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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	MM Docket No. 99-25
Creation of a Low	)	
Power Radio Service	)	RM-9208
	)	RM-9242

DOCKET FILE COPY ORIGINAL

REPLY COMMENTS OF

UNITED CHURCH OF CHRIST, OFFICE OF COMMUNICATION, INC.;

NATIONAL COUNCIL OF THE CHURCHES OF CHRIST, COMMUNICATION COMMISSION;

GENERAL BOARD OF GLOBAL MINISTRIES OF THE UNITED METHODIST CHURCH;

DEPARTMENT FOR COMMUNICATION OF THE EVANGELICAL LUTHERAN CHURCH IN AMERICA;

CIVIL RIGHTS FORUM;

LIBRARIES FOR THE FUTURE;

BLACK CITIZENS FOR A FAIR MEDIA;

AND

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Appendix: Report of Dr. Theodore Rappaport

Attachment: Diskette containing open source code

Note: This document, as well as the complete appendix and open source code are available online at: *www.mediaaccess.org/filings.*

Summary

UCC *et al.* demonstrate in these reply comments that opponents of the proposed Low Power FM (LPFM) service have employed questionable methodology in their self-serving efforts to prove low power radio is technically infeasible. To make the technical case in support of LPFM, UCC *et al.* hired a nationally-prominent wireless communications professor, Dr. Theodore Rappaport of Virginia Tech, to undertake a rigorous review of the technical documents submitted to the Commission by LPFM opponents.

This unbiased, detailed technical analysis demonstrates the fundamental soundness of the Commission's LPFM proposal. Stations with 100 watts or less will produce virtually no interference. Thus, neither second nor third adjacent protection is needed to authorize these stations. UCC *et al.* agree that, if one thousand watt stations are added, they should retain both second and third adjacent protection. By modifying the FCC's propagation software, Dr. Rappaport and his staff performed extensive computer modeling that picks up where the Commission's analysis left off -- it demonstrates the feasibility of 10 watt and 1 watt stations that the Commission's analysis did not explore. This computer model demonstrates that, even in the most congested urban markets -- excluding New York City -- there is room for at least a few 1 or 10 watt stations.

On average, a 100 watt LPFM station will serve 186,512 people, while, at most, it will interfere with 2,912 people. That means, ***at most, just under 1.6 percent of those served might experience interference.*** Moreover, ***between 64 and 680 times*** as many people gain access to LPFM broadcasts as may rarely experience interference from LPFM. Even for the few listeners who initially experience some interference, the solution to this interference could be as simple as ***repositioning their radios by a few feet.***

Dr. Rappaport explains that, to date, broadcasters have tried to frame the debate around the wrong question. The appropriate question is not whether receiver technology meets or exceeds the FCC protection ratios. Rather, the proper question is whether the technical standards the Commission has heretofore used to predict interference between radio stations reflect the realities of the radio listening environment. All the receiver studies clearly demonstrate that the Commission's standards do not. Despite studies by LPFM opponents purporting to show that radios do not perform well, consumers are satisfied with the radios that supposedly did not perform well in the tests. This satisfaction demonstrates the irrelevance of the FCC broadcast station spacing rules to radio receiver performance. Consumers will benefit and not suffer with the addition of new low power radio stations.

UCC *et al.* demonstrate that fears that low power radio will harm services such as reading for the blind are not supported. UCC *et al.* believe that the protections proposed by Dr. Rappaport will be sufficient. If they are not, additional regulatory protection could be extended to protect these important services.

Low power radio opponents, the National Association of Broadcasters ("NAB") and the Consumer Electronics Manufacturers Association ("CEMA")/National Public Radio ("NPR") /Corporation for Public Broadcasting ("CPB"), submitted studies containing significant errors. For example, the NAB tested radios that were doomed to fail -- they selected radios that did not meet their own performance standards ***in the absence*** of interference by low power radio stations. The NAB study assumes that the signals most people consider acceptable today are in fact suffering from unacceptable interference.

Five significant errors in NAB's mapping study provide "evidence the NAB's attempt to

portray potential interference from LPFM as much worse than it would look in an objective analysis." Rappaport Report at 48. The NAB Mapping Study is fraught with flaws. The study significantly overestimated the number of people who will receive interference by double, triple and quadruple counting individual listeners. The maps are based on the worst receiver results. The study overrepresented interference by completely excluding car radios, the best-performing radios. The NAB invented a fictional "worst radio" to produce maps for a radio that does not exist. The NAB failed to provide enough underlying technical information to allow an objective review of its results, and did not provide a map of current levels of interference that would act as a control and would allow comparison between projected LPFM interference and current levels.

LPFM will not jeopardize the future in-band on-channel, digital radio service ("IBOC DAB"). Digital radio has been designed to perform in the current radio environment. LPFM will not significantly change that environment, and therefore will have an insignificant impact on digital broadcasting. USADR expresses no concern about relaxation of third adjacent protection and it concerns regarding second adjacent protection are based on interference that will occur in areas ***outside*** full power stations' protected contours. The FCC would not protect these areas from full power broadcasters; they cannot hold low power broadcasters to a different standard. Additionally, because IBOC transmits redundant information in both the upper and lower sidebands of the FM channel, IBOC would only fail if a station receives ***simultaneous interference on both the upper and lower first adjacent channels,*** which is highly unlikely given stations of 100 watts or fewer.

NAB accompanies its self-serving and misleading engineering study with self-serving and misleading legal analysis. NAB's argument that media consolidation is not a danger is laughable. UCC *et al.*'s statistics and the FCC's recent conclusions show that radio stations are now, more than

ever, owned in large blocks by a few extremely large corporations. The National Telecommunications and Information Administration ("NTIA") and the Commission have repeatedly found that new entrants -- especially women and minorities -- find it difficult to break into the broadcasting business. NAB's additional argument that one large corporation providing several look-alike radio formats provides an adequate substitute for many separately-owned stations competing for listeners and providing diverse sources of public affairs information ignores basic Commission policy and precedent.

