/U ratio at the receiver is

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[26] Examples of well-designed scientifically valid listening tests include "*Subjective Evaluation of State-of-the-Art Two-Channel Audio Codecs*," Journal of the Audio Engineering Society, Vol. 46, No. 3 (1998) at p. 164, and "*Internet Audio Quality and the MUSHRA Test*," AES UK Conference 2002; *see also "Multi Stimuls Test With Hidden Reference and Anchors (MUSHRA) – EBU Method for Subjective Listening Tests of Intermediate Audio Quality*," Preliminary Draft New Recommendation, ITU-R document 10-11Q/TEMP/33 (Feb. 2000) which states that "[w]here the conditions of a listening test are tightly controlled on both the technical and behavioural side, experience has shown that data from no more than 20 subjects are often sufficient for drawing appropriate conclusions from the test" and adds that "[i]f, for any reason, tight experimental control cannot be achieved, then larger numbers of subjects might be needed to attain the required resolution."

[27] *Report*, Vol. 1 at 2-35. Note that although not stated in the *Report*, these thresholds can only be said to apply to upper third adjacent channel interferers since MITRE did no testing with lower third adjacent channel interferers.

more negative than the threshold value. MITRE, however, makes no mention of the fact that these thresholds cannot be applied to lower third adjacent channel interference scenarios.[28]

Table 1. Reception Degradation Threshold D/U Values Estimated by MITRE for a Full Power FM Desired Signal in the Presence of an Upper Third Adjacent LPFM Signal[29]

Receiver	Reception Degradation Threshold D/U Values (dB)
Auto	-60
Home	-55
Clock	-37
Boom box	-28
Walkman	-28
RSVI	-26

Determination of these thresholds also involves the arbitrary selection of a specific "relative degradation index" value meant to represent the point at which listeners will find audio interference perceptible. Having no basis with which to establish this value, MITRE literally pulls one out of thin air. MITRE admits, in explaining this process, that "[w]ithout a formal subjective testing, it would not be possible to reliably translate the relative degradation index to the more standard measure such as the Mean Opinion Score (MOS)."[30] Undeterred, MITRE instead elects to select "...a convenient reference value, say 0.3, of the relative degradation index. At this degree of degradation, it would be *safe to expect* that [a] certain level of interference

[28] As discussed in Section IV.F. below, MITRE only used upper third adjacent channel interferers in its field evaluation.

[29] *Id.*, Vol. 1, at 2-42, Table 2-5. Note that in the *Report*, there is a discrepancy in the reported threshold values for the Boom box, Walkman, and RSVI receivers: in Vol. 1 at 2-43, and in the conclusions section, Vol. 1 at 5-2, these values are reported as –27, -27, and –25 dB, respectively. No explanation is offered for this discrepancy.

[30] *Report*, Vol. 1 at 2-42.

should be perceptible to the listeners."[31] No valid, quantifiable justification as to why it would be "safe to expect" this is given.

In other words, having admitted that the absence of the subjective listening tests Congress mandated made it impossible to translate the data MITRE did collect into standard scientific measures of interference, MITRE candidly concedes that it simply made up a standard. The failure to perform the tests expected by Congress thus was compounded by MITRE's unsupported selection of a standard where it thought that listeners would not object. The issue before the Commission, however, is not what interference the Commission's contractor thinks might be harmful, but instead whether objective evidence shows that interference would or would not occur.

Having thus arbitrarily determined the point at which listeners would perceive interference, MITRE goes on to establish the threshold D/U ratios which form the foundation of their proposed rules (shown in Table 1). MITRE notes in its conclusion and recommendations that "[t]he most important predictor of whether a given location is susceptible to LPFM third adjacent channel interference is the D/U of the incumbent full power FM signal with respect to the LPFM signal at that location."[32] MITRE's decision to base this "most important predictor" on a number pulled out of thin air and then to suggest protection rules based on this demonstrates a complete lack of competence in subjective listening test analysis.

B. It Is Essential To Understand A Testing Receiver's Ability to Accept or Reject Third Adjacent Channel Interference.

In addition to the listening test deficiencies, MITRE fails to properly analyze receiver performance characteristics. To fully appreciate the flaws of MITRE's *Report*, examination of

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[31] *Id.* (emphasis added).

the 1999 receiver studies is quite relevant – in order to properly evaluate third adjacent channel interference effects in the FM radio service, it is first essential to fully understand a testing receiver's ability to accept or reject third adjacent channel interference. The Commission initially assumed that elimination of third adjacent channel protection would "entail, at worst, little risk of interference to existing radio service." *NPRM* at ¶ 43. The submitted receiver studies, however, strongly suggested differently. NAB's receiver study, for example, showed that for the twenty eight (28) receivers tested, all categories except automobile radios still had substantial difficulties in rejecting third adjacent channel interference, at levels far below those permissible by the FCC's spectrum planning factors for the FM service.[33]

Indeed, in the *LPFM Order*, the Commission itself noted that the creation of LPFM service could be justified "*only if* it does not cause unacceptable interference to existing radio stations." *LPFM Order* at ¶ 6 (emphasis added). Yet the Commission found no basis for claims that its conclusions with respect to interference were invalid because it had established no "benchmark" standard against which to measure whether interference is acceptable. The Commission explained that it consciously chose not to use such a standard for evaluating

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[32] *Id.*, Vol. 1 at 5-1.

[33] In regards to automobile radios, NAB referred to a point made by the North Carolina and Virginia Associations of Broadcasters ("NCAB/VAB"). In their comments, the NCAB/VAB argued that the Commission cannot eliminate third adjacent protections for LPFM because that particular protection matters most in the outer areas of a station's usage coverage – especially for mobile listeners. *See* Comments of NCAB/VAB, MM Docket No. 99-25, filed Aug. 2, 1999 at 35. While NAB's testing showed automobile radios were the best at rejecting such interference, the Pickholtz/Jackson study faulted all of the receiver studies for testing car radios in a non-mobile environment. *See* Report of Dr. Raymond L. Pickholtz of George Washington University and Dr. Charles L. Jackson attached as Appendix B to Reply Comments of NAB, MM Docket No. 99-25, filed Nov. 15, 1999 at 36 (hereinafter "Pickholtz/Jackson Report"). Further, the nature of the proposed LPFM service is such that, in addition to possible interference at the edges of existing stations, there will be areas of interference within the service area of full-power station that will resemble a "swiss cheese effect" that would not occur under existing Commission rules.

interference because it is better policy to "allow the market to identify the level of interference rejection performance consumers find to be acceptable for different types of FM radios." *Reconsideration Order* at ¶ 10.

Rejecting the Commission's abandonment of interference analysis, Congress instead directed the Commission to use field tests to identify the "benchmark" level for objectionable interference.[34] In order to quantify this "benchmark," the receivers used in the field tests must be a representative sample of consumer radio products, whose performance characteristics (*i.e.*, ability to accept or reject interference) are both known and quantified. Conspicuously absent from the *Report* is any analysis, discussion or even reference to the four 1999 receiver studies, including the performance characterizations and testing methodology of the over seventy-five (75) receivers studied. In fact, MITRE seemed wholly unconcerned with these testing components, as the *Report* fails to provide *any* receiver performance characterizations for the six receivers used in MITRE's field tests. Thus, readers of the *Report* are unable to fully evaluate these receivers' ability to accept or reject interference or compare them with previous studies.

C. MITRE Failed to Use a Sufficient Number of Receivers and Neglected To Characterize the Receivers.

Due in large measure to the broadcasting industry's development of digital radio broadcasting systems using in-band/on-channel ("IBOC") technology over the last decade, an increased understanding of the design and operation of AM and FM radio receivers has occurred above and beyond the 1999 LPFM receiver studies already cited. Numerous investigations have been conducted on behalf of the National Radio Systems Committee ("NRSC"), focusing on detailed examination of how receivers perform because the NRSC recognized that the

[34] *Radio Preservation Act* at § 632(b)(2)(B).

understanding of receiver operation forms the foundation for interpretation of studies conducted on RF interference testing.[35] These studies offered MITRE an example of receiver characterization methods while at the same time illustrating the fundamental need for this information. How MITRE could be wholly unconcerned with this critical issue is hard to fathom.

