Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:	)	
	)	
Updating FM Broadcast Radio Service Directional Antenna Performance Verification	)	MB Docket No. 21-422
	)	
	)	

REPLY COMMENTS OF
THE NATIONAL ASSOCIATION OF BROADCASTERS

February 4, 2022

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I. INTRODUCTION AND SUMMARY

The National Association of Broadcasters (NAB)[1] hereby submits reply comments in response to the Commission's Notice of Proposed Rulemaking regarding the use of computer modeling to verify the performance of directional antennas used in the FM broadcast radio service.[2] NAB generally supports the use of computer modeling as an alternative to physical measurements, provided the accuracy of the model can be reasonably assured. We agree with the Commission that allowing license applicants the option to submit the results of computer models can provide meaningful relief to FM broadcasters without substantially jeopardizing technical standards or service to the public.[3] This approach should also lead to lower costs for antenna manufacturers and their broadcaster customers and allow greater flexibility in transmitter site selection by FM broadcasters as tower space becomes

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[1] The National Association of Broadcasters (NAB) is the nonprofit trade association that advocates on behalf of free local radio and television stations and broadcast networks before Congress, the Federal Communications Commission and other federal agencies, and the courts.

[2] *Updating FM Broadcast Radio Service Directional Antenna Performance Verification*, MB Docket No. 21-422, Notice of Proposed Rulemaking, FCC 21-117 (Nov. 15, 2021) (NPRM). NAB appreciates the Commission's approval of NAB's request for an extension of the comment deadlines, which has allowed for a more robust technical record. *Media Bureau Extends Comment and Reply Comment Deadlines for FM Directional Antenna NPRM*, Public Notice, DA 21-1611 (Dec. 20, 2021).

[3] NPRM at ¶ 2.

increasingly precious. NAB submits that the record includes a sufficient cross-section of expert opinions, including comparisons between commercial electromagnetic modeling software and measurements of physical models or as-built antennas, to justify rules permitting software models to be used in lieu of physical measurements in most cases. The record further shows that electromagnetic modeling software is complex, can be subject to manipulation, and limited by the accuracy and completeness of the input data. Therefore, NAB proposes several caveats to help ensure the integrity of the frequency allotment process.

II. ABSOLUTE ACCURACY IS NOT PRACTICALLY ACHIEVABLE

NAB agrees with the Joint Petitioners that various factors limit the accuracy of pattern measurements taken of a physical antenna, including mechanical tolerances, human error, and the presence of reflections or imperfections in an antenna test range.[4] Computer modeling is also subject to limitations in accuracy, such as sometimes predicting unrealistically deep pattern nulls and shifting the location and magnitude of nulls and lobes from their true circumstance.[5] NAB submits that it is impossible to account for every aspect of the actual environment of the antenna location using either computer modeling or range measurements. While antenna manufacturers are careful to design and maintain test ranges to minimize the potential for measurement errors and ensure reproducibility, some reportedly with errors of less than 2 dB,[6] measurements taken of the same antenna on the same range

[4] Dielectric, LLC, Educational Media Foundation, Jampro Antennas, Inc., Radio Frequency Systems, and Shively Labs, Joint Petition for Rulemaking at 14-16 (June 15, 2021) (Joint Petition).

[5] *Id*. at Fig. 11

[6] Comments of Electronics Research, Inc. (ERI) at 13, MB Docket No. 21-422 (Jan. 19, 2022).

on different days may vary, reflecting the existence of additional uncertainties.[7] One study found that for five antenna ranges, the typical standard deviation of identical measurements taken over time was 0.6 dB.[8] Assuming a normal probability distribution applies to these additional errors, this would mean that 95% of the time, measurements taken would vary up to ±1.2 dB. Accordingly, it seems unlikely that range measurements can be demonstrably more accurate than ±3 dB. Further, variability of path loss with both time and location is a reality of all radio systems, including FM broadcasting, and the unavoidable introduction of small antenna pattern errors is unlikely to be measurable *in situ* or detectable by stations or their listeners. The Commission should not seek to attain or require predictive accuracies that cannot be practically realized and do not materially affect the interference environment.

III. THE COMMISSION SHOULD NOT REQUIRE *IN SITU* MEASUREMENTS BEYOND ENSURING OF THE PROPER INSTALLATION OF THE ANTENNA

As the Commission observes, complaints concerning interference attributable to directional FM broadcast stations have been rare.[9] While NAB and others are aware of some interference reports that could be attributable to the installation of non-directional FM transmitting antennas on a supporting structure in a way to intentionally cause them to become directional, the NPRM does not address this situation.[10] Further, it is already Commission policy that "[t]he use of any technique or means (including side-mounting) which intentionally distorts the radiation pattern of what is nominally a non-directional antenna

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[7] Comments of Cesium Communications, LP at 4, MB Docket No. 21-422 (Jan. 19, 2022) ("The test ranges in the United States are all different.").