Arguments that previous FCC decisions preclude adoption of a low power radio service also fail. The commenters advancing these arguments quote FCC decisions out of context. In no case has the FCC ever determined that a low power radio service is not in the public interest. The FCC's previous decision to eliminate 10 watt stations was aimed at the radio station spacing allocations in 1978. Radio has undergone revolutionary changes since that time. Opponents to LPFM grossly mischaracterize previous Commission decisions.

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Introduction

UCC *et al.* demonstrate in these reply comments that opponents of the proposed Low Power FM (LPFM) service have employed questionable methodology in their self-serving efforts to prove low power radio is technically infeasible. To make the technical case, UCC *et al.* hired a nationally-prominent wireless communications professor, Dr. Theodore Rappaport of Virginia Tech, to undertake a rigorous review of the technical documents submitted to the Commission by LPFM opponents. The results of this technical study are described in Section I and, with respect to digital terrestrial radio, Section II of these comments. Dr. Rappaport's analysis (hereinafter "Report") is attached as an appendix to these reply comments.

UCC *et al.* focus on several other substantive issues. UCC *et al.* refute broadcasters' contentions that radio is currently sufficiently diverse. In addition, UCC *et al.* show that the Commission's proposed ownership limits are compatible with the Communications Act and are fully warranted. To avoid duplication, UCC *et al.* do not address arguments addressed by other reply comments. UCC *et al.* endorse the reply comments of the Civil Rights Organizations to the extent that they have demonstrated that low power should not be rejected as detrimental to either the commercial or non-commercial service. UCC *et al.* also endorse the analysis of the National

Lawyers Guild and Committee on Democratic Communications ("NLG-CDC") reply comments regarding the appropriate treatment of translators, which largely incorporate the analysis presented in the National Federation of Community Broadcasters' ("NFCB") comments.

Finally, UCC *et al.* note that UCC *et al.* do not represent all of the grass roots religious organizations who have expressed their support of low power radio. The American Friends Service Committee and several individual members of the Presbyterian Church, for example, have also expressed their support. *See, e.g.,* American Friends Service Committee Comments (filed Aug. 2, 1999); Comments of Mr. and Mrs. Ralph H. Smith, Mendon Presbyterian Church (filed July 6, 1999). In addition, the United States Catholic Conference supports the UCC *et al.* comments. *See* United Catholic Conference Reply Comments (filed Sept. 17, 1999).

I. Low Power Radio is Technically Feasible.

Unbiased, detailed technical analysis demonstrates the technical feasibility of low power FM radio ("LPFM"). The technical analysis attached to these reply comments demonstrates that stations with 100 or fewer watts will produce virtually no noticeable interference. Thus, neither second nor third adjacent protection is needed to authorize these stations. One thousand watt stations can be added with no change in interference protections.

Moreover, smaller wattage stations allow far more stations to be authorized. Dr. Rappaport and his staff performed extensive computer modeling that picks up where the Commission's analysis left off -- it demonstrates the feasibility of 10 watt and 1 watt stations that were omitted from the Commission's analysis. This computer modeling demonstrates that, even in the most congested urban markets -- excluding New York City -- there is room for at least a few 1 or 10 watt stations.

As UCC *et al.* demonstrate below, on average, a 100 watt LPFM station will serve 186,512

people, while the most listeners with whom it could interfere is 2,912. That means, ***at most, just under 1.6 percent of those served might experience interference,*** and then only when they seek to listen to the one or two stations directly adjacent to the low power station. Moreover, ***between 64 and 680 times*** as many people gain access to LPFM broadcasts as may rarely experience interference from LPFM. Even for the few listeners who initially experience some interference, the solution to this interference could be as simple as ***moving their radios a few feet.*** The Commission should not deprive thousands of listeners a greater diversity of programming because some listeners will have to move their clock radios or boom boxes across the room.

Dr. Rappaport explains that, to date, the focus of the technical debate has been misplaced. The appropriate question is not whether radios meet or exceed the performance assumed by the FCC protection ratios. The submitted receiver studies show that consumers do not notice the interference when the FCC's standards assume they would. The FCC criteria are irrelevant to consumer perceptions of interference. In addition, the receiver studies did not address the improvements in radio technology that are not incorporated into the FCC's protection standards. None of the receiver studies compared older radios with newer radios.

Consumers are satisfied with the radios tested in the submitted studies. Thus, the premise of NAB's and CEMA's radio receiver studies is incorrect: the fact that consumers purchase and use the radios available in the marketplace shows that the FCC's regulations are irrelevant to consumer perception of interference.

The great radio listener rebellion predicted by the NAB will not occur. Most listeners will not notice a slight increase in interference.

Dr. Rappaport concludes that "holding the performance of modern FM receivers to the FCC

protection ratio standard completely misrepresents the purpose of the FCC interference protection ratios and could be an attempt to deceive the public about FM reception conditions." Report at 43. Dr. Rappaport concludes that the FM interference environment is "much more forgiving than the FCC ratios would indicate." Report at 44.

A. LPFM Stations of 100 Watts Or Fewer Will Produce Significant Benefits and Little Interference.

1. Stations of 100 Watts or Fewer Will Not Harm Current Broadcasts and Will Allow Authorization of More LPFM Stations.

One hundred watt stations produce a small signal, and thus, a small amount of interference. Consumer listening to the radio airwaves will barely notice the tiny amount of power of stations with 100 or fewer watts. Further, when the geographic scope of interference caused by a 100 watt station is compared with the significant number of listeners that such a station will serve, 100 watt stations clearly serve the public interest.

Dr. Rappaport concludes that 100 watt stations will produce so little interference that both second and third adjacent protection may be removed for those stations. One thousand watt stations, on the other hand, will require full second and third adjacent protection. Report at 19.