One of the lessons learned from the NRSC and 1999 LPFM-related receiver studies is that it is very difficult to try and reach conclusions on the performance of the deployed population of radio receivers (estimated to be in the hundreds of millions) based on testing done with a mere handful of examples.[36] The NRSC, in conducting its RF-interference related IBOC evaluation, was very careful in its receiver selection. Statistical information on receiver deployment compiled by CEA, one of the NRSC's co-sponsoring organizations, was obtained and reviewed; extensive receiver characterization testing was performed and receiver design architecture, including an identification of the "chip sets" common to various receiver designs, was studied.[37] These analytical steps were necessary to ensure that the receivers selected for use in the NRSC's interference tests offered the best possible cross-section available. Unlike MITRE, the NRSC recognized that neglecting these important tasks would render any resulting RF interference test results wholly incomplete and indefensible.[38]

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[35] *See "EVALUATION OF THE IBIQUITY DIGITAL CORPORATION IBOC SYSTEM Part 1 – FM IBOC,"* National Radio Systems Committee, Nov. 29, 2001 at 18 and Appendix D (hereinafter "NRSC IBOC Report").

[36] *Id.* at 18; *see also supra* note 5.

[37] *See* NRSC IBOC Report at 18.

[38] *Id.*

The Commission's staff recognized the inherent difficulties in small sample-size radio receiver-based interference tests, citing that its 1999 OET study "...was limited in size to a *fairly small sample* of 21 receivers."[39] OET also noted that "...follow on work is anticipated to expand the study sample" and that "...*extreme caution must be exercised* in interpretation of the data [collected on 21 receivers] *until sufficient additional examples can be tested to improve statistical significance.*"[40] This analysis equally applies to the testing done by MITRE, work based upon results obtained using only six uncharacterized receivers. Here MITRE used less than one-third the number of receivers OET utilized in its "small-sample" study. Thus, the Commission should not rely on the results yielded from six receivers as the basis for determining whether or not third adjacent channel protection for LPFM stations can be eliminated.

A further example of why receiver characterization is critical can be found in the 1999 CEMA receiver study.[41] CEMA performed fifteen (15) different tests on each receiver. Test number 12 – "Selectivity, 3rd adjacent channel 50 dB S/N (upper and lower)"– is especially relevant to this proceeding. The purpose of this test was to determine, for each receiver, the third adjacent channel signal level necessary to degrade the receiver's audio signal-to-noise ratio ("S/N") to 50 dB Root Mean Square ("RMS"), a test often used by the industry.[42] In the CEMA

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[39] *OET Interim Report* at 1 (emphasis added).

[40] *Id.* at 1, 4 (emphasis added).

[41] *See supra* note 5.

[42] *See, e.g.*, Lawrence C. Middlekamp, *Subjective Evaluation of Audio Degraded By Noise And Undesired FM Signals: A Report by the Technical Subgroup of the Advisory Committee on Radio Broadcasting*, attached to Comments of NAB in BC Docket No. 80-90 (Nov. 17, 1982); Comments of the National Radio Systems Committee in BC Docket No. 80-90 (1981); *see also* Standards of Good Engineering Practice Concerning FM Broadcast Stations, Docket 9407, 14 FCC Rcd 4986 (Aug. 12, 1949).

test procedure, this test was conducted four times on each receiver under different circumstances – twice with a single lower third adjacent channel interferer (that is, with the third adjacent channel interferer 600 kHz below the desired signal), with the receiver receiving first a mononaural signal then a two-channel stereo signal, and twice with a single upper third adjacent channel interferer (with the interferer 600 kHz above the desired signal), again with the receiver receiving first a mono, then a stereo signal. All of these conditions were necessary because *receivers can behave differently depending upon the location of the interferer* (*i.e.*, upper versus lower) and because receivers are generally more susceptible to interference (*i.e.*, will experience degradation with a lower level of interference) when receiving a stereo signal. The results of CEMA receiver characterization Test 12 are shown in Figures 1-3.

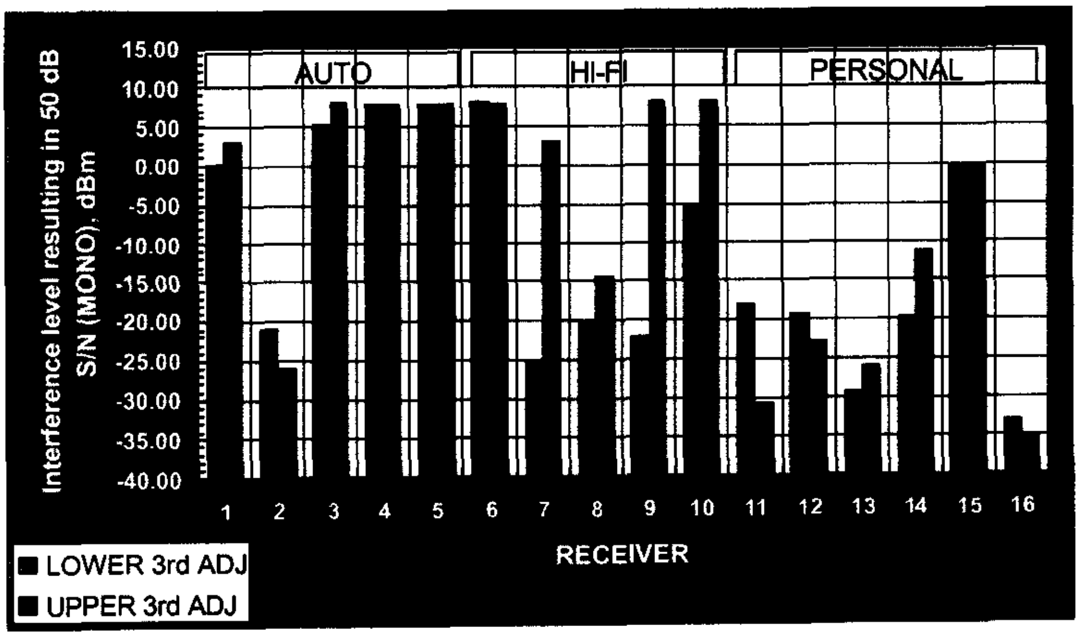

Figure 1. Results from CEMA Receiver Characterization Test 12 - Selectivity, 3rd adjacent channel 50 dB S/N (upper and lower) – MONO, -55 dBm desired signal level

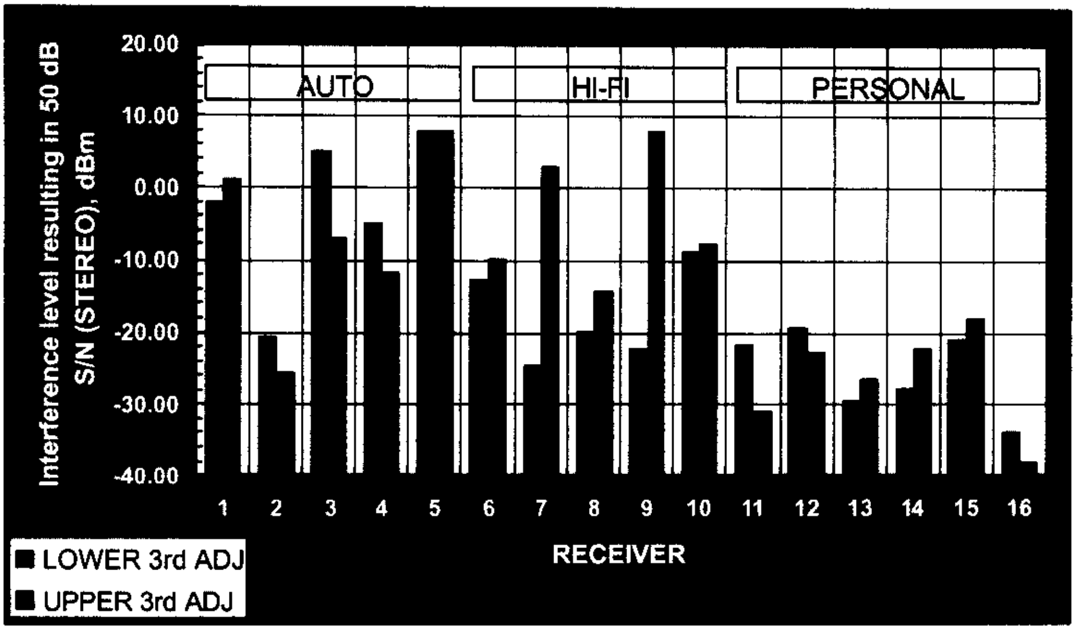

Figure 2. Results from CEMA Receiver Characterization Test 12 - Selectivity, 3rd adjacent channel 50 dB S/N (upper and lower) - STEREO, -55 dBm desired signal level

