APPENDIX A

MLJ *MOFFET, LARSON & JOHNSON, INC.*
CONSULTING TELECOMMUNICATIONS ENGINEERS

ENGINEERING REPORT

1110 N. Glebe Road, Suite 900 **Arlington, VA 22201**

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OFFICE OF THE SECRETARY

Engineering Statement
Analysis Of FM Receiver Test Results
In Support Of Reply Comments Of
The National Association Of Broadcasters
In MM Docket No. 99-25

September 15, 1999

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National Association of Broadcasters
Washington, DC

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Introduction

MLJ, Inc. has been retained by the National Association of Broadcasters (NAB) to study comments filed in MM Docket No. 99-25. In this proceeding the FCC proposes to create a low power FM broadcasting service (LPFM). In the Notice of Proposed Rule Making (NPRM) in MM Docket No. 99-25, the FCC sought ".... comments on the state of receiver technology and the ability of receivers to operate satisfactorily in the absence of 2nd-adjacent channel protection." In response to this request, NAB sponsored a measurement program to determine the interference susceptibility of contemporary FM broadcasting receivers. Reports presenting the results of the measurement program and analysis of the measurements were filed with the NAB comments in this proceeding. In addition, FM receiver measurements were filed by the FCC Office of Engineering and Technology (OET), Consumer Electronics Manufacturer's Association (CEMA) and the National Lawyers Guild (NLG). Relative to the Commission's proposals in MM Docket No. 99-25, the purpose of this study is to analyze the results of these other measurements and to compare the analysis to the NAB measurements. All of the tests are conceptually similar and employ similar test beds, however there are significant differences that, in some cases, lead to misleading conclusions. The source of the different results lies mainly in the choice of the criteria for interference. In particular, the OET and NLG used criteria that differ substantially from recognized standards, that is, standards developed by engineering associations such as the International Telecommunications Union (ITU).

Interference Standards

The NAB FM interference susceptibility tests are based upon ITU standards that were developed specifically for the purpose of measuring desired-to-undesired (D/U) interference ratios applicable to the FM broadcasting service.[1] The standards were developed over a period of time by a community of expert engineers to take pertinent technical factors into account. These factors include, among others, characteristics of the modulating audio signal, the strength of the desired signal and characteristics of human hearing.

OET Lab Tests

The test setup employed by OET is similar to that used in the NAB and CEMA tests, but the audio impairment standard is much different. The OET criterion for interference is measured distortion. Although not specifically stated in their report, the OET criterion is total harmonic distortion (THD) of a test tone on the desired carrier or, more precisely, THD plus noise as indicated on a modulation analyzer. The OET used distortion values of 1% and 3%, specified in percent of voltage as standards for interference. Distortion is not specified as the objective interference criterion in the ITU standard 641, on which the NAB tests are based, because distortion correlates more poorly with subjective level of impairment than noise level. Also,

[1] The NAB test procedures are based upon ITU standards, especially ITU 641.

distortion measurements are relatively insensitive indicators of impairment because the high-level tone modulation obscures the underlying noise products. Examples of these concepts are apparent in the NLG tests where both S/N and distortion were measured under similar conditions. Typically, when S/N changes by 20 to 30 dB in the NLG tests because of RF signal interference, the distortion only changes by about 10 dB or less (a distortion level increase from approximately 1% to 3%, the values used by OET). CEMA also measured distortion in addition to S/N; the CEMA tests also show that distortion is not a sensitive indicator of interference.[2]

OET used clipped "pink noise" as the modulating signal for the undesired signal and a 1 kHz tone for the desired.[3] Although OET does not clearly state it, we presume that the distortion values were applied as degradation factors from measured distortion without interference, that is, "baseline" distortion. Radiofrequency interference usually results in detected noise having high peak-to-average ratios. Interference from second- and third-adjacent channel undesired FM signals in particular contains brief high-amplitude noise spikes that are more perceptible and more objectionable to listeners than the long-term average energy. For this reason audible noise from undesired signals is generally measured with peak or quasi-peak reading meters having fast rise-time ballistics, as is specified in ITU standard 641. However, OET measured impairment with an audio distortion meter, which customarily has an averaging detector with a relatively

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[2] Data showing a comparison of rms THD in dB with quasi-peak signal to noise in dB is shown for the Denon TU380 and Pioneer SX201 receivers on p 30 of CEMA Appendix A.

slow ballistic. We believe this instrumentation will result in data that does not represent the severity of audible impairment experienced by most listeners.