[8] Lowell E. Kolb, *Statistical Comparison of Site-to-Site Measurement Reproducibility*, Proc. IEEE 1996 International Symposium on EMC, at 241-244, available at https://ieeexplore.ieee.org/document/561236.

[9] NPRM at ¶ 12.

[10] Comments of Edward A Schober, P.E. at 5, MB Docket No. 21-422 (Jan. 19, 2022).

makes that antenna directional and it must be licensed as such."[11] Any reduction in burden on an applicant seeking to use an FM directional antenna by permitting computer-based pattern verification would be lost by requiring *in situ* measurements of the antenna, and there is no corresponding requirement for post-construction measurement of non-directional antennas, which may in fact have directional properties.

The present rules require various affirmations concerning the proper installation of the directional antenna, including: (1) the antenna is mounted on the supporting structure in accordance with specific instructions provided by the antenna manufacturer; (2) no other antenna is mounted at the same height or within a distance specified by the manufacturer; and (3) a statement by a licensed land surveyor that the antenna is installed at the proper height and oriented in the proper direction as specified by the manufacturer.[12] NAB believes these existing rules are sufficient and should be retained to reasonably ensure that a properly-modeled FM directional antenna will perform as expected.

IV. THE COMMISSION SHOULD ACCEPT RESULTS FROM ANY APPROPRIATE ELECTROMAGNETIC MODELING SOFTWARE

There are at least three basic numerical approaches for electromagnetic simulation, namely: Finite-Difference Time-Domain (FDTD), Finite Element Method (FEM), and Method of Moments (MoM). All of these approaches have rigorous theoretical underpinnings, and all can be implemented through widely available commercial or developmental software. NAB believes that all FM pattern modeling is done using software implementations of either the FEM or MoM. FDTD is commonly used for near-field simulations of complex structures to

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[11] *Criteria for Licensing of FM Broadcast Antenna Systems*, Public Notice, FCC 84-437 (Sep. 14, 1984).

[12] 47 CFR § 73.316(c).

determine specific absorption rate (SAR) for RF exposure compliance purposes, such as with mobile phones, but NAB does not believe it is used to model far-field FM antenna patterns.

Commercial implementations of FEM include HFSS™, COMSOL Multiphysics™, and CST Studio Suite.[13] Commercial software implementations of MoM include FEKO®, MiniNEC, EZNEC, and WIPL-D.[14] The record reflects a range of opinions concerning which numerical approaches should be accepted for FM antenna pattern validation and which software implementations of those approaches might be accepted.[15] NAB believes that all of these commercial software products can produce accurate results of modeled FM directional antennas when used appropriately. The selection of an appropriate software model may depend, for example, on whether the antenna and mounting structure can be adequately represented as a wire or wire-mesh model, or whether surface modeling is required. That determination is best left to the discretion of a qualified engineer as discussed below in Section V. All commercial electromagnetic simulation software NAB is familiar with includes various internal "confidence checks" to help ensure that basic modeling constraints are not inadvertently violated. However, confidence checks can be overridden and constraints

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[13] Ansys, Inc. (HFSS™); COMSOL Multiphysics™; and Simuleon (CST Studio Suite).

[14] Altair Engineering, Inc. (FEKO); Black Cat Systems (MiniNEC); Roy Lewallen (EZNEC); and WIPL-D d.o.o. (WIPL-D).

[15] Comments of Dielectric, LLC at 2, MB Docket No. 21-422 (Dec. 29, 2021) (". . . the software used should be based on solid modeling and not on analysis of wire models."); ERI Comments at 12 (". . . HFSS [a commercial software product] predicts azimuth patterns with an error … greater than 3.6 dB for -8.0 dB nulls."); Comments of Albert Davis at 4, MB Docket No. 21-422 (Jan. 20, 2022) ("The obvious choice is "NEC2", the Numerical Electromagnetics Code" from Lawrence Livermore Labs, or a currently maintained derivative of it such as "nec2c"."); Comments of Hatfield & Dawson Consulting Engineers, LLC at 3, MB Docket No. 21-422 (Jan. 15, 2022) (" . . . [W]e normally employ versions of the Numerical Electromagnetic Code [sic] ("NEC") and MININEC for modeling, [but] other software, such as WIPL-D, has also been successful used.").

violated. Therefore, NAB believes that FCC applications supported by the results of commercial software used to validate FM antenna patterns should include evidence that the software executed normally, without producing errors or warnings.