LPFM stations will not deprive listeners of service. The chance that any particular listener will actually notice the impact of a LPFM station depends on several highly unlikely events occurring at the same time:

- First, the listener must want to hear only one particular incumbent station of the many available.
- Second, the LPFM station must be near the coverage fringe of that incumbent station.
- Third, that incumbent station must transmit on a channel 2 or 3 channels above or below the LPFM station's assigned frequency.

- Fourth, the radio receiver must be a poor performing table radio such as a clock radio.
- ***Fifth, the listener must not be able to relocate his or her radio to improve reception.***

Report at 20-21. Rarely will all five contingent events occur. Moreover, even if they did, the interference can be overcome by relocating a portable radio. Relocating a portable radio is a commonly accepted method of avoiding interference to most consumers, and could, at most, be considered an inconvenience. It is certainly not a deprivation of service.

Low power radio stations' service areas will far exceed the areas that experience interference. As calculated by Dr. Rappaport, LP 100 stations will produce a serving area of 38.5 square miles, but an interference area of only .6 square miles, no larger than a few square blocks. One and ten watt stations produce similar numbers.[1] The listeners who experience some interference may be able to avoid that interference by ***repositioning their radios.*** Report at 20-21. The Commission should not deprive American listeners a greater diversity of programming because some listeners will have to move their clock radios or boom boxes a few feet.

Dr. Rappaport concludes that 1000 watt stations should retain both second and third adjacent protection. Report at 58. No change to the FCC's protection ratios is needed to authorize 1000 watt stations with full protection, and thus no technological reason bars their adoption.

As Ohio State admits, the question is not whether ***some*** interference will occur, the question is whether the amount of additional interference is unacceptable. *See* Ohio State comments at 1-2.

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[1] One watt stations serve 4 square miles and have an interference area of .01 square miles; 10 watt stations serve 12.1 square miles and have an interference area of .06 square miles. Report at 20, table 1.

Relatively speaking, the level of interference caused by 100 watt and lower LPFM stations is well below the amount of interference currently considered acceptable by the Commission for full power stations.

This point bears emphasis. Some measure of interference is acceptable. The Commission's task is to balance the disadvantages of interference with the benefits of a new service.

For example, incumbent full power stations are allowed to cause blanketing interference. Blanketing interference eliminates reception of ***any*** station on ***any*** channel for affected listeners. Report at 21. Whereas the blanketing interference of full power stations ranges between 1.1 and 18.9 square miles, the adjacent interference of LPFM stations -- which limits reception of only stations transmitting on nearby frequencies -- ranges between only .01 and .6 square miles. Report at 20, 22; Tables 1 and 2. The Commission has concluded that such interference is acceptable despite the interference generated.

Finally, authorizing smaller wattage stations will also allow more stations to be added. By modifying the Commission's computer program, Dr. Rappaport is able to show the benefits of authorizing smaller wattage stations than calculated by the Commission in Appendix D of the *NPRM*. For example, while no LPFM stations could be placed in San Francisco if the Commission limits its authorization to 100 watt stations, five 1 or 10 watt stations are available. Report at 62, table 13. All assumptions, data outputs and alterations to the Commission computer program are fully detailed in the report.[2]

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[2] The color maps are included in Appendix A of the Report. A summary version of this data, including the number of stations produced with no second and third adjacent protection for 100 watt and 10 watt stations and full protection for 1000 stations is presented in Appendix B. The full data output is presented in Appendices C and D. The computer model developed by Dr. Rappaport has been provided on diskette to the FCC with this filing, and is available to members

2. Quantitative Analysis Shows Listeners Served Drastically Outnumbers Listeners Inconvenienced.

Dr. Rappaport performed extensive analysis to estimate the number of listeners who would be served by a new LPFM service. First, Dr. Rappaport provides an estimate of the average number of listeners served by a typical LPFM station. Report at 23-24. Second, through an extensive computer modeling effort -- which included making modifications to the Commission's contour-prediction software -- Dr. Rappaport and his staff estimated the number of channels, possible locations, and interference and coverage contour radii for LPFM transmitters at 3 power levels in the 60 markets studied by the Commission. Report at 55. Dr. Rappaport and his staff also developed representative maps of 10 cities illustrating this data. Report at Appendix A.

On average, a 100 watt LPFM station will serve 186,512 people, while the most listeners with whom it could interfere is 2,912. Report at 24, Table 3. That means, ***at most, just under 1.6 percent of those served might experience interference.***[3] *Id.* Even that 1.6 percent will likely be able to ***avoid interference by relocating their radio receivers***. *See infra* and Report at 23. For 1 and 10 watt stations, the numbers of listeners experiencing interference are even lower. For 1 watt stations, .24 percent of the 19,536 listeners served will experience interference and for 10 watt stations, .49 percent of the 58,423 listeners will experience interference. Report at 24, Table 3. As described below, ***these interference numbers overestimate the number of listeners that might***

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of the public -- along with electronic versions of all data outputs -- at www.mediaaccess.org/filings. Appendix E of the Report includes user instructions for the modified computer program.

[3] These are average calculations. These numbers could vary based on the specific topography and population of a city, and the height of the transmitting antenna. If most LPFM stations use an antenna of less than 30 meters height above average terrain (HAAT), as is likely, these numbers overestimate the number of listeners experiencing interference. *See* Report at 22-24.

experience interference. *See infra* at 13-14. Dr. Rappaport concludes, "the actual percentage of the population experiencing any kind of trouble would be significantly less than 1.6%." Report at 57.

As described in detail in Section 6 of the Report, by using a modified version of the Commission's computer model, Dr. Rappaport estimates that "***between 64 and 680 times*** as many people gain access to LPFM broadcasts as may rarely experience interference from LPFM." Report at 57 (emphasis added). Dr. Rappaport arrives at this conclusion by utilizing the concept of "citizen-channels" which measures the ability of one person to receive a single LPFM station. Report at 56.[4] Thus, Dr. Rappaport can estimate the ratio of served listeners to listeners who will experience interference.