In addition to the use of a non-standard interference criterion, here are a number of other concerns with the OET tests:

- No justification is given for the use of 1% and 3% distortion values;
- Measurement values for baseline distortion are not given in the OET report;
- No rationale for the selection of receivers is presented, and in particular, no receivers with integral antennas were tested because OET stated that it was difficult to determine input signal levels for these receivers;
- Two desired signal levels were used: 330 µV (-58.4 dBm across 50 ohms) and "noise limited" which OET defines as the power that results in 1% distortion without interference.

Each of these points is discussed in the following paragraphs.

OET Distortion Criteria

As noted above, distortion is a poor choice for use in FM interference testing because it does not correlate well with subjective effects of audible impairment. The OET report does not refer to any subjective tests or cite any standards that relate distortion to interference. Therefore, the values of 1 % and 3 % used in the OET tests appear to be arbitrary. CEMA and NLG measured

[3] Pink noise is a form of random noise having equal energy per octave bandwidth.

both S/N and distortion. The CEMA and NLG test data show that there is no simple and general relationship between distortion and S/N. Therefore, the OET distortion data cannot be converted to standard S/N values. The use of audio distortion notwithstanding, the actual degradation of the OET tests cannot be determined because baseline interference is not presented in the report. Degradation of signal-to-noise ratio is expected to be more than 5 dB[4], and it certainly much greater than 5 dB for the 3 % distortion case. For example, if baseline distortion is 0.5 % for a given receiver, then degradation in terms of distortion to 3 % is more than 15 dB ($20 \times \log_{10} 3/0.5 = 15$ dB). Furthermore, changes in distortion of approximately 15 dB as represented in the OET tests result in a much greater degradation in S/N, often more than 30 dB. Because of the impulsive, high-frequency nature of the audible interference, an average distortion level of 3% would result in noise spikes barely 20 dB below program level (assuming average program level to be 8 dB below full modulation and peak noise to be at least 2.5 dB above an average noise and distortion level of 3%). Therefore, distortion is not an accurate and sensitive measure of audio impairment. Impairment that causes relatively small increases in measured distortion as in the OET tests, can result in severely impaired or unusable FM service.

Receivers Tested By OET

Because receivers vary substantially in their susceptibility to interference, particularly regarding adjacent channel interference, the choice of receivers used in a test program can be critical. The

[4] A change of 5 dB represents a change of one audio quality grade. See NAB comments, Volume 2 in MM Docket 99-25 (filed August 2, 1999), MLJ report Standard of Service, p. 9.

OET does not explain the basis for its selection of receivers, other than only receivers where it is possible to easily inject signals, such as car and component receivers, were tested. Of particular concern is the total absence of receivers with integral antennas, such as table and clock radios. Sales of these receivers are high and such receivers tend to be among the most susceptible to interference.[5] Thus, there is an inherent bias in the OET tests because of the sole use of radios with external antennas. The OET states that it did not test receivers with integral antennas because of the difficulty of controlling input signal levels to these receivers. As noted in the OET report, there are procedures for such testing that yield meaningful results; such procedures were used in the NAB, NLG and CEMA programs. It is desirable for the OET to conduct its own tests on receivers with integral antennas, however to be useful, a standard test procedure including an objective interference criterion should be used, such as one based on ITU 641.

In its report, OET discusses a particular test procedure whereby receivers would be subject to radiated desired and undesired fields. At first glance, this technique appears to be desirable. It models actual reception conditions and overcomes the problem of signal injection into receivers without external antennas, however there are problems. Although it is not a standard test procedure, such a procedure was considered for NAB's tests. The radiated field procedure was not employed by NAB because of time constraints and potential problems with the procedure in

[5] NAB Comments in MM Docket 99-25, Volume 2 MLJ Report Selection of Receivers and Analysis of Test Results , p 6.

obtaining repeatable data. Additional time is involved in designing such a procedure, acquiring (perhaps even fabricating) equipment, and ultimately, setting up the test bed and calibrating the equipment. The performance of these receivers depends on the relationship between the receiver and the incident field, and thus there are potential problems with repeatability of results. NAB did not use this procedure not only because it may not yield repeatable results and the time involved, but also because it is a non-standard procedure, and results may be difficult to compare with data taken using standard tests. If the OET uses such a procedure, companion tests using standard methods similar to those used by NAB and CEMA should also be made on the receivers. This will permit comparison of the OET data with the NAB and CEMA data and permit determination of the relationship between field strength and received power for the tested receivers.