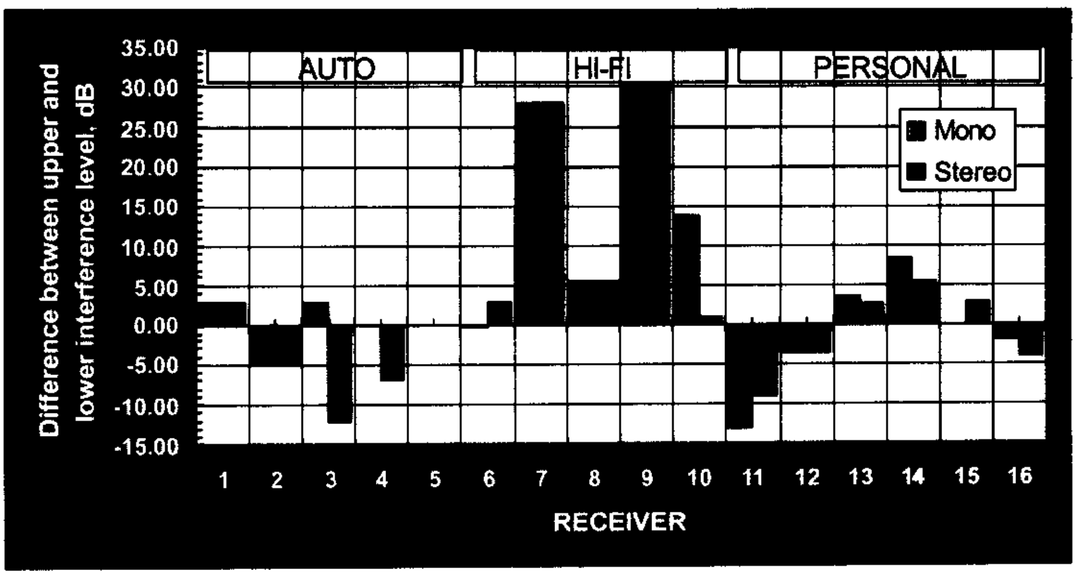

Figure 3. Results from CEMA Receiver Characterization Test 12 - Selectivity, 3rd adjacent channel 50 dB S/N (upper and lower) – Showing Difference Between Upper and Lower Third Adjacent Interferers, -55 dBm desired signal level

Figure 1 and Figure 2 show the measured absolute interfering signal levels (in dBm) resulting in the degraded 50 dB audio S/N condition, for mono and stereo reception, respectively. All three figures show that:

- For a given receiver, the interfering signal level required to degrade the audio S/N can be different depending upon *whether the interferer is an upper* (*i.e.*, +600 kHz) *or lower* (-600 kHz) third adjacent channel interferer. These differences are illustrated graphically in Figure 3, and in some cases are pronounced (as much as 30 dB);
- For a given receiver type (CEMA tested three types—auto, hi-fi, and personal *i e.*, "Walkman" type) the level of interference necessary to achieve 50 dB audio S/N *varies from receiver to receiver*, and again this variation can be pronounced, on the order of 30 dB.

No such data, however, exists for the receivers used in the MITRE tests. Consequently, it is simply not possible to determine how the performance of these receivers compares with the spectrum of other receivers of a similar class, or ascertain how the MITRE-tested receivers relate to those used by actual listeners. Nor is it possible to determine how the MITRE-tested receivers behave with respect to upper versus lower third adjacent channel interference, a crippling problem which will be explored in greater detail below in Section IV.F. Without this vital receiver characterization information, neither MITRE, the Commission nor any other entity can properly interpret the data collected in the *Report*, much less use the data to craft a third adjacent channel allocation rule for LPFM stations.

D. MITRE Failed to Properly Test the Receivers It Did Use.

MITRE's decision to use an insufficient number of receivers, and then offer test data obtained using these receivers apparently without first subjecting them to a single characterization analysis, seriously compromised the scientific integrity of the *Report*. Further clouding this effort is the lack of quantification of the field environment. There is no transparent indication as to how RF coupling was achieved (*i.e.*, how did the radio signals get into the receiver) during testing.

Proper measurement and handling of the RF energy delivered to each receiver is one of the most critical and difficult steps involved in the kind of interference testing described in the *Report*. In looking at the example set by the NRSC's evaluation of IBOC, where characterization of interference to FM analog signals was also under investigation, it is clear that there are significant, incurable flaws in the approach undertaken by MITRE which render the data, and the conclusions based on that data, unusable.

To understand why the collection and distribution of RF signals in an FM broadcast interference test regime is so critical, it is important to recognize some of the basic attributes of how FM signals propagate through space as they travel from the transmitting antenna to the receiving antenna. FM signals exist in the very high frequency ("VHF") band of the electromagnetic spectrum. VHF signals are subject to a variety of impairments as they travel from source to destination including reflection (from both stationary and moving objects), refraction, and diffraction, which combine to result in what is commonly referred to as multipath fading.[43] Virtually every FM radio signal in the real world (as opposed to signals which can be created in a laboratory environment) is subjected to various degrees of multipath fading, and this phenomenon manifests itself at the radio receiver in a variety of ways.

For example, FM radio listeners are universally familiar with the phenomenon of the "stoplight fade" whereby an FM signal "disappears" when a vehicle is stopped but then re-appears after the vehicle moves only a short distance (on the order of inches). This behavior

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[43] *See Reference Data for Engineers. Radio, Electronic, Computer & Communications*, Eighth Ed., SAMS Prentice Hall Computer Publishing, 1993 at Chapter 33; *see also NAB Engineering Handbook*, Ninth Ed., National Association of Broadcasters, 1999 at Chapter 2.1.

(due to multipath fading) illustrates how the attributes of an FM signal can change over a very short distance. The example of a stoplight fade is particularly instructive in understanding how an FM interference test system utilizing multiple receivers (such as that used by MITRE) needs to be designed so that the fading characteristics of the FM band do not fatally corrupt the data being collected.

The challenge is to design the test system so that the *same* FM signal is delivered not only to each receiver under test, but also to any test instrumentation used in the characterization of the received signal. Indeed, the assumption throughout the *Report* is that for a particular receiving location, each of the six receivers, as well as the spectrum analyzer used to establish the characteristics of the LPFM and full power FM received signals, are presented with the same signal. This is evidenced by the fact that only a single spectrum analyzer measurement was made for each test condition; the audio recordings were made for all of the receivers under test simultaneously; and, most notably, a single D/U ratio (the power ratio of the full power FM signal to the LPFM signal) is assigned to the recordings made for all receivers under test for each test condition.[44]

Nowhere in the *Report* does MITRE offer a shred of evidence as to why this assumption, that each receiver and the test instrumentation are receiving the same FM signal, is valid. The only information offered which does relate to this all-important aspect of the test system is shown in Figure 4.[45] Here, each receiver is shown utilizing a *separate* antenna and the spectrum analyzer used to establish the D/U ratio for each test condition is not even shown at all.

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[44] *See Report*, Vol. 2 at Annex 3. This data is recorded in Figures 11-18 (Avon), Figures 20-27 (Brunswick), Figures 29-36 (East Bethel), Figures 38-45 (Owatonna), Figures 56-63 (Winters), and Figures 65-72 (Benicia).

[45] *Id.*, Field Test Plan Annex at 10.

However, the physics of FM signal propagation in such a situation make two points clear: (1) six FM receivers all using different antennas, even when in close proximity to one another, may or may not be receiving the same signal (as exemplified by the "stoplight fade"); and (2) the signal strength measurements made by the spectrum analyzer may or may not properly reflect the signal strengths received by any (or all) of these receivers.

In electing to structure its test system in this fashion, MITRE has made it impossible to determine the input signal conditions for any of the receivers; hence the D/U ratios existing at the time the audio recordings were made is unknown. Interestingly, MITRE identifies the D/U ratios as " ...[t]he most important predictor of whether a given location is susceptible to LPFM third adjacent channel interference ..."[46] The only thing known about the RF input data MITRE used is the D/U ratio incident upon the antenna connected to the spectrum analyzer. The D/U ratio at each of the receivers is unknown. Because all of the conclusions in the *Report* trace back to these D/U ratios, these conclusions must be discounted as without basis in fact.

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[46] *Id.*, Vol. 1 at 5-1.

