Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In re Petition for Rulemaking of	)	
	)	
USA Digital Radio Partners, L.P.	)	
	)	
for Amendment of Part 73 of the	)	RM-9395
Commission's Rules to Permit	)	
the Introduction of Digital Audio	)	
Broadcasting in the AM	)	
and FM Broadcast Services	)	

To: The Commission

COMMENTS OF THE CONSUMER ELECTRONICS MANUFACTURERS ASSOCIATION

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December 23, 1998

SUMMARY

The Consumer Electronics Manufacturers Association ("CEMA") supports efforts to implement terrestrial digital audio radio technology. CEMA believes that the introduction of digital audio radio technology is in the public interest. Already, alternatives to analog radio are becoming the preferred method of listening to music, and CEMA is optimistic that advances in digital audio radio technology might permit the creation of a terrestrial broadcast service to offer digital quality sound. The implementation of digital audio radio technology will provide improved radio broadcast services to consumers and will help promote the future viability of radio broadcasting in the United States.

While CEMA is studying the technical assertions of the performance of USA Digital Radio Partners' latest design of its in-band, on-channel ("IBOC") digital audio radio ("DAR") system, CEMA makes clear that it has no vested interest in any particular DAR technology. CEMA's objective in this proceeding is to provide information to the Commission that will be useful in evaluating not only the technical viability of IBOC DAR, but also other concepts that enhance terrestrial DAR services, which include exploring the availability of spectrum for these services. Fundamentally, the Commission must be assured that, whichever terrestrial DAR system is selected, the chosen system meets listeners' expectations and affords the public with the highest value and degree of services required to successfully compete with non-broadcast services.

CEMA urges the Commission to initiate a proceeding to deliberate how best to craft a DAR service that meets the needs and expectations of the American public. The purpose of the proceeding should be to promote a terrestrial DAR service with better than CD-quality, multi-channel capability with robust coverage and performance for mobile reception, and high ancillary data capacity. Such a service would have a clear appeal to the public and help usher

radio broadcasting into the digital age with long-term viability. CEMA notes, however, that past IBOC DAR system designs thus far have fallen short of such a goal. CEMA thus recommends conducting comprehensive technical assessments to weigh the performance of competing systems with emphasis on audio quality, compatibility with existing analog services, and digital coverage and performance – *i.e.*, those areas critical to a successful deployment of DAR.

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APPENDIX B: *Technical Evaluations of Digital Audio Radio Systems: Laboratory and Field Test Results; System Performance; Conclusions*, Final Report (December 1997)

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for Amendment of Part 73 of the Commission's Rules to Permit the Introduction of Digital Audio Broadcasting in the AM and FM Broadcast Services	)	RM-9395

To: The Commission

COMMENTS OF THE CONSUMER ELECTRONICS MANUFACTURERS ASSOCIATION

The Consumer Electronics Manufacturers Association ("CEMA") hereby respectfully submits its comments in response to the Commission's Public Notice in DA 98-2244, issued on November 6, 1998, regarding the above-captioned Petition for Rulemaking ("Petition") filed by USA Digital Radio Partners ("USADR").[1]

In its Petition, USADR requests that the Commission initiate a rulemaking proceeding to amend Part 73 of the Commission's Rules to permit the introduction of terrestrial audio radio ("DAR") in the AM and FM radio bands. Specifically, USADR seeks modification of the Commission's Rules to permit existing AM and FM licensees to upgrade their analog broadcast transmission to digital, using in-band, on-channel ("IBOC") DAR technology. According to USADR, IBOC technology provides a means for introducing DAR without the

[1] *See generally* Petition for Rulemaking of USA Digital Radio Partners, L.P. (filed Oct. 7, 1998) ("USADR Petition").

need for new spectrum allocations for the digital signal.[2] USADR asserts that it has used IBOC technology to create a hybrid mode which will allow each AM and FM station to simultaneously broadcast the same programming in analog and digital.[3] USADR further asserts that by allowing simultaneous broadcasting of analog and digital for all radio programming, this hybrid mode permits a rational transition to an all-digital environment without the need for additional frequency allocations to accommodate the digital signal.[4]

As identified in its Petition, USADR specifically urges the Commission to: (1) determine that IBOC is the most appropriate means to transition from analog to digital broadcasting; (2) establish interference criteria to insure the compatibility of analog and digital radio; (3) establish a plan to foster the transition to an all-digital environment; (4) conclude that a Commission-adopted DAR transmission standard is necessary to insure equipment compatibility and maintain the universal availability of domestic radio services; (5) establish a criteria and a timetable for the evaluation of IBOC systems; and (6) select a single IBOC system and transmission standard.[5]

I. INTRODUCTION AND STATEMENT OF INTEREST

As a general matter, CEMA fully supports efforts to implement terrestrial digital audio radio systems. CEMA, a sector of the Electronic Industries Alliance, is the principal trade association of the consumer electronics industry. CEMA members design, manufacture, distribute and sell a wide variety of consumer electronics equipment, including radio broadcast

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2 *Id.* at ii.