OET Desired Signal Levels

The OET conducted tests for a constant desired signal level of 330 μV (-58.4 dBm). This lies within the range of values used by NAB (-65 dBm, -55 dBm and -45 dBm). In addition, "noise limited" tests were conducted. As defined by the OET, this is the desired signal strength that results in 1% distortion without interference. Because the value of received power for noise limited service varies between receivers, the data is difficult to relate to the -58.4 dBm measurements or to analyze by itself. Multiple desired received power levels are useful in identifying "non linear" effects in receivers. In many cases, the measured D/U changes with desired signal strength and interference is worse than might be expected when the desired signal is strong. Data taken with inconsistent desired signal power is not particularly useful in this regard.

In summary, although OET states that additional tests will be performed, the results of the OET tests performed thus far are incomplete and are not useful in assessing performance of contemporary FM radios. This is caused by the use of a non-standard criterion for interference and failure to test receivers with integral antennas.

NLG Tests

Only eleven receivers were tested by NLG compared to twenty-eight receivers that were tested by NAB. NLG tested all categories of receivers, however because of the small sample size all categories are underrepresented, especially personal portables or "walk man" radios where only one was tested. NAB tested five categories of receiver, characterized as: automobile, clock/table, component, personal portable ("walk man") and portable. At least five receivers of each category were tested by NAB.

Furthermore, NLG apparently made adjacent channel tests on only one side of the desired station. The susceptibility of particular receivers to interference is often different depending on whether the interfering station's frequency is above or below the frequency of the desired station. In the NAB program, tests were made for both upper and lower cases and the data was averaged. Also, no data is present on the age of the NLG receivers nor are the criteria for the selection of the receivers presented. Thus, the NAB tests are intrinsically more complete and representative than the NLG tests.

NLG Methodology

The NLG test bed is basically similar to the others. Tests are based on measurements of total harmonic distortion plus noise (THD + N). As in the OET tests, the NLG tests are flawed because distortion does not relate well to subjective observations of interference and is not sensitive to changes in interference. As with the OET tests, average reading meters were used instead of quasi-peak meters that are standard. In the NLG tests, desired signals consisted of a 1 kHz tone and the undesired consists of music or a tone. Few conclusions are given in the test report. The report states that there is no standard for interference and implies that total loss of service - that is, 100 % distortion - is appropriate. This statement is incorrect, organizations such as the ITU, the FCC, and CEMA have defined standards for interference.[6] Loss of service in these cases is based upon a defined objective signal to noise ratio that is measured and can be related to subjective observations.

[6] For example, ITU standard 641; FCC Docket No. 9407 (1949) both use S/N of 50 dB and CEMA comments in this proceeding (45 dB).

As shown in the NAB comments, the objective interference criteria can be related to standard audio listening grades of quality. The concept of total loss of service is inherently incompatible with the Commission's existing allocation standards, which are based upon interference ratios selected to control interference. As a practical matter, total loss of service occurs at much lower values of distortion than 100%. Even when desired audio signal exceeds the undesired audio, service can be lost. For example, as an undesired signal is increased, a point is reached when listeners will turn off their radio or choose another station. To the best of our knowledge, the Commission has never defined loss of any service, broadcasting or other, as degradation to the point where distortion is 100% or S/N is unity (0 dB) because of concerns over quality of service. Such a definition would result in unusable and severely impaired service within a station's normally protected service contour. Use of an interference standard based upon a criterion such as the ITU 50 dB signal-to-noise ratio insures that high quality service generally is available in a stations protected area. In its comments, NLG proposes to eliminate second and third adjacent channel interference protections in LPFM allocations.[7] Using total loss of service as defined by NLG leads NLG to the erroneous conclusion that second and third adjacent channel protection is not required.