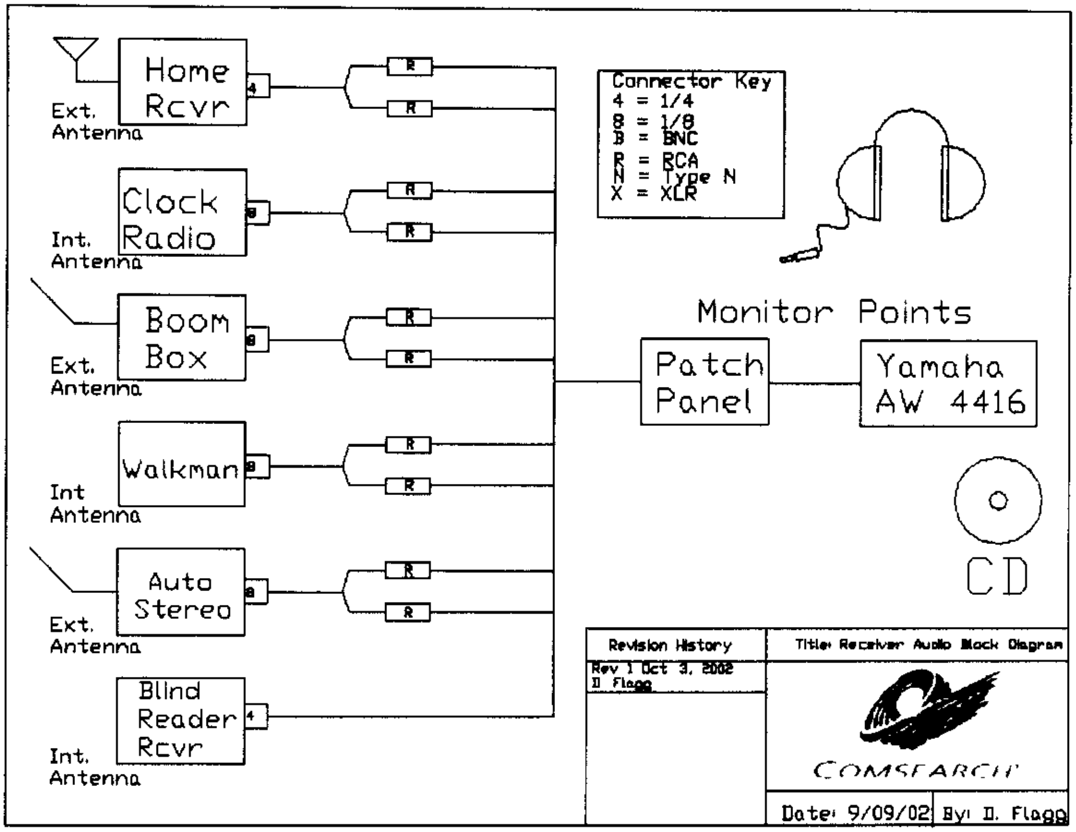

Figure 4. Receiver Block Diagram - from "Field Test Plan - LPFM Third-Adjacent Channel Interference Analysis," The MITRE Corporation (Oct. 29, 2002) at p. 10

In contrast, Figure 5 illustrates how the interference testing done for the NRSC IBOC evaluation avoided this incurable flaw and resulted in an accurate characterization of D/U ratios. Figure 5 shows, in the upper left-hand corner, a *single* "31 in. Whip on Van Roof" antenna connected to an antenna distribution network ("Ant. Dist. N/W" in the figure), which in turn is connected to three receivers (Delphi, Pioneer, and iBiquity) and test equipment used for measuring the characteristics of the received signal (RF spectrum analyzer). For the IBOC testing, four different antenna distribution networks were used, each one tailored to a specific reception environment (*e.g.*, high signal areas near transmitter; edge of coverage areas).[47] A feature common to all of these networks is that all of the receivers, and the test instrumentation, were delivered an identical FM signal because *they all shared a single antenna*. For this test system, the D/U ratio measured by the spectrum analyzer can also *correctly* be attributed to the receivers under test.

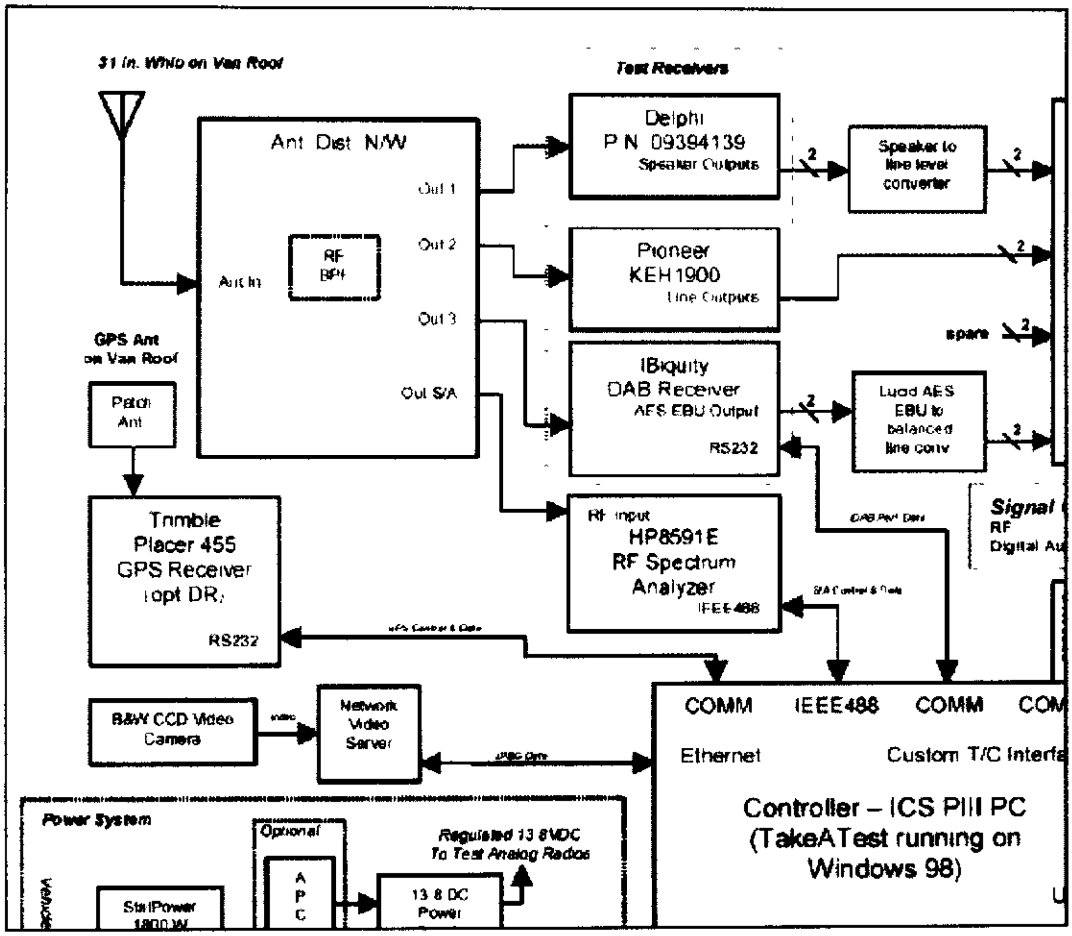

Figure 5. Mobile Test Platform Generalized Block Diagram (excerpt) - from "FM Field Test Procedures & Notes," iBiquity Digital Corporation (July 7, 2001) at p. 7

[47] *See* "FM Field Test Procedures & Notes," Appendix E, "Report to the National Radio Systems Committee - FM IBOC DAB Laboratory and Field Testing," iBiquity Digital Corporation, Aug. 2001, at p. 9.

The IBOC interference evaluation test plan was also structured to accommodate the situation where it was either not possible or not desirable to connect the receiver-under-test antenna to a common antenna distribution network. This is typically the situation for clock radio and personal (*i.e.*, "Walkman") receivers that utilize built-in antennas. A detailed procedure was followed for this circumstance during IBOC interference testing that recognized the complexities of FM radio signal propagation. It involved a characterization of the RF environment over a two-wavelength by two-wavelength area (referred to as a "2λ x 2λ" grid) as shown in Figure 6.