3 *Id.* at iii.

4 *Id.*

5 *Id.* at 83-104.

receivers. As such, CEMA has an interest in maintaining the integrity of current radio products and, at the same time, supporting efforts to open the electronics manufacturing industry to new product opportunities.

As a matter of background, CEMA notes that its past evaluations of proposed IBOC DAR technologies revealed that their potential implementation would have caused an unacceptable degradation of the reception of "host" station transmitters as well as interference to other stations. Further, due to the existing congested occupancy of the AM and FM bands, it was determined that analog-to-digital interference would severely limit potential IBOC DAR digital coverage. These deficiencies must be overcome if the new versions of IBOC DAR are to form the basis for the provision of digital radio service in the United States. CEMA welcomes the opportunity to assist the Commission in this proceeding in the examination of the technical viability and quality of currently available IBOC system designs, such as that proposed by USADR.

II. TERRESTRIAL DIGITAL AUDIO RADIO IS IN THE PUBLIC INTEREST

DAR is poised to revolutionize radio in the same way that digital television is revolutionizing TV. Although radio continues to be a strong medium, it is clear from CEMA's consumer research that consumers desire improved service and enhanced audio quality. Unfortunately, the current analog broadcasting system presents limitations in improving AM and FM performance. These limitations have had a greater impact on AM than FM, because AM is currently not able to provide high quality sound and its relatively lower spectrum occupancy leaves less room for improvements. Further, as USADR astutely points out, "[c]hanges in

listener expectations have been fueled, in part, by improvements in pre-recorded music and new digital broadcast services."[6]

Indeed, digital compact discs ("CDs") and tapes offer superior audio quality when compared to analog radio broadcasts. Already, over two-thirds of American homes listen to CDs, and that CD use is not only growing in the home, it is growing in the car. This is important because most radio listening today takes place in the car. Although radio continues to be a strong medium, it is clear that there is consumer demand for improved service and enhanced audio quality. The issue that remains, however, is finding a workable system in a defined period of time. Independent of whether the system selected is that of USADR, what is paramount is that the DAR system selected does not interfere with existing radio reception, will work in home and mobile environments, and will produce the "CD-quality" sound that consumers have come to expect and enjoy.

Additionally, we find that the Commission has previously expressed support for terrestrial digital audio radio technology, stating:

> We believe that existing radio broadcasters can and should have an opportunity to take advantage of new digital radio technologies, and we are optimistic that technical advances will, in the near future, permit both FM and AM broadcasters to offer digital sound. To this end, we are committed to continuing our work with the broadcast industry to ensure that broadcasters are able to promptly implement terrestrial DARS.[7]

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6 *Id.* at 5.

7 *In the Matter of Amendment of the Commission's Rules With Regard to the Establishment and Regulation of New Digital and Audio Radio Services*, GEN Docket No. 90-357, Notice of Proposed Rulemaking and Further Notice of Inquiry, 7 FCC Rcd 7776, 7780 (1992).

CEMA agrees with USADR that the time is ripe for the Commission to consider incorporation of terrestrial digital audio radio technology into radio broadcasting.[8] It is now the radio broadcasting industry's turn to enter the digital revolution, and it appears that the Commission would support that new challenge.

III. PAST EVALUATIONS ON DAR TECHNOLOGIES ESTABLISH A THRESHOLD BENCHMARK FOR FUTURE EVALUATIONS OF SYSTEM PERFORMANCE.

In 1991, CEMA formed its Digital Audio Radio Subcommittee of the R-3 (Audio Systems) Committee and established a comprehensive initiative to evaluate all proposed DAR technologies. Over the course of the next six years, comprehensive laboratory and field tests were conducted and evaluated. The results provided a clear, objective portrayal of the capabilities of these systems to meet listener expectations. Part of this effort was to assess IBOC DAR systems under the National Radio Systems Committee's ("NRSC") DAB Subcommittee. Recently, all the laboratory and field test results for all systems evaluated were summarized and assessed in the Final Report of the CEMA DAR Subcommittee, entitled "Technical Evaluations of Digital Audio Radio Systems: Laboratory and Field Test Results; System Performance; Conclusions,"[9] which is attached as Appendix A to these comments.

The Final Report describes the systems tested and the test methods used, summarizes laboratory and field test results, evaluates systems performance relative to the Subcommittee's performance objectives and, most relevant to the instant proceeding, assesses

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8 *See* USADR Petition at 17.