This detailed analysis demonstrates that for 100 watt stations only 1.5 percent of listeners served may experience interference -- this means LPFM will serve 64 times more listeners than it will potentially inconvenience. For 10 watt stations the service to interference ratio is 200, and for 1 watt stations the ratio is 680. Report at 57.

3. The Industry's Arguments Against 1000 Watt Stations Do Not Apply to the Whole LPFM Service.

The broadcast industry opposes LPFM using criticisms applicable only to 1000 watt stations authorized without adjacent channel protection. As discussed above, UCC *et al.* do not recommend relaxation of interference protections to accommodate 1000 watt stations. Thus, UCC *et al.* are in

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[4] Citizen channels produce an accurate estimate of the ratio of served citizens to citizens who will experience some interference but does not present an accurate picture of the total population served. Citizen-channels have this characteristic because, in some locations, there is room for more than one LPFM station. Citizen-channels multiply the total number of new channels available by the number of citizens served by those channels. Citizen channels are presented in Appendix B. *See* Report at 56-57.

agreement with the more reasonable oppositions to widespread deployment of 1000 watt stations. No party has argued that 1000 watt stations cannot be authorized with full protection. Those stations should be considered in rural areas where a larger service area may be necessary.

For many commenters, concerns about interference produced by LPFM stations stop with 1000 watt stations. When these commenters discuss 100 watt stations, they begin to criticize 100 watt stations because they may ***receive*** interference. *See, e.g.,* NAB comments at 20; Disney comments at 8. Potential low power broadcasters are willing to accept some interference in order to obtain a lawful radio license. The possibility that full power stations will interfere with LPFM stations causes no burden on incumbent broadcasters. These arguments, therefore, must be disregarded.

The weight of the record supports the lower wattage stations. *See, e.g.,* NLG-CDC comments at §§ VI-VII. Supporters favor these stations over others, *see, e.g.,* Prometheus comments at 5, and the opposition of some commenters ceases with respect to low wattage stations. *See* Radio One comments at 11-12.

B. The FCC's Protection Standards are Over-Cautious and Leave Ample Room for Low Power Stations.

The NAB and CEMA have demonstrated an irrelevant fact: many popular radio receivers do not match the performance criteria assumed by the FCC standards. The FCC criteria are irrelevant to consumer perceptions of interference. The studies show that consumers do not notice the interference when the FCC's standards assume they would.

In addition, the receiver studies did not address the improvements in radio technology that are not incorporated into the FCC's protection standards. The FCC criteria are based on the lower-level performance of older radios.

1. Consumer Satisfaction is Not Measured by FCC Protection Ratios.

The "FCC interference protection levels . . . have very little to do with the actual interference protection needed for today's household FM receivers." Report at 13. As Dr. Rappaport explains, the fact that the receivers did not perform even as well as the Commission's existing standards assume ***supports adoption of LPFM.*** Report at 11. These results show that consumers are satisfied with levels of interference not contemplated by the FCC ratios. Thus, "an enormous amount of excess (i.e. wasted) interference protection and untapped spectrum utilization is free available to all modern FM receivers." Report at 11.

Consumers have demonstrated the type of radios they prefer through their purchases in the marketplace. The FCC criteria are irrelevant to those market-driven decisions. In response to market pressures, manufacturers have adjusted the performance of receivers to match consumers' price expectations. Manufacturers have discovered most consumers would prefer a less expensive radio that does not possess extraordinary interference protection.

Contrary to the assumptions of the NAB and CEMA studies, consumers do not compare the performance of their radios with a hypothetical performance of a higher quality radio embodied in the FCC standards.[5] Dr. Rappaport concludes, "consumers appear to be pleased with FM radios that have much less protection immunity than the FCC protection guidelines, and the small additional interference from LPFM can be tolerated without noticeable differences." Report at 14. The level of performance consumers expect from their radios will not change because the FCC changes its

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[5] For example, complaints to the Commission's Mass Media Bureau and the Commission's national toll-free telephone hot-line number only a little over two thousand each year. Telephone conversation between Cheryl A. Leanza and, respectively, Roy Stewart, Mass Media Bureau and Roy Kolly, Compliance and Information Bureau (Sept. 7-9, 1999).

standards -- manufacturers have already ignored these standards in meeting consumer demands.

As demonstrated above, consumers who are pleased with their radio performance now will not notice the tiny amount of additional interference added by LPFM stations of 100 watts or fewer. Because one hundred watt stations produce very little additional energy, they will cause unnoticeable interference to consumers who accept the performance of radios available in the market today.

The FCC guidelines perform their function well, but that function is not a gauge of consumer perceptions of interference. Dr. Rappaport concludes that, "[h]olding the performance of modern FM receivers to the FCC protection ratio standard completely misrepresents the purpose of the FCC interference protection ratios, and ***could to be an attempt to deceive the public about FM reception conditions.***" Report at 43 (emphasis added).[6]

2. Radio Receiver Technology Has Improved in Recent Years For All Classes of Radios.

The FCC ratios were adopted at a time when radios did not perform as well as they do now. The FCC ratios were designed to "provid[e] acceptable reception by early generations of FM radios with discrete RF components and AFC tuning. Today's FM receivers drift less, have more reproducible electrical characteristics, and better detection capabilities." Report at 10. Today's radios have "more effective FR front end filtering and phase lock loop (PLL) tuning mechanisms." Report at 11. The receiver studies did not attempt to show that radio receiver technology hasn't improved. They did not compare older radios against newer radios. In addition, none of the studies measured drift or adjacent channel capture, because these technological issues are no longer

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[6] As explained further below, *see* Section I.D.3, fifty-four percent of the NAB's sample radios did not meet its standard of quality ***in the absence of any interference.***

relevant.