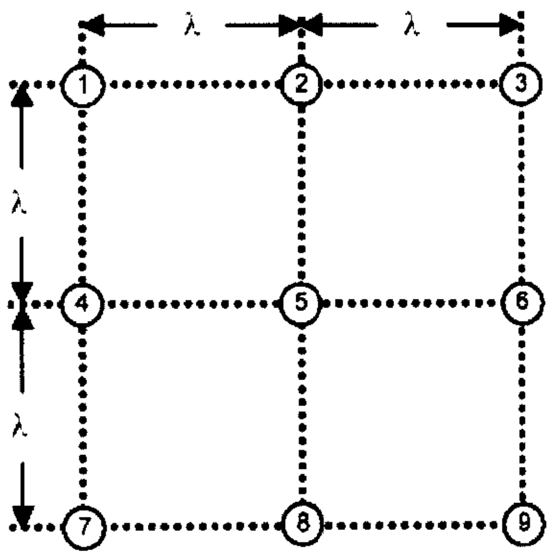

Figure 6. 2λ x 2λ Measurement Grid - from "FM Field Test Procedures & Notes," iBiquity Digital Corporation, 7/7/01, pg. 28

Under this procedure, six RF signal measurements centered on the desired signal frequency were made at each of the nine vertices shown in Figure 6 using a calibrated dipole antenna, so as to offer a complete characterization of the RF environment. If an inspection of those measurements revealed that the RF environment was relatively constant over this area, then the area was deemed suitable for testing and the receiver under test was placed at the central vertex point (number 5 in Figure 6) and interference measurements were then made.[48]

It is difficult to know from the *Report* exactly how MITRE handled the situation where the receiver under test had an internal antenna. Based on the sketchy description of the test procedure provided, it appears that no attempt was made to characterize the RF field in the general vicinity of the receiver (as was done in the case of the NRSC evaluation), save for a single spectrum analyzer measurement which, as previously discussed, may or may not be a valid representation of the signal impinging upon the receiver. It also appears, from the description given in the *Report*, that all of the receivers under test (irrespective of the type of antenna) were operated within the confines of the test vehicle itself, despite the fact that only the automotive receiver had an antenna mounted externally to the vehicle. Because there is no description of (1) the vehicle where the field testing took place, therefore the makeup of attenuated enclosure, and (2) its effect on the testing receivers, is impossible to establish the characteristics of the RF environment. Again, without this very basic information, the validity of the MITRE test results cannot be determined.

E. The Test Site Selection Process Was Inappropriately Driven by Administrative Convenience.

The Commission provided MITRE with a list of thirty nine (39) non-mutually exclusive LPFM license applications.[49] In the *Report*, MITRE explains that these sites were ". . .in markets where there were not duplicate filings, in order to preclude the chance that the field tests

[48] *Id.* at pp. 26-27.

[49] *Report*, Vol. 1 at 1-5 and Appendix A.

might favor one applicant over the other."[50] NAB fails to understand how site selection based on the administrative convenience of applications which are not mutually exclusive could have possibly resulted in a scientifically valid group of field test sites.

In order to determine which field test sites were appropriate, the Commission and MITRE should instead have focused on the technical parameters which define such field sites and determined in a scientifically appropriate and rational manner which sites, if tested, were most likely to be fairly representative of the interference scenarios to be encountered. These technical parameters would include full power FM station class, full power FM antenna height and effective radiated power, interference environment due to adjacent channel stations, topography of the region between full power FM and LPFM transmission sites, and the like. Only by selecting test sites based on technical considerations would it have been possible to establish a record of test data upon which a nationwide allocation scheme can be developed. Thus, the Commission erred in basing site selection on administrative convenience.

F. MITRE Testing of Only Upper Adjacent Channels is Flawed.

The problems of administrative convenience are further exacerbated by MITRE's failure to test both upper and lower third adjacent channels. In Section IV.C. of these comments, NAB offered evidence taken from the 1999 CEMA FM receiver characterization study which illustrated both that different receivers reject third adjacent channel interference to varying degrees, and that many receivers reject upper and lower third adjacent channel interferers by (sometimes vastly) different amounts.[51] The main point of our earlier discussion was to show that without receiver characterization information, data obtained from a receiver under test

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[50] *Id.*, Vol. 1 at 1-5.

cannot be properly interpreted nor can it be used as the basis for rules designed to provide for third adjacent channel protection as MITRE has proposed.

Here, the CEMA data serves to highlight yet another fatal flaw in the MITRE tests, namely, in selecting from the thirty nine test sites, MITRE only utilized *upper* third adjacent interferers in its study. Table 2 lists the frequencies of the full power FM desired signals and the LPFM interfering signals for each test location, and in each case, the frequency of the LPFM interferer is 600 kHz greater than the full power FM signal. Thus, in each case the LPFM signal is an upper third adjacent channel interferer.

Table 2. FM Test Frequencies used in the MITRE study[52]

Site	Full Power FM frequency (MHz)	LPFM frequency (MHz)
Avon CT	106.9	107.5
Brunswick ME	96.7	97.3
East Bethel MN	91.1	91.7
Owatonna MN (site A)	105.7	106.3
Owatonna MN (site B)	90.5	91.1
Winters CA	102.5	103.1
Benicia CA	99.7	100.3

The absence of any tests utilizing lower third adjacent channel LPFM interferers represents a serious deficiency in the test program because, as illustrated in Figure 3, a receiver's ability to reject adjacent channel interference can be different depending upon whether the interferer is upper or lower third adjacent. In the case of the MITRE tests, this deficiency is

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[51] Figure 3 in particular illustrates that some receivers demonstrated as much as a 30 dB difference in their ability to reject upper versus lower third adjacent channel interferers.

[52] *Report*, Vol. 1 at Table 1-1.

compounded due to the fact that MITRE had no knowledge of each receiver's sensitivity to upper and lower third adjacent channel interferers.

To fully appreciate the conundrum created by these deficiencies it is helpful to consider an example utilizing test data included in the *Report*. Consider a measurement MITRE made at the East Bethel, MN LPFM site, at receiver location 2. The test data indicates that for the case of an LPFM transmitter power of 10W at an antenna height of 10 meters, interference due to the LPFM signal being present on the upper third adjacent channel was heard on the FM home hi-fi receiver under test.[53] (In the parlance of the *Report*, a N>Y transition was noted, meaning that no interference was heard on the FM receiver without the LPFM interferer present, but it was heard when the LPFM interferer was turned on.) For this case, the measured full power FM signal power was –54.16 dBm, and the measured LPFM signal power was –16.45 dBm, resulting in a D/U ratio of –37.71 dB.[54] Cases of N>Y transition such as this are used in the *Report* as the basis for proposed third adjacent channel protection rules.

MITRE's conclusion for this test case is that this receiver will experience interference from an LPFM third adjacent channel interferer at a D/U ratio of –37.71 dB. However, because of the dual deficiencies of no lower third adjacent channel interference testing and no receiver characterization (and if one ignores for the moment the fact that the measured D/U value itself cannot reliably be attributed to the receiver under test), there are a number of possible conclusions resulting from this test, and *no way* to determine which one is correct. These

[53] *Id.*, Vol. 2 at Annex 3, p. 88. The record identification for the data used in this example is EB225P5.

[54] In other words, MITRE is claiming that the LPFM signal power was 37.71 dB higher than the full power FM signal power at the input to the receiver under test. As previously discussed, this D/U number itself is inherently flawed as it cannot be attributed to the receiver under test, because the signal powers were measured using a spectrum analyzer not connected to the same antenna as the receiver under test.

possibilities stem from the fact that in practice full power FM signals can expect to receive interference from *both* upper and lower third adjacent signals, not just upper adjacent signals:

- If the receiver under test responds identically to either upper or lower third adjacent channel interferers, then the conclusion that the receiver will experience interference at –37.71 dB would be valid. Because there is no receiver characterization data, there is no way of knowing if this receiver does, in fact, respond identically to upper and lower adjacent channel interferers;

- If the receiver under test does not respond identically to upper and lower interferers, there are a number of possibilities. For example, if the receiver is similar to receiver number 9 in Figure 3, which demonstrated a 30 dB difference in sensitivity between upper and lower interferers, then it would experience interference due to a lower third adjacent channel interferer at either –7.71 dB D/U (if the receiver were 30 dB more sensitive to lower adjacent channels) or –67.71 dB D/U (if the receiver were 30 dB less sensitive to lower adjacent channels).