9 "Technical Evaluations of Digital Audio Radio Systems: Laboratory and Field Test Results; System Performance; Conclusion," Final Report, December 1997 ("Final Report"). *See* Appendix A. This and other supporting technical reports, which were previously filed with the Commission's Office of

further IBOC system design modifications suggested by USADR up to that time. CEMA believes that these results constitute technical information directly relevant to the Commission's assessment of terrestrial DAR. The lessons learned from these studies provide a technical perspective and orientation to fully assess system capabilities and performance. CEMA asks the Commission to consider the results contained in the Final Report.[10]

IV. RECENT NRSC DAB SUBCOMMITTEE ACTIVITIES PROPOSE A STRUCTURE FOR FURTHER IBOC SYSTEM EVALUATIONS

The NRSC is jointly sponsored by the National Association of Broadcasters ("NAB") and the Consumer Electronics Manufacturers Association. The NRSC serves as a technical forum to examine technologies for free, over-the-air radio broadcasting systems in the United States. The NRSC's Digital Audio Broadcasting ("DAB") Subcommittee previously focused on industry-sponsored testing of IBOC DAR systems. The current goal of the DAB Subcommittee is to establish whether or not IBOC DAR systems are a significant improvement over existing AM and FM analog radio services. In this regard, the current focus of the Subcommittee has been the drafting of uniform system test procedures, which spell out in detail the information and test results the NRSC needs in order to evaluate IBOC systems and compare them against existing analog services.

CEMA and NAB submitted a joint filing of the test guidelines with the Commission on December 14, 1998.[11] As noted in the December 14, 1998 joint filing by CEMA

Engineering and Technology, are also available to order from CEMA at its web site located at "*http:/www.cemacity.org/ works/pubs/files/dar.htm*."

10 An Executive Summary of the results can be found in Appendix A, at ii.

11 *See* Letter from the National Association of Broadcasters and the Consumer Electronics Manufacturers Association to Magalie Roman Salas, regarding RM-9395 (In the Matter of Amendment of Part 73 of the Commission's Rules to Permit the Introduction of Digital Audio Broadcasting in the AM and FM

and NAB: "These guidelines are designed to be used by the system proponents, to help them structure the testing of their system, or alternatively, to structure the presentation of their test results, in a way that will be most meaningful for NRSC evaluation of this information."[12] The DAB Subcommittee is available to system proponents conducting the tests to help clarify any issues that may arise concerning use of the test guidelines, and to offer any general suggestions or comments based on its prior experience in conducting tests of this sort.

V. THE COMMISSION SHOULD ESTABLISH DETAILED TERRESTRIAL DAR SERVICE PERFORMANCE OJECTIVES THAT SHOULD, AT A MINIMUM, BE MET BY PROPOSED SYSTEMS FOR FURTHER CONSIDERATION.

CEMA urges the Commission to establish performance objectives that should be attained by any proposed DAR technology. The CEMA DAR Subcommittee performance objectives are well-documented in its Final Report.[13] Additionally, the NRSC DAB Subcommittee's performance objectives are set out in the joint CEMA and NAB filing.[14] These documents may serve the Commission in evaluating competing terrestrial DAR systems, and in determining whether, and to what extent, they meet public expectations. CEMA offers below its analysis of several performance objectives for the Commission's consideration.

Broadcast Services), dated December 14, 1998 (Attached to the Letter was Appendix A: *National Radio Systems Committee, DAB Subcommittee, In-Band/On-Channel (IBOC) digital Audio Broadcasting (DAB) System Test Guidelines, Part 1 – Laboratory Tests*, December 3, 1998).

12 *Id.* at 2.

13 *See* Appendix A.

14 *See* note 11, *infra*.

A. "CD Quality"

"CD quality" is what listeners have come to expect in their listening experience. This implies not only a high degree of frequency response, dynamic range and signal-to-noise ratio, but also continuity of service (*i.e.*, immunity to interference and other impairments, and robust coverage without signal "drop-outs"). The enormous success of compact discs, replacing as it has vinyl recordings, argues strongly for its adoption as the threshold benchmark to determine whether a new DAR system is likely to meet listener expectations.

USADR refers to the improved level of sound quality of its system as "virtual CD-quality."[15] Other IBOC DAR system proponents purport to offer what they term "FM-like quality," "near-CD quality" and other such descriptions which some system proponents profess is an adequate audio quality target. CEMA believes that this lowering of expectations is due in part to the limited amount of data capacity devoted to audio coding, which, in turn, relates to the limited RF bandwidth available to implement an IBOC signal. Coupling these factors with the capabilities today of low bit-rate coders, offers a resultant limited audio quality level that has yet to be demonstrated as acceptable by consumers as approaching the "CD quality" they have come to expect from audio delivery systems. The NRSC DAB Subcommittee nonetheless largely accepts that quality limitation with its current quality objective (*i.e.*, "greater quality and durability than available from the AM and FM analog systems that presently exist in the United States"). While it may be possible to devise an IBOC system with unimpaired audio that offers AM broadcast stations "FM-like quality," or offers FM broadcast stations "near-CD quality," the Commission must ensure that the level of performance of the DAR system selected will be attractive to listeners.

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[15] USADR Petition at 41.