NLG conducted tests for several interfering signal modulation cases. These include no modulation, tones, stereo pilot only and program material; none of which are standard. The ITU

[7] NLG Comments section XI.

standard used by NAB uses filtered noise to modulate interfering signals in a manner that is designed to model normal program material yet yield repeatable data. In addition to measuring distortion, NLG measured S/N for each of the modulation cases. Measurements of distortion and S/N were made for undesired-to desired (U/D) signal ratios in 10 dB increments over a 50 dB range from 20 dB below the OET standard ratio to 30 dB above the OET standard (relative to each U/D channel frequency relationship). As noted earlier, distortion is an insensitive indicator of impairment level. This is apparent from the NLG test data itself where both S/N and distortion were measured in the same test. Typically, when S/N changes by 20 to 30 dB in a test because of impairment by interference, distortion only changes by about 10 dB or less. For example, in the first case tabulated by NLG where a full set of data is shown, S/N changes by 22 dB and distortion by only 6.9 dB over the 50 dB test range[8]. Similar results are shown in Appendix A of the CEMA tests[9].

The NLG tests were conducted by holding the desired signal level constant and increasing the level of the undesired signal. The level of the desired signal was set to - 54 dBm (for an assumed load of 50 ohms), however there was no attempt to match receiver impedance. Thus, actual input powers not known. The NAB used an RF bridge to match the signal powers to each receiver's particular input impedance, and found considerable changes in compensation

[8] NLG test data, receiver Number 1, 2nd adjacent channel interference, data is for program material modulation. For stereo tones, S/N changes by 28 dB and distortion by 9.5 dB.

from unit to unit. Without use of a device such as an RF bridge, receiver input power is not precisely known. If receiver input power is not precisely known, it is difficult to replicate measurements, analyze data taken on multiple receivers, correlate measurements with field strength and determine non linear effects in receivers. In short, receiver performance depends on the strength of the desired signal and it is necessary to determine the value in a test program. This is especially true for receivers with integral antennas where the receiver may be designed to match a non-standard impedance from a line such as a power cord that serves as an antenna.

NLG Data Contradicts Its Conclusions

In the NLG report, their data is analyzed using graphs of measured distortion for each receiver for each type of interference. Because of the use of distortion and the graphic presentation, serious cases of interference are not readily apparent. Although non-standard techniques, were used in taking the measurements, the NLG data can be analyzed using standard interference criteria to illustrate that the data does not support the NLG's conclusion regarding second and third adjacent channel interference.

MLJ performed such an analysis for second and third adjacent channel interference using the data where program material is the modulation of the interfering signal. In this analysis, desired to undesired signal ratio is determined for each receiver. Because NLG measured signal-to-

[9] Data showing a comparison of rms THD in dB with quasi-peak signal to noise in dB is shown for the Denon TU380 and Pioneer SX201 receivers on p 30 of CEMA Appendix A.

noise ratio for desired-to undesired ratios in 10 dB increments, interpolation is used to derive desired-to-undesired ratio for the standard 50 dB signal to noise ratio specified in ITU standard 641. The result of the analysis is shown in the following table which lists the measured desired to undesired ratio for both second and third adjacent channel interference for each receiver tested by NLG:

Receiver Desired to Undesired Ratio (dB)

Number	Manufacturer	Type	2nd Adjacent	3rd Adjacent
1	Marantz	Component	-46.7 [1]	-28.9 [1]
2	Sony	Personal	-- [2]	-- [2]
3	Toyota	Auto	-51.3	-30.0
4	Denon	Component	-39.5	-42.1
5	Sony	Clock	-40 to -50 [3]	-41.8
6	Aiwa	Portable	> -30	> -20
7	Sony	Portable	> -30	~ -40 [4]
8	Technics	Component	-41.7	-50
9	NAD	Component	-43.4	-52.7
10	Ford	Auto	-65.3	-66.0
11	Aiwa	Portable [5]	- 39.8	-35.1
		Median	- 42	-42

[1] Tone modulation data used; program modulation data corrupted on 2nd adjacent channel.
[2] Data not tabulated excessive interference.
[3] Loss of service between 40 and 50 dB.
[4] Estimated with 5 dB degradation factor.
[5] Characterized as "integrated system" in the NLG report.

The above medians are approximate because of uncertainties shown in the table. Also, they are based on data taken in a non-standard procedure and on a limited number of receivers, particularly considering that the NLG tested only one personal portable and one clock radio was tested. Although, the usefulness of the data is limited, the median ratios do not disagree significantly from those of the rules and do not support NLG's conclusions regarding potential LPFM interference, or more importantly, absence of interference. NLG also claims that receivers have improved, that is " Modern radios are far superior to those of a few years ago."[10] In addition NLG states that about half of the radios perform "...dramatically better than the FCC interference ratios would suggest".[11] But as shown by the above table, their own data does not bear this out; only the Ford car radio could be considered "dramatically better" and the medians are approximately equal to the FCC ratios used for commercial allocations. A more balanced selection of receivers including more clock radios and personal portables would be expected to show increased susceptibility to interference than the medians from the above table.