The FCC was wise to originally adopt rough rules of thumb that conservatively spaced stations, particularly given the receiver technology of the time. Nevertheless, these standards might be too conservative even without improvements in receiver technology. But advances in receiver technology remove any doubt that the FCC's standards are too strict. The FCC may relax its protection standards for second and third adjacent channels.

C. Reading for the Blind Services Will Not Be Harmed.

Several commenters fear that Reading for the Blind services will be harmed by LPFM. *See, e.g.,* NAB comments at 58-59. UCC *et al.* are committed to retaining protection for these important services. At this time, however, no evidence has been submitted that interference with these services will occur.

Nothing in the CEMA or NAB studies covers reading for the blind services. In addition, there appears to be no technical basis to distinguish between subcarrier services for niche audiences such as reading for the blind and particular linguistic groups and the services provided commercially. Yet, commercial broadcasters express no concern about interference with their own revenue-generating subcarrier services. Dr. Rappaport concludes that, to avoid interference with subcarrier transmissions (known as SCA services) such as broadcasts for the blind, "LPFM stations should obey co-channel and first adjacent interference guidelines of 20 dB D/U and 6 dB D/U respectively, just as current FM stations are required to do." Report at 17 (footnote omitted). Moreover, Dr. Rappaport concludes that there is "no reason to expect adjacent channel bleedover except for blanketing conditions." Report at 16. According to the record, most radio station transmitters perform substantially better than FCC emission mask regulations require. *See* AFCCE

comments at 11; Report at 15-16. Dr. Rappaport concludes that transmitter certifications, as proposed by the Commission, will "ensure spectral protection to adjacent channel subcarrier transmissions for the blind" in addition to other adjacent services. Report at 16.

UCC *et al.* believe that, if the proposed protections can be shown to be insufficient to protect reading for the blind, other options are fully available. For example, the Commission could grandfather additional protection around these stations, or simply refuse to authorize LPFM stations that would cause them harm.

In short, LPFM does not pose a general threat to SCA services that would warrant withholding this service from the public. Individual problems may be dealt with on a case-specific basis.

D. The NAB Study and the CEMA/NPR Study Make Several Significant Technical Errors.

Dr. Rappaport undertook an extensive review of the two studies submitted by the NAB, a radio receiver study included in Volume 2 of its comments ("NAB Receiver Study") and a mapping study included in Volume 3 of its comments ("NAB Mapping Study"), and the radio receiver study submitted by Consumer Electronics Manufacturers Association, National Public Radio, and the Corporation for Public Broadcasting ("CEMA Study").

Dr. Rappaport concludes that the NAB and CEMA studies were "conducted inappropriately and presented with unfair bias against LPFM." Report at 25.

By choosing an unrepresentative sample, NAB and CEMA over-emphasized the poor performance of some types of radios. Neither study reflects CEMA's own data with respect to the type of radios actually in use today. Thus, their results do not represent an accurate picture of radio performance in the United States.

The NAB Mapping Study is fraught with flaws. The study significantly overestimated the number of people who will receive interference by double, triple and quadruple counting individual listeners. The maps are based on the worst receiver results. The study overrepresented interference by completely excluding car radios, the best-performing radios. The NAB invented a fictional "worst radio" to produce maps for a radio that does not exist. The NAB failed to provide enough underlying technical information to allow an objective review of its results, and did not provide a map of current levels of interference that would act as a control and would allow comparison between projected LPFM interference and current levels.

The NAB Receiver Study used an audio quality benchmark that most radios do not meet and most listeners do not need. The NAB study assumed that acceptable broadcast transmissions would meet at 50 dB signal to noise (S/N) ratio which "is an extraordinarily high standard for sound quality from FM broadcasts." ***Fifty-four percent*** of the radios the NAB chose to test in its study ***did not meet this standard*** of quality ***in the absence*** of any interference.

1. The Radios Tested Do Not Reflect the True Universe of Radios.

Both the NAB and CEMA studies made several errors with respect to the selection of their test radios. An accurate study should reflect the universe of radios actually used by consumers today.[7] The errors in NAB's and CEMA's sample skew the results of the study by over-representing the worst performing radios, thus presenting a picture of radios that perform worse than they actually do.

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[7] Because it is not feasible to test every radio in use today, a sample must be chosen to represent the underlying population. However, representative sampling is necessary to produce valid technical results. "If a sample is not representative, no conclusion can be drawn about the underlying population." Report at 26-27.

Neither study reflects CEMA's own data with respect to the number of radios in use today. Report at 26-32. For example, while CEMA's sales data states that 16.8 % of all radios in use today are table radios (such as clock radios), ***none*** of their sample radios were table radios. Report at 28; CEMA Study at Appendix R. Similarly, CEMA over-sampled component radios -- 43.8 percent of their sample included component radios, while only 15.4 percent of radios in use today are component radios. Report at 28, Table 4. Although the NAB's sample more closely matches the number of receivers in use, it also did not reflect the radios in use today. Report at 29-30. Twenty-four percent of its sample was comprised of the lowest-performing "personal" radios, such as walkman radios. Report at 30, Table 5. The simple application of weighting factors -- designed to correct any error in a small sample -- would have been "proper and more objective" Report at 30; *id.* at 31, Table 7.

By choosing an unrepresentative sample, NAB and CEMA over-emphasized the poor performance of some types of radios. Report at 30. Thus, their results do not represent an accurate picture of radio performance in the United States today.

2. The NAB Mapping Study Suffers From Severe Flaws.

Dr. Rappaport's analysis concludes that five significant errors in NAB's mapping study provide "evidence the NAB's attempt to portray potential interference from LPFM as much worse than it would look in an objective analysis." Report at 48. In addition, Dr. Rappaport concludes that the NAB incorrectly excludes car receivers from its maps. Report at 32-33.

a. The NAB Mapping Study Drastically and Fraudulently Overestimates the Number of Listeners that Will Experience Interference by LPFM Stations.