Further, the Commission should be aware that recent developments in consumer electronics may soon raise consumer expectations even beyond "CD quality." With Digital Television (DTV) implementation this year, viewers are now exposed to the new listening experience of Dolby (AC-3) Digital audio which has not only true CD-quality, but importantly, multichannel capability with its discrete 5.1 channel surround sound. This fully integrates the high resolution viewing experience of HDTV with the full complement of multichannel audio that makes the home viewing experience so attractive to consumers. Also, new advances in pre-recorded audio technologies (including audio Digital Versatile Disc or "DVD") will soon provide 5.1 multi-channel, and higher-than-CD quality audio (96 ksps, 24 bit) which is similarly expected to attract consumer attention. It appears, therefore, that not only is "CD-quality" minimally required by a proposed DAR service, but, if that service is to have future appeal, an even higher audio quality, with multi-channel capability may be required.

B. Robust Mobile Reception

One of the target objectives of a DAR service has been to provide listeners in cars with robust reception, without interference or impairments. However, achieving that is a most demanding challenge for system designers. The CEMA DAR Subcommittee Final Report (and other Subcommittee Documents) details the types of multipath scenarios used in past laboratory testing and the system performance results. One finding then was the demonstrated success of certain modulation and channel coding techniques to overcome multipath impairments. For example, the Eureka-147 DAB system uses Coded Orthogonal Frequency Division Modulation ("COFDM") which is a multi-carrier system with carrier spacings, symbol durations, and guard intervals (among other parameters) specifically designed to overcome multipath and other interference expected with mobile reception. That system performed very successfully in the

laboratory simulations and field tests, in part due to its modulation coupled with another design parameter -- using 1.5 MHz-wide channels -- required to overcome wide-band fading known to occur, especially in urban areas.

Newly designed IBOC DAR systems apparently are predicated on the use of Orthogonal Frequency Division Multiplexing ("OFDM") in some fashion, although all the technical details of all the proposed systems are currently unknown. Even the satellite DAR systems may take advantage of OFDM in their deployment of terrestrial gap-fillers. These events are encouraging, but more information is required to make further assessments of these designs and their potential performance improvements.

C. Spectrum Implications

While IBOC DAR has the advantage of introducing a form of DAR without the need for new spectrum allocations for the digital signal, the Commission must not hastily foreclose the possibility of using other spectrum for terrestrial DAR services. CEMA believes that achieving key DAR service performance objectives (*e.g.*, audio quality, interference immunity, robust digital coverage) collectively remains tied to spectrum occupancy – the higher the performance quality desired, the more RF spectrum is needed to provide that service. CEMA's preference would be for the Commission to craft a terrestrial DAR service solution that addresses these demanding requirements and offers a service that meets the public's expectations. In any rulemaking proceeding undertaken in response to the USADR request, the Commission should conduct an inquiry into the possibilities for acquiring additional spectrum to address the contingency that current in-band designs will not achieve the level of performance required for technical viability and audience acceptance and that new approaches to achieving high performance digital radio must be considered. However it decides to address the issue of

additional spectrum requirements, the Commission must conduct a comprehensive evaluation of competing systems and select that system that offers the highest quality of service to the listening public.

D. Assessment of USADR's Technical Showings

In considering IBOC DAR, the Commission must evaluate the following areas: audio quality, compatibility with the host and other analog stations, and digital performance. The past laboratory evaluations of IBOC DAR systems have developed a broad and comprehensive technical understanding of performance trade-offs and the inter-relationships of spectrum occupancy, audio and transmission coding, digital signal injection levels, etc., of IBOC system designs. CEMA has formulated its suggestions on applying the appropriate assessment tools to both critical performance objectives and the technical showings presented in the USADR Petition. CEMA urges the Commission to consider the analysis of performance objectives and technical assessments set out in Appendix A.

VI. THE COMMISSION MUST ADOPT A SINGLE DAR STANDARD

Like USADR, CEMA also urges the Commission to adopt a single DAR standard.[16] Technical standardization is critical because the choice of one standard over another can have a major effect on the development of entire industries. Once technological decisions are made, technology develops along a given path. A single standard provides certainty to

[16] *See* USADR Petition at 92 ("[a] government-mandated standard is required by virtue of the ubiquitous nature of radio").

consumers, licensees, and equipment manufacturers, especially during the launch of this new technology.[17]

A required standard will protect consumers against losses by assuring them that their investments in DAR equipment will not be made obsolete by a different technology. In addition, requiring use of a single standard guarantees compatibility. This assures consumers that the DAR equipment used to listen to one station can be used to listen to every other station. The compatibility guaranteed by a single required standard will also reduce consumer costs by eliminating the need to purchase duplicative equipment or special devices to convert from one standard to another. Finally, a required standard will lead to a more rapid development and acceptance of DAR equipment. Absent a required standard, some consumers and licensees may be reluctant to purchase DAR equipment if they believe that different DAR technologies may become available in the near future. A required standard will reduce such "wait and see" behavior.