Proprietary or non-commercial software implementations of electromagnetic codes can produce results equivalent to commercial software and there are good reasons to allow their use. For example, some antenna manufacturers have developed software tools for internal or customer use that are specific to the modeling of broadcast antennas.[16] Given that such products are not always subject to marketplace scrutiny, however, some threshold validation of the software should be required of submissions based upon non-commercial software.[17] Some commenters suggest that the software be initially qualified or validated by comparison of calculated and measured antenna performance.[18] NAB agrees that an initial comparison with measured data would be acceptable, or comparison with the results of one or more commercial software implementations, to qualify the software for use in predicting FM directional antenna performance. Additionally, adequate documentation describing the methods used in the software should be required, as suggested by another commenter.[19]

NAB disagrees with commenters stating one or another modeling approach should always be accepted or excluded, but it may be helpful for the Commission or industry to develop best practices to guide modelers toward greater accuracy for different situations. That said, NAB does not believe it is necessary to exhaustively study different modeling approaches

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[16] Comments of Aldena Telecomunicazioni Srl at 2, MB Docket No. 21-422 (Jan. 18, 2022).

[17] NPRM at ¶ 13.

[18] Schober Comments at 2; Comments of Albert Davis at 3, MB Docket No. 21-422 (Jan. 20, 2022).

[19] Hatfield Comments at 2.

prior to routinely allowing FM pattern verification by software modeling, as was required in the decades-long AM Directional Antenna proceeding.[20] The record demonstrates that software modeling is a mature practice that can produce accurate results by qualified modelers. In addition to the comparison included with the Joint Petition, one of the petitioners submitted 53 additional comparisons between software simulation and *in situ* measurement that generally show good agreement.[21] NAB notes, however, that many of the computer models used to develop the comparisons may be unacceptable due to lack of complete tower structure and appurtenance information included in the model, and recommends that all models should include those mechanical details, as discussed below in Section V. Despite these shortcomings, the comparisons exhibit good agreement and a more complete computer model would be expected to further improve agreement with measured pattern data.

V. THE COMMISSION MUST RETAIN AND EXPAND REQUIREMENTS TO HELP ENSURE COMPUTER MODELING IS DONE CORRECTLY AND ACCURATELY

A number of "guardrails" presently exist in the Commission's rules concerning FM directional antennas.[22] To ensure the integrity of FM antenna pattern verification by software modeling, it is important that these requirements be retained and in some cases expanded. These requirements include:

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[20] *See generally An Inquiry Into the Commission's Policies and Rules Regarding AM Broadcast Radio Service Directional Antenna Performance Verification*, MB Docket No. 93-177.

[21] Dielectric Comments at 1-53. NAB notes that one of the VHF antenna comparisons submitted shows significant discrepancies between predicted and measured patterns. *Id*. at 26, showing a Dielectric Model THV-11A12/VP-R 04 antenna with significant discrepancies in the measured vertically-polarized pattern compared with the predicted pattern. Dielectric has confirmed to NAB that the measurement system used to collect those data was malfunctioning and the resulting pattern comparison was submitted in error.

[22] 47 CFR § 73.316(c).

Statement of qualifications of the person(s) responsible for modeling. NAB agrees with commenters that computer modeling should be performed only by qualified persons experienced in this work. NAB expects that most modeling will be performed by antenna manufacturers, but disagrees that data supplied by any manufacturer should be automatically accepted.[23] Modelers should have a substantial background in electromagnetic theory or should be under the supervision of someone with that background, and should not merely be software appliance operators. Persons with a degree in Electrical Engineering or Physics or the equivalent will almost certainly have taken courses in electromagnetics and have the necessary background to spot unreasonable or unlikely results from software models. While specification of qualifying factors seems unnecessary, the Commission should require at least the name(s) of the individual(s) responsible and a statement of their background in electromagnetics, antenna theory, and computational modeling of antennas.

A complete description of the antenna system.[24] This requirement should be expanded to include specification of the mechanical and electrical properties of the antenna used in the model. Typically, this information will be supplied by the antenna manufacturer and should include detailed dimensions of the antenna radiating elements, attachment brackets, and feed system, as well as the electrical characteristics (such as conductivity) of those components. The "antenna system" description should also be expanded to include the mechanical and electrical properties of the supporting structure and appurtenances used in the model as proposed in new rule section 73.316(c)(2)(iv). Typically, this information will be supplied by the tower owner or be collected during a field survey and would include details of

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[23] Schober Comments at 3.