The NAB bases its conclusions on the number of listeners that will lose service on grievously

flawed assumptions. Any one of these erroneous assumptions would seriously undermine the results of the study. Together, they demonstrate a blatant attempt to present inaccurate and misleading data to the Commission. NAB, thus, counts certain portions of the population four, three and two times. Report at 51. As UCC *et al.* demonstrate above, in reality very few listeners will experience interference.

Instead of measuring the number of *listeners* that will experience interference, the NAB measures the number of *radios* experiencing interference. Report at 50. Moreover, they assume, without basis, that every listener has four types of radios and that each listener listens to all four radios simultaneously. The NAB erroneously assumes that each listener knows which radio stations she should be able to receive under the FCC's criteria.[8] Thus, the NAB concludes that any listener who does not receive a station the FCC believes she can receive has lost service or experienced interference. *Id.*

Finally, the NAB assumes that a listener who does not receive a signal at 50 dB S/N will consider a signal to be unacceptable. As discussed above, most radios in use today do not receive signals of that quality. Thus the NAB study assumes that the signals most people consider acceptable today are in fact suffering from unacceptable interference when it calculates the number of listeners who will experience interference with the introduction of LPFM. Report at 50.

b. The NAB Provided Test Results Using a Fictional Radio.

The NAB study includes contour maps projecting interference using a fictional "worst radio." Report at 53, NAB comments, Volume 3, Appendix B. The NAB deliberately ***imagines*** a radio that would perform worse than any real world radio, and then produces wholly speculative maps

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[8] As demonstrated above, most radios are not as sensitive as the FCC criteria anticipate.

imagining where interference could be found. As demonstrated above, the NAB is already skewed to include radios that are worse than the typical radio in use today. Dr. Rappaport characterizes the methodology of using a "worst radio" after using an unrepresentative sample of radios as "extraordinary." Report at 53. Dr. Rappaport concludes that the NAB's intention in combining this methodology with the decision to exclude car radios, *see infra* section D.1.b, is to "exaggerate potential LPFM interference beyond any levels indicated by realistic assumptions." Report at 54.

c. The NAB Maps Results of the Worst of the Three Receiver Test Results Without Basis.

Although the NAB performs receiver tests at three different input signal levels, -45 dBm, -55 dBm and -65 dBm, it maps the results of the -45 dBm desired signal power. Report at 52-53. Because the signal power should be -55 dBm at the fringe of a FM station's protected coverage area, a correct selection would be -55 dBm. NAB provides no explanation of its decision, and Dr. Rappaport concludes "the -45 dBm results were used because they are the worst." Report at 53.

d. The NAB Mapping Study Completely Excludes Car Radios, Thus Invalidating its Results.

The NAB Mapping Study excludes consideration of car radios. These are, by far, the best performing radios and the ones used for the greatest proportion of radio listening. Report at 32-33. The NAB provides incorrect reasons for excluding car radios. Report at 32, NAB Mapping Study at 10. The NAB shockingly asserts that it did not include car radios because they perform better than FCC protection ratios would assume. Dr. Rappaport concludes that "eliminating [car radios] for good performance indicates a clear intent to slant the report toward a pre-decided conclusion." Report at 32-33. In addition, the NAB provides several rationales for excluding car radios that would apply to all radios, and thus are meaningless to distinguish between car radios and other

radios.[9]

e. The NAB Mapping Study Does Not Disclose the Underlying Methodology Used to Produce its Maps.

Dr. Rappaport explains that the NAB fails to disclose basic scientific assumptions necessary for a thorough review. The report does not disclose: its propagation model details; an explanation of how the affected population is calculated; details of any Geographic Information System (GIS) data used in the analysis; which protections are assumed in the placement of LPFM stations; and which of the nine scenarios run by the FCC are used to discover how many LPFM stations might be placed in major cities. Report at 51-52.

Ordinarily, a technical report of this type includes enough information about the methods and formulae to allow other researchers to reproduce the work independently. Report at 52. Out of concern with respect to this issue, UCC *et al.* solicited agreement among several parties who indicated publicly they would be preparing studies that such protocol would be followed.[10]

The NAB mapping study does not include the information necessary to allow for a critical third-party review of their analysis. Dr. Rappaport says that:

> Omitting this information invites doubt as to the actual source of the results: calculations and scientific analysis, or wishful thinking. It also limits the utility of the work for further research . . . . * * * * For example, there are many propagation models that estimate the signal power of a radio wave. Some are more accurate at FM frequencies than others. Since they are not detailed, we cannot assess the accuracy of the interference predictions on the NAB's maps.

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[9] The NAB states that the interference for car radios would be contained within the interference of other types of radios, but all radios' reception overlap each other. The NAB also claims that it excluded car radios because it wanted to evaluate the Commission's current protection ratios -- this reason is without basis. See Report at 33.

[10] Letter from Andrew Jay Schwartzman, President and CEO, Media Access Project, to William Kennard, Chairman, Federal Communications Commission (filed July 15, 1999).

Report at 52. The Commission cannot accept as valid any scientific arguments that cannot be independently verified. The NAB Mapping Study must be completely disregarded.

f. The NAB Does Not Provide a Comparative Map of Current Interference.

The NAB produces maps showing potential interference after the introduction of LPFM, but does not produce a map showing current levels of interference. As Dr. Rappaport states, this omission "implies that no FM interference exists now, which is impossible." Report at 54. An objective analysis would provide both before and after data to serve as an experimental control and baseline reference for evaluating new interference. Report at 54. Current FM receivers "see" plenty of interference in the current environment without LPFM. Report at 54-55. Dr. Rappaport concludes that these comparative maps are excluded because they "would have weakened the NAB's contention that LPFM stations will cause more interference than FM listeners have yet been exposed to." Report at 54.