Moreover, free over-the-air broadcast radio (like television) is an established industry upon which the American people rely for both information and entertainment. Unlike other new services such as PCS, DBS, and satellite DARS, free over-the-air broadcast radio (like broadcast television) is a mass market media serving nearly all of the American public nationwide rather than a subscription service in which the service provider may supply the reception equipment. In this case, the goals of certainty and reliability take on a different significance than may have been present with respect to other communications services, and strengthens the case for adoption of a single DAR standard.

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[17] *See In the Matter of Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service*, MM Docket No. 87-268, Fifth Further Notice of Proposed Rule Making, 11 FCC Rcd 6235, 6247-48 (1996).

While some may argue that the adoption of a single standard will limit competition and narrow the possibilities of innovation, such consequences can be avoided through the adoption of a robust, scalable, and extensible standard. This is the approach that the Commission has used in devising rules to implement digital television and this is the approach that should be adopted for digital radio. CEMA is confident that a single standard will preserve conventional forms of competition, such as price, service and product features. Requiring the use of a single DAR standard is appropriate because it would provide a measure of certainty and confidence to manufacturers, broadcasters and consumers. Further, it will help ensure a smooth implementation of digital audio radio and the preservation of a free and universally available broadcast radio service.

VII. THE COMMISSION SHOULD DETERMINE AN APPROPRIATE VENUE AND/OR PROCESS TO EVALUATE, SELECT AND STANDARDIZE A SINGLE DAR SYSTEM.

In its Petition, USADR asks the Commission to establish a criteria and a timetable for the evaluation of IBOC systems and to select a single IBOC system and transmission standard.[18] CEMA agrees that establishing an evaluation criteria are essential, as is a proposed timetable for evaluations. Thereafter, depending on how well (or how poorly) IBOC DAR systems perform, the next steps could be structured. The construction of an appropriate venue for these evaluations/system selection, however, is unclear. CEMA suggests that the following alternatives exist for the Commission and offers its views on each.

As an option, the Commission could establish a government/industry advisory committee to guide evaluations of terrestrial DAR. Establishing such a joint committee is

[18] *See* USADR Petition at 87-104.

admittedly a time-consuming enterprise. Further, domestic IBOC system evaluations could take years to conclude under an advisory committee. Another approach would be to rely on established expert bodies, such as the NRSC DAB Subcommittee, CEMA's R-3 (Audio Systems) Committee, or other appropriate bodies. This approach would take advantage of considerable technical expertise developed in the field, but would need a strong degree of empowerment, sanction, and commitment by the Commission to await and rely upon the recommendations from the expert body.

As a third alternative, the Commission could initiate a formal proceeding with established time periods under which system proponents must complete their final system designs, divulge their technical details, submit laboratory and field test data on technical performance, entertain industry input, and make an informed decision based on the record so developed. This is the approach apparently contemplated by the USADR Petition. No matter which venue the Commission finds most appropriate, CEMA and its members are available and willing to participate in any initiative that stimulates and nurtures adoption of a terrestrial DAR service that meets listener expectations.

VIII. CONCLUSION

For the foregoing reasons, CEMA urges the Commission to initiate a rulemaking proceeding to permit the introduction of terrestrial DAR consistent with the comments submitted herein. CEMA recommends that the Commission undertake efforts in that proceeding to establish comprehensive technical assessments to weigh the performance of competing systems with emphasis on audio quality, compatibility with existing analog services, and digital coverage and performance – *i.e.*, those areas that are critical to a successful deployment of digital radio.

Respectfully submitted,

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LIST OF APPENDICES

APPENDIX A: CEMA Views on Performance Objectives & Analysis and Assessment of Technical Showings in USADR Petition for Rulemaking

APPENDIX B: *Technical Evaluations of Digital Audio Radio Systems: Laboratory and Field Test Results; System Performance; Conclusions*, Final Report (December 1997)

APPENDIX A

APPENDIX A

CEMA Views on Performance Objectives

And

Analysis and Assessment of Technical Showings in USADR Petition for Rulemaking

In considering IBOC DAR as the means to implement terrestrial digital audio radio, the Commission must evaluate the following areas: audio quality, compatibility with the host and other analog stations, and digital performance. The past laboratory evaluations of IBOC DAR systems have developed a broad and comprehensive technical understanding of performance trade-offs and the inter-relationships of spectrum occupancy, audio and transmission coding, digital signal injection levels, etc., of IBOC system designs.

The analyses presented in the Final Report[1] provide numerous examples of how to organize, present, and assess laboratory and field test results, and the summary discussions presented there, in Appendices 10 & 11, are especially relevant to IBOC system designs. These may well serve the Commission as a template to derive meaningful conclusions now on newer IBOC DAR system designs. CEMA encourages the Commission staff to become familiar with these evaluation tools.[2]

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1 *See* CEMA Comments, Appendix B.