[24] 47 CFR § 73.316(c)(2)(i).

transmission lines, tower structural members, electrical conduits, guy wires and attachments, ladders, and climbing safety lines that are within the antenna aperture or close enough to affect antenna performance. In an application for construction permit, it may be sufficient for the applicant to simply identify the sources of the electrical and mechanical information used in the model, but those details must be retained by the applicant for a period of time (such as one year following completion of construction) sufficient for the Commission or interested parties to review the accuracy and completeness of the computer model.

Limit of 15 dB max/min in the azimuth plane.[25] NAB agrees with commenters that errors associated with computational modeling are likely to increase with the depth of nulls in the antenna pattern.[26] Therefore, NAB recommends retaining the existing limitation that directional antennas that propose a maximum-to-minimum radiation in the horizontal (azimuth) plane of more than 15 decibels will not be accepted. Most commonly, the purpose of employing a directional antenna by a commercial full-power FM station is to allow that station to "short-space" to another FM station, while maintaining contour protection to that station. The Commission's short-spacing rules provide a lower limit on the distance to which a station may locate with respect to other stations[27] and NAB believes that the present 15 dB maximum-to-minimum ratio is adequate to reasonably allow for alternative transmitter sites within the spacing limits while minimizing the risk of interference.

Limit of 2 dB/10-degree rate-of-change in the azimuth plane.[28] The pattern comparisons in the record demonstrate that the rate-of-change of the antenna pattern is

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[25] *Id*. at § 73.316(b)(1).

[26] ERI Comments at 12.

[27] 47 CFR § 73.215(e).

[28] *Id*. at § 73.316(b)(2).

critically dependent upon the accuracy of the data used in the model. Small errors in the physical dimensions used in the model can translate into larger errors in predicted antenna gain in a particular direction. Therefore, NAB recommends retaining the existing limitation that directional antennas that propose a radiation pattern in the azimuth plane which varies more than 2 decibels per 10 degrees of azimuth will not be accepted or authorized. This requirement helps ensure that modeled patterns will be realized in practice.

Certification by a licensed land surveyor (or other licensed or registered person, where permitted) that the antenna is properly oriented and installed at the proper height. Perhaps the most critical assurance that a directional FM antenna will perform as designed is correct installation of the antenna. The position of the antenna on the supporting structure, including its height, offset from the structure, and orientation are perhaps the most important input variables to the computer model. Even small discrepancies in the installed antenna, such as orientation with respect to Magnetic North rather than True North, or shifting the height by a few feet during installation to avoid a gusset plate on the tower, can result in significant changes to the radiation pattern and will require that the model be updated and rerun. Therefore, a licensed individual must certify the proper installation of the antenna. A Licensed Land Surveyor or Registered Professional Engineer is subject to disciplinary action by the licensing jurisdiction and can be fined or their license revoked for failure to correctly assess that the antenna is properly installed. Therefore, certification by a licensed individual is the final and a critical step in ensuring that an FM directional antenna will perform as expected. NAB believes that the present allowance of "…not more than 2 meters above or 4 meters below the authorized values"[29] is adequate only for towers that are uniform in profile and if

[29] *Id*. at § 73.1690(c)(2).

there are no changes in appurtenances within the antenna aperture from those modeled. The +2/–4 meter allowance is too lax to ensure that directional antenna patterns will not vary in all cases, particularly when towers are tapered and when there are other appurtenances attached. Instead, NAB suggests that any change in the mounting height of an FM directional antenna should require an updated computer model unless the mounting structure is substantially uniform over the relocation distance.

VI. CONCLUSION

NAB applauds the Commission's efforts to reduce the burden on FM broadcasters by permitting flexibility in verifying FM antenna directional patterns by either measurement or computer simulation. With appropriate guardrails as described herein, NAB believes that computational simulation of FM directional antennas is already mature and can produce comparable accuracy to physical measurements, thus minimizing the potential for new interference. NAB cautions that the accuracy of computer simulation is fundamentally dependent on the accuracy of the data input to the software and therefore urges the Commission to require that full documentation of the underlying data and its sources be available to the Commission and interested parties upon request. NAB also urges the Commission to ensure that identity, qualifications and experience of the modeler are included

in applications proposing FM directional antennas to ensure transparency.

Respectfully submitted,

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