NLG Fourth Adjacent Channel Tests

Measurements of fourth adjacent channel interference were also made in order to show that fourth adjacent channel interference is "similar" to third adjacent channel interference. This is part of the NLG argument that second and third adjacent channel interference is "blanketing" interference.[12]

The results of the fourth-adjacent channel tests are only shown for three receivers of the eleven in the test program. Furthermore, complete data is given for only one receiver so that it is not

[10] NLG Comments in MM Docket 99-25 in section I.

[11] NLG Comments in MM Docket 99-25 in section XII B.
[12] Ibid.

possible to draw any conclusions from the NLG fourth-adjacent channel interference tests. Therefore, the data in the NLG report is too limited to be used to conclude that second and third adjacent channel interference is not a problem because it is equivalent to blanketing which is not regulated by distance separations.

Under the FCC rules blanketing interference is considered to occur in areas where undesired field strength exceeds 115 dBu. This is at least 15 dB greater than the field interfering field strength based upon the 40 dB ratio used for second and third adjacent channel interference at a stations protected contour.[13] The NAB tests show that the second adjacent channel interfering signal would be even lower. The above table for the NLG data indicates that the interfering field strength in these cases is approximately 12 dB short of blanketing. The measured interference ratios result in interfering field strength substantially weaker than that required for blanketing under the FCC rules. Thus, second and third adjacent channel interference cannot be considered the same as "blanketing."

CEMA Lab Tests

The CEMA tests are very thorough. In addition to conducting interference tests, CEMA performed receiver characterization and other tests according to IEEE standards and IEC

[13] Using the value of 60 dBu for the protected contour; if Class B and B1 stations were considered, the difference would be greater, 18 dB for Class B1 and 21 dB for Class B.

standards.[14] Procedures for the characterization tests are similar to the interference tests but are based upon somewhat different values for various parameters such as desired signal levels and acceptable S/N. Thus, results of the characterization tests may not be compared to measured interference ratios or the present ratios used in the FCC rules. However, the CEMA interference measurement procedure is very similar to that used by NAB. CEMA tested 16 receivers; essentially all types are included, however only one "walkman" and no clock/table radios were included. Thus, although low-cost receivers were tested, these very important classes were underrepresented in the CEMA tests.

In the NAB tests, the basic criterion for interference is a S/N of 50 dB; CEMA used a 45 dB criterion. However, the resulting ratio in the NAB tests was close to 45 dB or lower because generally most receivers in the NAB tests failed to achieve a ratio higher than 50 dB without interference. Desired signal levels of -50 dBm and -70 dBm are used by CEMA for the co-channel, first adjacent and second adjacent channel "45 dB target" tests. No third adjacent channel tests of this type were made. For third adjacent channel tests, CEMA apparently only performed the inverse test, that is, for a given D/U, S/N was measured. For these tests D/U from - 20 dB to -50 dB in increments of 10 dB were used. Thus, the third-adjacent channel CEMA tests may not be compared directly with the NAB test results although the CEMA test results show that the third adjacent channel interference case cannot be ignored.

[14] IEEE IHF-T-200 and IEC 315-1

A comparison between the results of second adjacent channel tests conducted by CEMA and NAB is shown in the following table. In this case, the average of the NAB data for desired signals levels of -45 dBm and -55 dBm is compared with the CEMA data for -50 dBm. The NAB -65 dBm data is compared with the CEMA -70 dBm data.

Measured Median Desired to Undesired Ratio (dB)

Desired Signal	-50 dBm	-65 dBm & -70 dBm
NAB	-20.4	-30.5
CEMA	-28.3	-33.5
Difference	7.9	3.0

For the -70 dBm desired signal strength, CEMA only reported test results for nine receivers. The median of data for these receivers is listed above. Although the NAB data indicates that receivers are more susceptible to second adjacent channel interference than the CEMA measurements, both sets of data indicate that receivers are poorer than the ratio used by the FCC for the commercial channel distance separations. The second adjacent channel separations are based upon a desired-to-undesired ratio of -40 dB. As noted above, in the CEMA tests receivers with integral antennas, such as clock radios, were underrepresented. It is likely that inclusion of additional such radios by CEMA would improve the agreement between the CEMA and NAB results.