2 Other technical publications supplementing these technology assessments include: Gruse, T., Thibault, L., and Soulodre, G., "EIA/NRSC DAR Systems Subjective Tests, Part I: Audio Codec Quality," IEEE Transactions on Broadcasting, Vol. 43, No. 3, at pp. 261-267 (Sept. 1997); Gruse, T., Thibault, L., and Soulodre, G., "EIA/NRSC DAR Systems Subjective Tests, Part II: Transmission Impairments," IEEE Transactions on Broadcasting, Vol. 43, No. 4, at pp. 353-369 (Dec. 1997); G.A. Soulodre, T. Grusec, M. Lavoie and L. Thibault, "Subjective Evaluation of State-of-the Art Two-Channel Audio Codecs," Journal of the Audio Engineering Society, Vol. 46, No. 3, at 164-177 (March 1998).

A. Audio Quality

Formal subjective assessments of audio quality, if conducted under carefully controlled conditions, can produce definitive and repeatable characterizations of the capabilities of digital audio source coding techniques. Appendix 2 of the Final Report shows the results of comprehensive examinations of the DAR systems under testing that primarily use PAC and MUSICAM audio coding techniques.[3]

These studies used the internationally-accepted methodologies adopted in ITU-R Rec. BS.1116, *Methods for the Subjective Assessment of Small Impairments in Audio Systems Including Multichannel Sound Systems*, that fully characterize the listening room requirements, evaluation methodologies and statistical assessments on the meaningfulness of results.

B. Compatibility Assessments

One of the original promises of IBOC DAR systems was that digital energy could occupy the same spectrum as the host analog (AM or FM) broadcast signal, compatibly, without causing interference to or degradation of the host station. Actually, those early designs injected more digital energy into the host station's first-adjacent channel and very little, if any, "on-channel." Subsequent evaluations determined that significant host station degradation was observed more than 25 dB degradation of the signal-to-noise ratio (S/N) on some of the reference test FM receivers.[4] This degradation is receiver-dependent. Some receiver circuitry tapes in current use resist this degradation such as those using Walsh function detection or 114 kHz interference filtering. However, those represent less than 10% (estimated) of the existing

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3 *See* CEMA Comment, Appendix B (Appendix 2 of the Final Report). Other evaluations of low bit-rate coders can be found in other sources. *See, e.g.*, G.A. Soulodre, T. Grusec, M. Lavoie and L. Thibault, "Subjective Evaluation of State-of-the-Art Two-Channel Audio Codecs," Journal of the Audio Engineering Society, Vol. 46, No. 3 (March 1998).

population of in-use receivers. Most receivers use phase lock loop (PLL) stereo decoders that are sensitive to noise at the odd multiples of the stereo difference signal.[5]

Also instructive is an examination of the RF spectra of the systems tested, shown in Figure IA-IE of Appendix 4.[6] These are useful to compare new IBOC DAR designs, their occupied spectra (whenever such showings are available), and then determine the anticipated (relative) performance impact, both on compatibility and interference potential.

C. Assessments of the Technical Showings in USADR's Petition

To illustrate applying these analysis tools, CEMA offers an assessment of some of the technical Appendices of the USADR Petition, and presents its understanding of the implications of some of the USADR simulation results presented therein. It is important to note that the USADR performance data presented in its Petition are from simulation only, not hardware test results.

1. Hybrid IBOC FM (USADR Petition at Appendix B)

a. General

In the analysis of these simulations, it was necessary to make two basic assumptions that are not detailed in the USADR Petition: (1) that the simulations were conducted over a period of time that allowed the 9-ray multipath fading simulations to repeat several cycles; (2) that the Threshold of Audibility (of impairment), or "TOA," represents the peak block error during multiple 9-ray multipath scenario cycles. At no time during TOA simulations did the block error rate exceed 0.01. If these assumptions are incorrect, reasonably accurate assessment of these data is not possible.

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4 *See* CEMA Comments, Appendix B (Appendix 4, Table 6)

5 Receiver characterizations are discussed further in Appendix 4 of CEMA's Comments.

Table E-5 of Appendix E of the Petition summarizes the results of twenty-three Hybrid IBOC simulations. These can be divided into three groups: no multipath fading/no interference, 9-ray multipath fading, and urban-fast multipath fading with interference. The metric for evaluation is the TOA margin in dB at the 54 dBu protected contour (Class B station). The simulations used block error rate to find the TOA.

Apparently all of the simulations were conducted using the signal level set to the average level expected at the protected contour with the receiving antenna thirty feet above the ground. If this is correct, the simulations may not represent the digital performance for the average vehicle with the receiver antenna mounted a few feet from the ground. For the fixed site simulations, the receiving antenna should be at 30 feet.

b. No multipath fadings/no interference simulations

The result of the no fading/no interference simulation is a 22.5 dB TOA margin. This is close to the levels measured on the AT&T/Amati IBOC system during the previous CEMA/NRSC laboratory tests.

c. 9-ray multipath fading simulations

The four 9-ray multipath scenario simulations showed that in the urban-slow mode the IBOC system margin was 6.5 dB less than with urban-fast multipath. The urban-slow result was also 9 dB lower than the average of the other three multipath scenarios. The margin ratios observed between the urban slow multipath scenario and the other three scenarios is similar to ratios measured on the AT&T/Amati IBOC system during the previous CEMA/NRSC laboratory tests. This points out the fundamental limitations of all narrow-band DAR systems and their susceptibility to multipath at lower speeds. It is also important to point out that the