3. NAB and CEMA Incorrectly Pre-Select Benchmarks for Evaluating Audio Quality.

The NAB uses an audio quality benchmark that most radios do not meet and most listeners do not need.[11] The NAB study assumes that acceptable broadcast transmissions should meet at 50 dB signal to noise (S/N) ratio. This means that the acoustic power of the desired program must be greater than the undesired noise by a factor of 100,000 in order for reception to be considered acceptable. As Dr. Rappaport concludes, "this is an extraordinarily high standard for sound quality

[11] Two quantitative measurements of audio quality are used: signal to noise ratio (S/N or SNR) and/or distortion. To compare one radio with the next, a threshold or benchmark of audio quality is used and all receivers are "stressed" until the audio quality drops below the threshold. Report at 34.

from FM broadcasts." Report at 36. As partially explained above, 54 percent of the radios the NAB tests in its study did not meet this standard of quality ***in the absence of any interference.*** Report at 36-37.

Dr. Rappaport notes that, for radios that could not meet the 50 dB S/N standard, the NAB tests for a 5 dB decrease in S/N. This use of two different testing criteria indicates that the 50 dB S/N "had an importance to them outside its utility as a test benchmark," Report at 39, thus implying that the NAB is aware of the flaws in its standard but uses it nonetheless.

Dr. Rappaport concludes that choosing fixed thresholds without addressing the problems associated with this choice would be considered flawed in an academic setting and "the results from such tests would be disregarded." Report at 41.

CEMA's study shares the flaw of pre-selecting a quality threshold, although it adopts the slightly lower standard of 45 dB. In contrast with the NAB, it ensures that all tested radios meet that standard,[12] but in so doing, invalidates the representativeness of its sample. Report at 35, 38-39. *See also supra* at 11-12.

By comparison, both the Broadcast Signal Labs study submitted by NLG ("BSL Study") and by the Commission's Office of Engineering and Technology ("OET Study") avoid the flaws associated with selecting a fixed benchmark. BSL does not select a benchmark prior to conducting the test, but rather analyzes the results of the data, hoping to find a general D/U at which radios begin to fail rapidly. The OET Study tests for a 1 percent to 3 percent rise in distortion, starting at whatever distortion the radio could produce in perfect reception conditions. Report at 40.

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[12] Without explanation, neither NAB nor CEMA use the widely-accepted threshold of 40 dB S/N. Report at 39.

II. LPFM is Not Inconsistent with a Transition to Digital Radio.

A. Technical Analysis Demonstrates that Digital Radio Will Not Be Precluded by Adoption of LPFM.

Several commenters express concern that deployment of LPFM may interfere with the development of In-Band, On Channel Digital Audio Broadcasting ("IBOC DAB"). Specifically, these commenters worry that the potential loss of second adjacent channel interference may interfere with IBOC DAB transmission. *See, e.g.,* NAB comments at 47; Greater Media comments at 11-12; USADR comments at 6-7.

As Dr. Rappaport demonstrates, the deployment of LPFM and relaxation of second-adjacent channel protection will not harm the deployment of IBOC DAB. Report at 63. For this analysis Dr. Rappaport analyzed the engineering statement submitted by USADR study and the comments of Lucent Digital Radio.

Second adjacent protection for LPFM stations of 100 watts and lower is not necessary to protect IBOC DAB transmissions. Digital radio has been engineered to perform acceptably well in the current FM interference environment. LPFM will not significantly change that environment, and therefore will have an insignificant impact on digital broadcasting. *Id.*

Moreover, proponents' concerns about LPFM are significantly based on the cost of future hybrid digital-analog receivers. This cost-performance tradeoff is no different from the cost-performance tradeoff of any new category of radio receiver, and thus presents no novel reason to reject LPFM.

1. As with Current Analog Stations, Interference for Digital Radio Broadcasts from LPFM Stations with 100 Watts or Fewer is Not Noticeable.

The proposed LPFM service will not significantly alter the interference landscape. The

Commission has not proposed allowing placement of 100-watt stations without concern for interference. Although opponents of the service portray LPFM stations springing up like wild mushrooms and generating unpredictable interference, the Commission and UCC *et al.* have always proposed a service that would limit interference and make any necessary interference predictable.

As Dr. Rappaport explains:

> LPFM stations of 100 watts or less will not significantly change the interference level in any market if they are placed according to reasonable separation rules which take into account the co-channel and first adjacent channel neighbors, as well as the standard FM transmission spectrum mask rules.

Report at 69.

As discussed at length in Part I *supra*, LPFM will at worst create only limited interference in the immediate area around each station. This "is a minuscule interference source when compared to the current FM environment." Report at 68.

IBOC transmissions are currently formulated to be very robust. "IBOC transmits redundant information in upper and lower sidebands of the FM channel . . . . [i]f interference temporarily interrupts the data stream from the upper sideband, the program can be reconstructed from the lower sideband data stream and vice versa." Report at 71. "Sidebands are most threatened by first adjacent channel interference." *Id.* IBOC would only fail if a station received simultaneous interference on both the upper and lower first adjacent channels. *Id.*

Developers of digital radio, such as Lucent, have developed robust digital technologies designed to meet the interference concerns that already exist in the FM band. *See, e.g.,* Lucent Technologies comments at 6-7. Given the tiny impact on interference that low power stations would have, any technology designed to meet the needs of the FM band as it exists now will prove sufficient to handle any additional interference from LPFM stations.

2. USADR Expresses No Concern about Third Adjacent Protection and USADR's Concerns Relating to Second Adjacent Protection Occur Outside Stations' Protected Contours.

USADR comments do not mention third adjacent interference. This is because the digital filters already designed for DAB receivers reject third adjacent interference very well. *See* Report at 66.

USADR's engineering study expresses concern that relaxing second adjacent protection could disrupt IBOC DAB transmissions in areas ***outside*** a station's protected contour. Report at 70-71. The USADR study assumes the "real" service contour of incumbent FM stations is near the 44 dBu contour. But FCC rules protect the service contour of most stations only to 60 dBu, except commercial class B1 stations, which are protected to 54 dBu and commercial class B stations which are protected to 57 dBu. Report at 70. The Commission has already made determinations as to the contours that it will protect. A full power station that met other Commission criteria could not be rejected because it interfered with an incumbent's 44 dBu contour. It would be untenable to hold LPFM stations to a double standard.