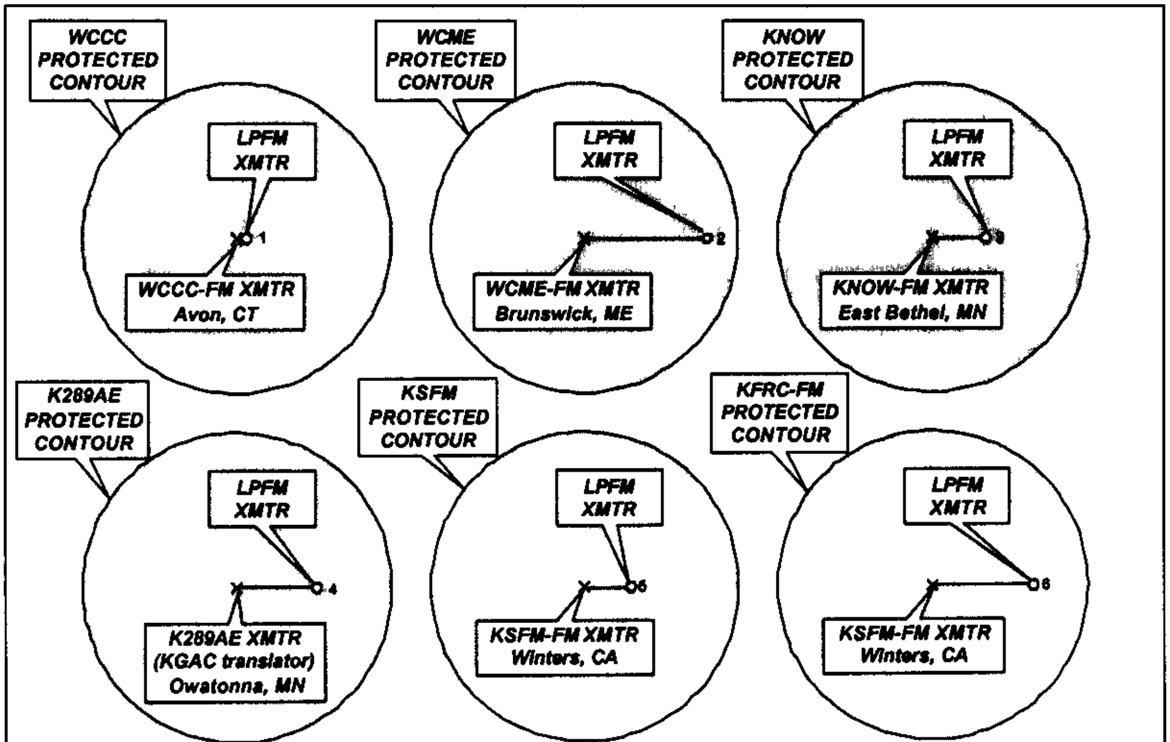
Thus, MITRE's conclusions regarding how receivers behave in the presence of third adjacent channel interferers are invalid because they do not take into account a receiver's performance in the presence of lower third adjacent channel interferers. Any protection rules based on this data would be no better than guessing because, as shown in the example above, the combination of no lower third adjacent channel data, no receiver characterization data, and D/U measurements not directly attributable to the receivers under test fatally flaw this analysis.

G. MITRE's Selection of Test Locations Was Improper.

MITRE continues to worsen site selection based on administrative convenience and the testing of only upper third adjacent channels by its specific choice of test sites. Despite the Congressional mandate allowing up to nine test sites,[55] MITRE elected to only use six, further diminishing the opportunity to build a more representative and significant data set. Figure 7 is a schematic representation of the six test sites used by MITRE for the collection of interference data, where each circle in the figure represents one of the LPFM test sites and its location relative

[55] *Radio Preservation Act* at § 632(b)(1).

to the transmitter and protected contour of the desired full power FM site. Once having selected the sites for the LPFM interfering stations, MITRE then limited its testing at each site to only five receiver locations, all of which were located on an imaginary line connecting the full power FM transmitter site to the LPFM transmitter site, and between the two transmitters.



TEST SITE	NO.	PERCENT DISTANCE TO PROTECTED CONTOUR
Avon, CT	1	9 0%
Brunswick, ME	2	82 0%
East Bethel, MN	3	37 0%
Owatonna, MN (A)	4	54 0%
Winters, CA	5	33 0%
Benicia, CA	6	68 0%

Figure 7. Schematic Representation of MITRE Test Sites[56]

MITRE's decision to characterize LPFM interference to a given full power FM station by locating the LPFM station at only a single site within the full power FM service area is misguided – it typically takes numerous sites throughout a service area to characterize the impact

[56] *Report*, Vol. 1 at 1-7.

of interference on a radio station, with those sites being selected carefully based on technical considerations specific to the desired station.[57] Broadcasters have to deal with a variety of reception conditions within their service area due to differences in terrain, environment (urban, rural, etc.), weather patterns, seasonal changes, and whether a listener is stationary or mobile. These varying conditions can have a significant influence on a listener's degree of susceptibility to interference from a third adjacent LPFM station since they can all affect the D/U ratio (of the desired to the undesired third adjacent channel) at the receiver. Careful field test planning needs to take these factors into account – none of them have been considered in the field testing described by the *Report*. Field testing dictates a large number of measurement locations must be documented: typical field testing programs involve hundreds of locations.[58]

In addition to the paucity of sites used for interference data collection, the value of many of the receiver locations was compromised by the fact that there was so much interference due to sources *other* than the third adjacent LPFM transmitter that for one or more of the receivers tested at these locations, no useful information was obtained. For example, Figure 8 shows that, at the Brunswick location, absolutely no information for the clock radio and Walkman receivers was obtained:

[57] A good example of the variability of the interference environment created by adjacent channel FM signals can be found in "Report to the National Radio Systems Committee - FM IBOC DAB Laboratory and Field Testing," "Field Test Results," Appendix F, "Report to the National Radio Systems Committee - FM IBOC DAB Laboratory and Field Testing," iBiquity Digital Corporation (Aug. 2001). In particular, maps labeled "Appendix F9" at pp. 4, 6 and 8 show the predicted D/U ratios for two full power FM stations, and illustrate the terrain-dependent nature of adjacent-channel interference as well as the wide variability of D/U over limited geographical areas.

[58] *See, e.g.*, "Field Test Results of the Grand Alliance HDTV Transmission System," submitted to SS/WP2 Field Testing Task Force of the Advisory Committee on Advanced Television Service of the FCC by MSTV *et.al.* (Sept. 16 1994) at Ch. 53. For these tests a total of 199 reception sites were used for a single transmission site.

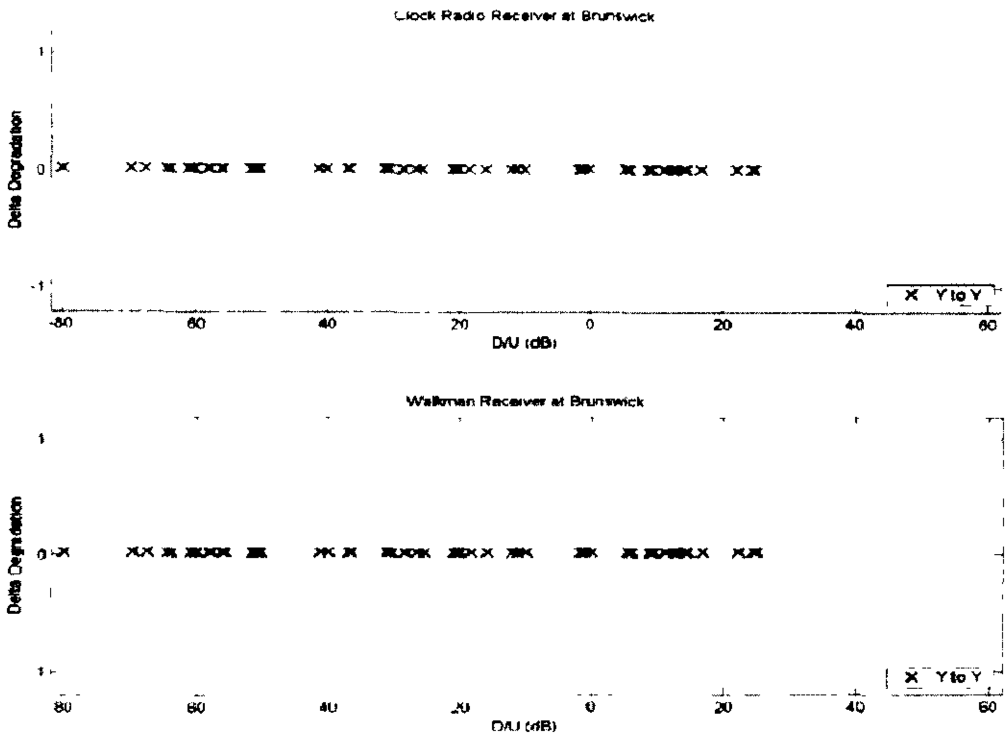


Figure 8. Delta Degradation for the Clock Radio and Walkman Receivers at Brunswick.[59]

All of the test data shown in this figure indicates that, for *all* the conditions tested, there was interference heard for these receivers both before and after the LPFM transmitter interferer was turned on. There is no indication as to whether or how much the presence of interference of the LPFM signal worsened the interference heard by the listener. All told, seven out of thirty six receiver/location combinations yielded essentially no information about the interference generated from the LPFM transmitter simply because some interference was already deemed present. Use of this technique effectively hides deleterious effects that the presence of LPFM signals have on full power FM signals in numerous practical situations.