In summary, a review of CEMA's report indicates that CEMA's measurement techniques are similar to those employed by NAB and CEMA's conclusions generally agree with NAB's.

Summary

The setups employed in all of the test programs (NAB, OET, CEMA and NLG) are generally similar. NAB's test procedures are based upon the ITU standard that is specifically designed for the purpose of testing the interference susceptibility of FM receivers. The CEMA procedure is similar to NAB's. OET, however, used distortion as the only criterion for interference and because of this the OET results are not useful. Distortion measurements are inferior to signal-to-noise ratio measurements employed by NAB and CEMA because subjective impairment correlates much better with the objective criterion of signal-to-noise than distortion.

Deficiencies in the OET and NLG tests enable them to conclude that the protection of FM service from third and even second adjacent channel interference is not necessary. This conclusion is primarily caused by choice of standards for interference assessment, not by the details of the test procedures. Although NLG used distortion as the primary criterion of interference, NLG also made signal to noise measurements. It has been shown that test results from CEMA and the NLG signal-to-noise data support NAB's conclusion that second and third channel interference from LPFM stations cannot be ignored. The OET tests contain no signal-to-noise data and cannot be used in such a comparison.

NLG has attempted to discount LPFM interference by comparing it to "blanketing." However, field strength for blanketing is much greater than that required for second and third adjacent channel interference based upon measured interference ratios. The reports, including the NLG report, do not provide the basis to support the blanketing contention.

The OET did not test any receivers with integral antennas, such as clock radios. Special time consuming tests on receivers with integral antennas are discussed in the OET report. In these tests, receivers are immersed in known desired and undesired fields. Although tests of this type may appear to be intuitively desirable, problems of control and repeatability are expected and may limit the value of the results. OET should also test with controlled desired power input to the receivers to permit comparison of the data with other data developed in this proceeding. Tests on these receivers should be made using standard signal-to-noise measurement procedures. OET should also retest receivers only subject to distortion tests using standard test signal-to-noise ratio measurement procedures.

In conclusion, the OET, CEMA and NLG test results, as well as the NAB results, do not support the hypothesis that receivers have improved over the years with regard to interference rejection performance. The OET tests are fundamentally flawed. The most valid NLG data and the CEMA data also support NAB's conclusions regarding interference from proposed LPFM stations. These tests do not uphold the contention that third and even second adjacent channel interference from LPFM stations can be ignored.

AFFIDAVIT

COUNTY OF ARLINGTON	)	
	) SS:	
COMMONWEALTH OF VIRGINIA	)	

JOSEPH W. STIELPER, being duly sworn upon oath deposes and says:

That he is employed as a Senior Engineer by the firm of JMS Worldwide, Inc. d/b/a MLJ consulting telecommunications engineers;

That this firm has been retained by the National Association of Broadcasters to prepare this engineering statement;

That he has either prepared or directly supervised the preparation of all technical information contained in this engineering statement; and that the facts stated in this engineering statement are true of his knowledge, except as to such statements as are herein stated to be on information and belief, and as to such statements he believes them to be true.

Joseph W. Stielper

Subscribed and sworn to before me this 15th day of September, 1999

Jacqueline Marie Richardson

Jacqueline Marie Richardson, Notary Public

My commission expires October 31, 2001.

AFFIDAVIT

COUNTY OF ARLINGTON)
) SS:
COMMONWEALTH OF VIRGINIA)

JOHN C. KEAN, being duly sworn upon oath deposes and says:

That he is employed as a Director of Engineering by the firm of JMS Worldwide, Inc. d/b/a MLJ consulting telecommunications engineers;

That this firm has been retained by the National Association of Broadcasters to prepare this engineering statement;

That he has either prepared or directly supervised the preparation of all technical information contained in this engineering statement; and that the facts stated in this engineering statement are true of his knowledge, except as to such statements as are herein stated to be on information and belief, and as to such statements he believes them to be true.

John C. Kean

John C. Kean

Subscribed and sworn to before me this 15th day of September, 1999

Jacqueline Marie Richardson

Jacqueline Marie Richardson, Notary Public

My commission expires October 31, 2001.