3. Other Concerns Regarding Second Adjacent Protection May be Resolved by the Same Commercial Trade-Offs Between Receiver Performance and Retail Price that Currently Take Place in Today's Marketplace.

Dr. Rappaport's analysis carefully explains the various options available to digital radio manufacturers. Report at 66-68. Based on this analysis, he concludes that "[d]igital radio manufacturers will simply be able to repeat the pattern they established for analog FM radio manufacturing. That is, cheap radios will receive fewer DAB stations than more costly ones and the market will find the right balance of cost and quality in each receiver category." Report at 68.

For example, USADR appears concerned over the performance of digital car radios. Report

at 68. *See* USADR comments at 9. USADR does not account for the fact that most car radios today already perform to high specification levels and cost significantly more than other radios. Report at 68. Because car radios face a more challenging reception environment they must incorporate more expensive filtering and better-performing circuit designs, thus causing them to be more expensive than personal and portable radios. But "nothing will prevent manufacturers from making and selling high quality expensive car radios for IBOC DAB, just as they have for analog FM." Report at 68.

B. Adoption of a Final Digital Radio Technology May Take Considerable Time.

UCC *et al.*, at least at this stage, support the development of digital radio. UCC *et al.* object, however, to industry insistence that digital radio must be fully developed and adopted prior to adoption of LPFM. LPFM is ready now. The history of terrestrial digital radio demonstrates that it may not be ready for some time. UCC *et al.* emphasize that the advocates most insistent upon delaying LPFM for IBOC are the advocates that know the least about IBOC. Most of the IBOC proponents themselves have been relatively balanced in their reviews of LPFM's technical issues. Incumbent broadcasters use IBOC to disguise their concerns that they might be forced to complete with new and innovative broadcasters.

Nonetheless, digital radio may take some time to develop. Although proponents of digital radio have been working for almost ten years on developing a successful in-band, on-channel broadcast technology, they have not as yet produced a single, agreed-upon technical standard. Not only has the technology proven difficult to develop, but each competing company investing in research and development hopes that its own proprietary technology will become the single national standard. As the Commission saw with digital television, and in many other instances, competitive

angling between companies can delay the development of technical standards.

Digital radio has often suffered from testing disputes, delays, and decisions develop a new technological approach from scratch. Digital radio proponents have been working since 1990 to develop IBOC technology. Yet, in 1994, "following a series of technical mishaps," IBOC proponents "decided the only solution was to start over. They went for a 'total redesign' . . . ." John Merli, "Local Digital Radio Gets Closer to Reality," *Broadcasting & Cable* (Oct. 27, 1997). Later, in 1996, a series of field trials ended in disarray, when IBOC proponents would not agree to continue participating in technical tests sponsored by CEMA and NRSC. "Last IBOC Proponent Withdraws from DAB Tests," *Audio Week* (Sept. 23, 1996). Shortly thereafter, when "independent third parties . . . primarily acknowledg[ed] interference and multipath problems," USADR shifted strategies and personnel. "Back to the Drawing Board for USADR," *BE Radio* (Nov. 1, 1996).

In 1997, IBOC proponents tried again to conduct joint testing. Once again disagreements led to the withdrawal of USADR. *BE Radio*, News Summary (Sept. 30, 1997). In 1997 USADR and Lucent developed a joint venture to develop a single technology standard. Donna Petrozzello, "Radio Raves Over Digital Plan," *Broadcasting & Cable* (May 19, 1997). The broadcast industry, which prefers the development of a single standard, heartily endorsed this effort and hailed it as a major milestone. *Id.* But in 1998, Lucent again began its own independent effort, not based on USADR's technology. Grant Buckler, "Lucent Announces Digital Radio Venture," *Newsbytes* (May 11, 1998).

The most recent attempts to engage in joint testing have also come under dispute. In August 1999, Lucent began contesting the testing procedures adopted by the NRSC. Lucent favors common testing, whereas the current process envisions use of separate labs. Leslie Stimson, "Lucent Pushes

for Common Testing" *Radio World* at 1 (Aug. 4, 1999). As a result of this dispute, "president and Chief Executive Officer Suren Pai said LDR [Lucent] has not yet decided if it will submit lab and field test results to the NRSC by Dec. 15." *Id.* This dispute persists. The NRSC was unable to obtain a signed agreement from all the digital radio test participants before its meeting on October 7, 1999. Leslie Stimson, "NRSC Struggles With Test Pact," *Radio World* at 3 (Oct. 27, 1999). Lucent Digital Radio has stated that it considers the data to be submitted on December 15, 1999 to be "preliminary." *Id.*

In short, although digital radio technology may have improved since some of the prior tests, digital radio's future is by no means clearly charted. As one industry journal pointed out after the 1999 NAB trade show, none of the three industry leaders in IBOC "has yet accomplished what the government has called for: an in-band, on-channel (IBOC) transmission system that would allow DAB to operate atop the existing terrestrial radio." Chuck Taylor, "Industry Still Waiting for Progress on Digital Radio," *Broadcasting & Cable* (May 8, 1999).

Although digital radio is not necessarily around the corner, this is not to say that initiating a proceeding on IBOC is unwise or premature. The Commission must carefully separate the positions taken by the IBOC researchers themselves and the positions taken by broadcaster opponents of digital radio, many of whom display no knowledge regarding the technical requirements of IBOC. *See, e.g.,* Cumulus Media comments at 6-7. The Commission should separate advocates who favor ***initiating*** an IBOC proceeding from advocates who favor concluding an IBOC proceeding before even beginning to move forward on LPFM.

III. Adopting a Low Power FM Service Will Promote Diversity in a Manner Consistent with Congressional Intent.

The Commission should adopt a low power FM service to provide opportunities for