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[6] *See* CEMA Comments, Appendix B (Appendix 4, at 7).

blend to analog can run out at very low speeds and will stop working altogether when the receiver is stationary.

d. Urban-fast multipath with interference simulations

The remaining 18 simulations were run with the urban-fast multipath scenario. As pointed out above, the urban-slow scenario highlighted the narrow band system weakness. In order to assess system performance of the IBOC hybrid system, a complete set of simulations should be supplied using all four-multipath scenarios. In addition, fixed (stationary) simulations should be added to make the test complete.

e. 1st Adjacent Interference

Table 1, below, summarizes the USADR 1st adjacent interference simulations. The third column and second data row of the table shows that, at the 6 dB protected contour, the 1st adjacent undesired analog signal is actually 19 dB stronger than the desired digital sideband. In the simulation where the 1st adjacent undesired analog is 30 dB below desired analog FM, the undesired FM is actually 5 dB below the desired digital. It is interesting to note that the TOA margin varies only 1.5 dB between the point where the undesired FM is 19 dB above the desired digital to a point 5 dB below.

Table 1

First-Adjacent with Urban-Fast Simulation Summarization And Conversion

The third column is the ratio in dB for the 1st adjacent analog power over a single digital sideband power. The single digital sideband is 25 dB below the host FM.

Undesired to FM DBfm	TOA Margin DB	1st adj. fm/single digital db	Conventional D/U DB
12	6.5	+37	-12
-6	13.0	+19	+6
-18	13.0	+7	+18
-24	13.5	+1	+24
-30	14.5	-5	+30

f. Dual 2nd adjacent interference

With two first-adjacent interferers, both of the digital signals are corrupted by 1st adjacent analog interference. The first four tests in this series have equal interference, cannot have the benefit of diversity, and depend heavily on the proposed use of a (new) "First Adjacent Chancellor" (FAC). This is one of the most important tests that should be duplicated in hardware to certify the validity of the simulations. Table 2, below, summarizes the results of the USADR simulations, and the third column shows the first adjacent FM-to-digital ratios.

With two first adjacent (predominantly analog) interferers set at the FCC 6 dB level, the system TOA margin is 12.5 dB poorer than the urban fast scenario without interference. With two first-adjacent (predominantly analog) interers set at the FCC 6 dB level, the system TOA margin is 12.5 dB poorer than the urban fast scenario without interference.[7]

Table 2

Dual First-Adjacent with Urban-Fast Simulation Summarization And Conversion

The third column is the ratio in dB for the 1st adjacent analog power over a single digital sideband power. The single digital sideband is 25 dB below the host FM.

Undesired to FM DBfm	TOA Margin DB	1st adj. fm/single digital db	Conventional D/U DB
L-6	3.0	+19	+6
L-18	7.5	+7	+18
L-24	7.75	+1	+24
L-30	12.5	-5	+30
L-6 U 30	9.0	L + 19 U-5	L + 6 U + 30

[7] This can be derived from the USADR Petition, Appendix E, Table E-5, at 13, that shows a 9-Ray Fading margin of 15.5 dB, compared to Table 2 of these comments showing a 3.0 dB margin.

g. Single 2nd adjacent interference

The second adjacent interference is always digital-to-digital with the sideband hybrid IBOC systems. The USADR signals do not overlap but adjoin with a 2 kHz guardband. In the second-adjacent case the digital-to-digital D/U ratio will be the same as the analog. The single second-adjacent simulations were conducted with the undesired signal operating at 40 dB and 50 dB above the desired signal. The small changes in the TOA margin may be attributed to the backup of the diversity sideband.

h. Single 1st and single 2nd adjacent interference

This simulation was run with a constant lower first adjacent interferer set at the maximum for the protected contour (6 dB below). The lower second-adjacent interference was increased in four steps from 0 to 40 db, the desired FCC limit. The TOA margin decreased by 7.5 dB over this range. This simulation indicates that an IBOC second adjacent signal does not affect the TOA performance of the desired signal within the protected contour.

This simulation acts more like one of the interferers was on the upper adjacent channel. If the interference was only on one digital sideband, the vibration would be more like those in the single first-adjacent simulation where the margin varied by only 1.5 dB from –30 dB to 6 dB dBfm.

Table 3

First and Second Adjacent with Urban-Fast Simulation Summarization and Conversion

Lower 1st adjacent DBfm	Lower 2nd adjacent dBfm	Margin dB	2nd Adjacent Conventional D/U
-6	40.0	2.0	-40

-6	30.0	4.0	-30
-6	12.0	5.0	-12
-6	0.0	9.5	0

i. Co-channel interference

Co-channel was simulated at 10 dB and 20 dB below the desired FM carrier. With the desired 10 dB higher, the undesired the TOA margin dropped 6 dB. With the desired 20 dB above the undesired, the TOA margin dropped by 1 dB.