[59] *Report*, Vol. 1 at Appendix C pp. C-6 – C-7.

V. MITRE's Tests Revealed That Interference to Full Power FM Stations From Third Adjacent Channel LFPM Interferers Exists and Is Significant.

Throughout this proceeding NAB and others have offered technical studies and evidence demonstrating that LPFM stations will interfere with full power FM stations if existing third adjacent channel protection rules are eliminated. Notwithstanding major statutory and technical deficiencies, MITRE's *Report* also ultimately shows that significant new interference to full power FM stations would be created by the elimination of third adjacent channel protection rules for LPFM stations.

Despite the problems which plagued the MITRE effort, problems which make it impossible to arrive at technically sound, quantitatively accurate conclusions regarding the nature and extent of the interference studied, MITRE tested around six sites that the Commission would have licensed to LPFM applicants were it not for Congressional intervention. For each of these sites, by MITRE's own admission, "significant interference" to full power FM stations from LPFM stations operating on third adjacent channels was observed.[60] Figure 9 and Figure 10 show the total number of "significant" (as determined by MITRE) N>Y transitions (each transition representing a significant LPFM-into-full power FM interference event) for each LPFM site and for each receiver type, respectively. MITRE defined significant interference as:

- The full power FM program was heard, but the recording had a lot of static; or
- The full power FM program was not heard at all; or
- The full power FM program was heard but a different program could also be heard in the background. This program might be transmitted by the LPFM or by a different radio station. If the LPFM ERP was 0W (LPFM was not transmitting) and a different program was heard in the background, then the program was received from a different radio station that was not involved in the tests.[61]

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[60] *Id.*, Vol. 1 at 2-9 – 2-11, Table 2-1.

[61] *See id.*, Vol. 1 at 2-8.

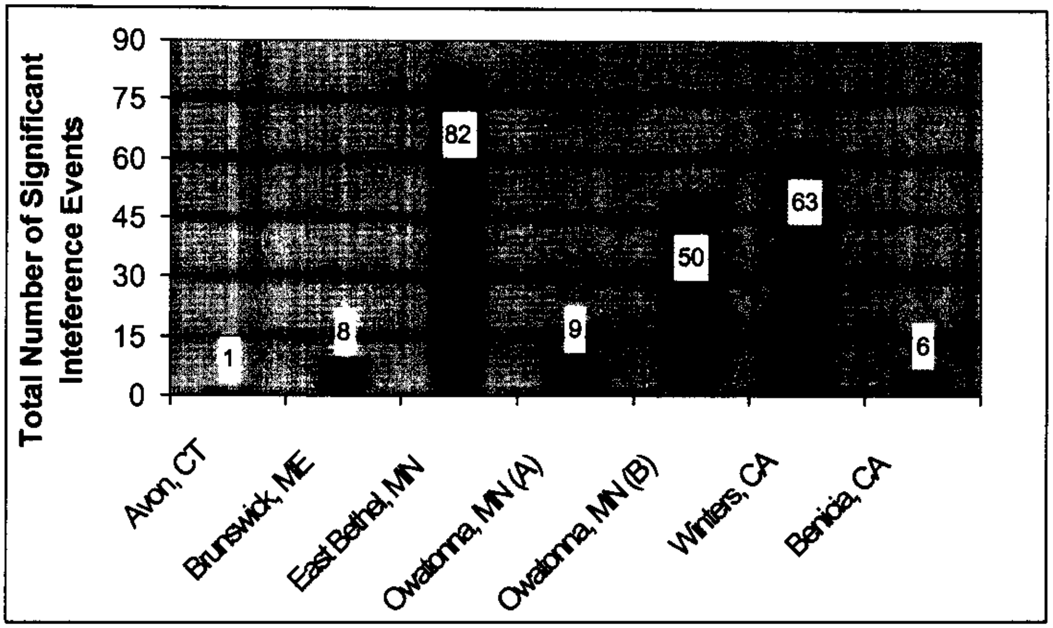

Figure 9. Total Number of Significant Interference Events as a Function of LPFM Site[62]

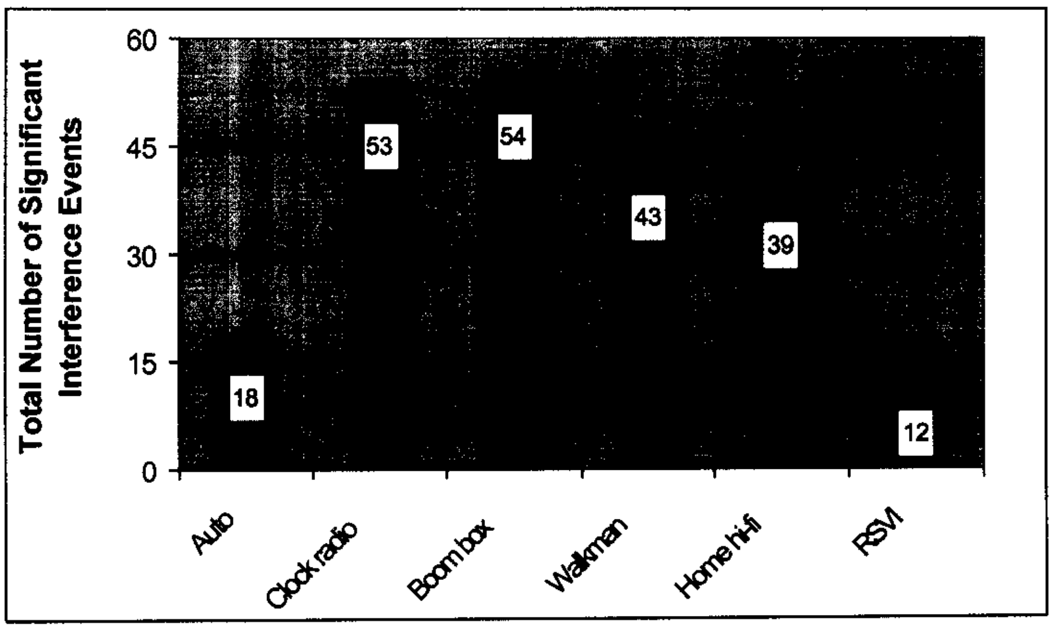

Figure 10. Total number of Significant Interference Events as a Function of Receiver Type[63]

[62] *Id.*, Vol. 1 at Table 2-1. These interference events are referred to as "N>Y" transitions in the *Report*.

[63] *Id.*

Thus, MITRE observed numerous instances of significant interference. Significant interference (as shown in Figure 10) as well as non-significant interference was *heard on all six receiver types tested*—auto, home, clock, "boom box," "Walkman," and RSVI. Faced with interference, listeners are likely to either change the channel or turn off their radio.[64] Additionally, numerous instances of "non-significant interference" were observed for every LPFM station, defined by MITRE as "...[s]ome static was detected for the recording, but it was not bothersome and the [full power FM] program was still clearly understandable."[65] MITRE's un-scientific characterization of "non-significant" interference may not adequately reflect that consumer tastes are trending towards audio equipment with a higher signal-to-noise ratio, and that this arbitrarily-assigned "non-significant" interference threshold may, in fact, be unacceptable to today's listeners.[66]

Again, *no one*, save the single field test engineer, ever listened to the recordings made in those cases where either no interference was detected (both before and after the LPFM interferer was introduced *i.e.*, N>N) or interference *was* detected both before and after the LPFM interferer was introduced (Y>Y). It is entirely unclear whether additional cases of "non-significant" and "significant" cases of interference would have been identified had all of the recordings been properly examined. Thus, MITRE's "sample of one" method may again be underestimating the level of harmful interference. Additionally, in instances where interference was present before

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[64] *See* Engineering Report of Moffet, Larson & Johnson, Inc., attached as Appendix A to Reply Comments of NAB, MM Docket No. 99-25 (Nov. 15, 1999) at 10.

[65] *Report*, Vol. 1 at Table 2-1. MITRE also classified as non-significant interference situations where "[n]o degradation was detected during listening by the MITRE engineer, but the recording was marked as an N>Y transition by the subcontractor field engineer."