2. Hybrid IBOC AM (USADR Petition at Appendix H)

This compares the AM hybrid simulation performance with previous laboratory CEMA/NRSC test results of the former USADR AM system.

a. Interference simulation results

Table 4, below, is a summary of the D/U ratio results presented from Appendix H of the USADR Petition (AM IBOC DAB technical report). Those simulations show the co-channel, first-adjacent, and second-adjacent channel D/U ratios at TOA for the AM hybrid system.

The co-channel TOA D/U of 29.5 dB is close to the 26.8 dB found on the previous AM system in the CEMA/NRSC laboratory tests. In fact, at 48 kbps the new system is not as robust to co-channel interference as the previously tested AM system.

The USADR first-adjacent channel simulation places the 48 kbps desired signal at TOA when the D/U is 25.5 dB. In the CEMA/NRSC tests, the average upper and lower first-adjacent D/U ratio was 31.5 dB. The new system is 6 dB less sensitive to first adjacent interference. The 6 dB improvement can be attributed the fact that the new 20 kHz system

extends only half way into the 1st adjacent channel. The new Forward Error Correction (FEC) and interleaver may also have contributed to this improvement.

The second-adjacent channel simulations produced a –30 dB D/U ratio. With the new 20 kHz system the digital signals do not overlap and the D/U ratios do look reasonable for laboratory test. With the signal going through a transmitter and the lack of a sufficient guardband, these test results could change.

Table 4

Results of USADR AM Hybrid Simulation

(All interferers hybrid)

Single Interferers at FOA		
Audio codec 48 kbps 32 kbps 18 kbps	Co-Ch D/U 29.5 dB 19.5 dB	1st Adjacent D/U 25.5 dB 20.5 dB
Second adjacent above-30 dB		
Pairs of Interferers at TOA		
Audio codec 48 kbps 32 kbps	Up & Lower 1st Adjacent D/U +28 dB D/U +25 dB	

b. Hybrid system performance

(i). daytime operation

The FCC daytime D/U ratio at the protected contour is at best 6 dB for first-adjacent interference. Most AM stations are grandfathered at 0 dB D/U. With this 0 dB D/U and

the system in the 48 kbps mode, the signal would fail at a D/U ratio of 25.5 dB within the grandfathered protected contour. In the 32 kbps mode the 1st adjacent D/U performance improves by 5 dB. This is still 20.5 dB short of the protected contour.

Co-channel interference can be a problem in the higher data rate mode. At the lower data rate 32 kbps, the co-channel D/U improves, and the system should survive most situations.

(ii). nightime operation

Using a spectrum analyzer to monitor AM band signal levels, it is difficult to find one station where the first-adjacent D/U ratio comes near the 20 dB that would be required to allow the digital signal to survive in the 32 kbps mode. It is also difficult to find a station that meets the 25 dB dual first-adjacent D/U ratio requirements. The results would that the receiver would switch to the analog (blend) mode on all but the closest stations at night. Except for situations where the receiver is close to the transmitter, no digital signal would be heard.

c. Summary

The USADR AM simulations are believable and comport with past experience. However, the data show that the system will not operate with first-adjacent nighttime interference. Further, large holes in digital coverage is expected within the protected contour for many stations daytime operations.

3. All-digital Modes

a. All-digital AM

In the all-digital AM mode, we assume the 5 to 10 kHz OFDM carriers are used for the transmission of the main portion of the program audio. If so, the same first-adjacent problems that existed in the hybrid mode will exist for the all-digital mode. Further, the use of a

low bit-rate digital channel to replace the analog AM in the all-digital mode to backup blend operation will be slower than the analog (blend) acquisition and will most likely result in unacceptable tuning delays.

b. All-digital FM

The all-digital FM band system's increase in sideband power will cause an increase in interference to first-adjacent analog reception for stations operating in analog or hybrid mode on most automotive receivers and some home receivers listening to these stations. Further, the use of a low bit-rate digital channel to replace the analog FM in the all-digital mode to backup blend operation will be slower than the analog (blend) acquisition and will most likely result in unacceptable tuning delays.

D. More Detailed System Information is Required

The above discussion illustrates some assessment techniques useful to analyze the data presented in the USADR Petition. However, many key details of their system are not divulged or specified. This is not unexpected at this juncture in time, with competing system proponents present. However, if the Commission is to make informed decisions about IBOC DAR systems, comprehensive, detailed information is needed. Further, to evaluate system performance claims from multiple proponents, a common testing regimen is required that both provide adequate technical performance data useful to make informed judgments, and to ensure that common testing procedures and methodologies are followed. Developing just such testing procedures has been an objective of the re-activated NRSC DAB Subcommittee efforts to date.

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Comments of the Consumer Electronics Manufacturers Association (in RM-9395) was served this 23rd day of December 1998 by hand delivery upon the following:

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