[66] *See* Pickholtz/Jackson Report at 43.

the LPFM transmitter was turned on,[67] a valid listening assessment should have included an analysis of whether the LPFM worsened the interference. Yet MITRE offers no insight in these cases.

MITRE further notes in its conclusions and recommendations that "[n]umerous significant degradation cases were identified at distances less than 240 meters, and especially at distances less than 100 meters and that significant degradation could occur at somewhat larger distances in certain unfavorable circumstances. . . ."[68] With due caution noted that this reported interference is based upon the opinion of only a single individual, nevertheless it has now been demonstrated in the field that that the introduction of LPFM service without third adjacent channel protection will indeed create new interference to full power FM stations, thereby preventing some populations within the protected full power FM station's contour from listening to stations they currently enjoy and depend on. Simply stated, listeners sited within these distances will experience harmful interference to their full power FM station.

This creates an interesting paradox: unless LPFM stations are to be located where the surrounding terrain will *never be suitable* for current or future populations, the Commission cannot eliminate third adjacent channel protections without creating a loss of service to the full power FM service – yet the Commission's *LPFM Order* states its goals to site LPFM stations at or nearby populations to serve local communities. *LPFM Order* at ¶¶ 3-6. The paradox is also irreconcilable with the Commission's conclusion that LPFM stations may be allocated "only if" no unacceptable interference occurs to existing radio stations and their listeners. *Id.* Thus, the elimination of third adjacent channel interference protections is not feasible.

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[67] *Report*, Vol. 1 at 2-7

[68] *Id.*, Vol. 1 at 5-1.

VI. MITRE's Formulas for Waiving Third Adjacent Channel Distance Restrictions Have No Basis In Fact.

After improperly collecting its field test results, MITRE mistakenly concludes that, based on these results, "...existing third-adjacent channel distance restrictions should be waived to allow LPFM operation..." subject to a number of enumerated stipulations.[69] This proposed basis for waiving third adjacent channel protection should be rejected by the Commission for the following reasons.

First, MITRE states that "...[n]o LPFM station should be licensed with x_{min} meters of any location [where a formula for x_{min} is provided] that is likely to have a high density of receivers that lie within the FPFM protected area."[70] This again raises the paradox that unless LPFM stations are to be located where current or future populations are not likely to want to use radio receivers, the Commission simply cannot eliminate third adjacent channel protections. Consequently, the proposal by MITRE that LPFM sites be placed where there is a small likelihood of receivers being found subverts the very reason for the existence of the LPFM service, to serve local communities.

Second, MITRE's formula for x_{min}, the parameter which determines where an LPFM site may be placed, is derived from field test data which, as explained above in detail in Section IV.D., is based on D/U measurements that may or may not have reflected the field test conditions under which the receivers were tested. Again, there is no way of knowing from the information contained in the *Report* whether these D/U values are accurate, or, if not, what the accurate values might be. Further, the D/U values used to derive x_{min} are the threshold values which, as

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[69] *Id.*, Vol. 1 at 5-3.

[70] *Id.*, Vol. 1 at 5-4.

previously discussed, are based on assumptions about listener behavior that MITRE literally pulled "out of thin air" and thus have no underlying technical or statistical basis.

Third, this formula does not factor in the impact of LPFM sites which are lower third adjacent channel interferers of full power FM stations. Even if the underlying data could be deemed valid (which it is not), the formula would only be appropriate for an LPFM allocation scheme for waiving adjacency protection for upper third adjacent sites.

Fourth, MITRE states that if the actual D/U ratio experienced by a desired full power FM station due to a third adjacent channel LPFM interferer ". . .can be shown to be –15 dB or better (*i.e.*, more positive) at most locations in the area of high receiver density for a candidate LPFM transmitter site, then the proposed site may be used, even if it is closer then x_{min} meters from the area of high receiver density."[71] Again, this is based on the flawed threshold D/U values and ignores the facts that, as discussed in Section IV.B., (1) no receiver characterization was performed, (2) the RF signal levels were improperly measured , and (3) the D/U ratios which form the basis of this proposal may or may not be accurate.

Fifth, MITRE offers a rule for siting LPFM transmitters near FM translator receivers, stating that "[n]o LPFM station with an ERP of P_{eu} dBW should operate within d_u kilometers of an FM translator receiver on the third adjacent channel..."[72] Because the underlying data is so riddled with flaws this rule must be rejected out-of-hand. This is particularly important because interference to one translator in a chain may cause service to be lost from other translators as well.

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[71] *Id.*

[72] *Id. See also* the formulas for siting near translators, Vol. 1, at 5-2.

Finally, MITRE's spacing-requirement formulas are premised on a static assumption as to affected populations in an area surrounding the proposed LPFM station site.[73] But population shifts will inevitably occur: the Commission must ensure that *all* persons within a station's protected contour, including those who have relocated near a LPFM station, are not subjected to harmful interference when listening to their desired full power FM station.

Indeed, the Commission's steadfast policy is that presently-served populations should not lose broadcast service. *See, e.g.*, In re Application of New City Communications of Massachusetts, Inc., *Memorandum Opinion and Order*, 10 FCC Rcd 10 at ¶ 6 (1995); *aff'd WSB, Inc. v. FCC*, 83 F.3d 695 (D.C. Cir. 1996) (in which the Commission denied radio station's owners request to reduce the station's radio signal); *Busse Broadcasting Co. v. FCC*, 87 F.3d 1456 (D.C. Cir. 1996); *In re Huron Shores*, 53 FCC 2d 216 (1976) (in which the Commission denied waiver of duopoly rules based, in part on a "[concern] is heightened where population presently served would lose service if a modification of facilities were to be granted).

Congress has also recognized that the very purpose of third adjacent channel field testing "is to protect broadcasters. It is to protect licensees. And it is, above all else, to protect the listeners of the FM radio spectrum."[74] Spacing formulas premised on static populations are inherently contrary to this stated purpose. Listeners located within and at a station's protected contours should now, and in the future, be shielded from harmful interference.

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[73] *Id.*

[74] 146 Cong. Rec. H2303 (daily ed. Apr. 13, 2000) (Statement of Rep. Dingell).

VII. Conclusion.

The MITRE *Report* is fatally flawed because it wholly ignores two key Congressional mandates – independent audience listening tests and an economic analysis on the impact on full power FM stations if third adjacent channel protections were eliminated. Further, the *Report* contains so many major technical errors and omissions that the resultant test data is rendered unusable; thus, the Commission cannot fulfill its statutory obligations. Finally, despite its deficiencies, MITRE's study clearly demonstrates listeners within a full power FM station's protected contour will experience harmful interference from LPFM stations located on third adjacent channels. For the reasons stated above, the Commission *cannot recommend* to Congress the elimination of third adjacent channel protections for LPFM radio service.

Respectfully submitted,

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October 14, 2003

AFFIDAVIT

CITY OF WASHINGTON)
) SS:
DISTRICT OF COLUMBIA)

ALFRED E. RESNICK, P.E., being duly sworn, deposes and says:

I am a Registered Professional Engineer in the employ of the Carl T. Jones Corporation and I am authorized to make this affidavit on behalf of the Carl T. Jones Corporation.

The Carl T. Jones Corporation is an engineering services organization headquartered in Springfield, Virginia. The Carl T. Jones Corporation provides professional consulting and engineering services to broadcasting stations, agencies of the United States and state and local governments and others. The Carl T. Jones Corporation specializes in the areas of communications systems and facilities design, computer-aided propagation and interference studies and frequency management and allocation studies. The Carl T. Jones Corporation has extensive experience in evaluating the potential for interference from new facilities and is knowledgeable concerning the engineering standards and applicable practices developed to evaluate the impact of new spectrum uses.

The Carl T. Jones Corporation was retained by the National Association of Broadcasters to assist it in evaluating a report prepared by the MITRE Corporation concerning the impact of reducing the third adjacent channel protection standards for Low Power FM stations.

I have reviewed the Comments of the National Association of Broadcasters concerning the MITRE Corporation Report. The engineering portions of the NAB Comments and the criticisms of the MITRE Corporation Report accurately reflect, in the opinion of the Carl T. Jones Corporation, the application of sound engineering practices and widely accepted engineering standards for evaluating interference to radio services.

Alfred E. Resnick, P.E.

Subscribed and sworn to before me this 14th day of October, 2003

SALLY J. SIMMONDS
NOTARY PUBLIC DISTRICT OF COLUMBIA
My Commission Expires October 31, 2007