

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

MM Docket No. 88-56

In the Matter of

Designation of a Standard Computer  
Algorithm for Propagation Prediction  
in the FM and TV Broadcast Services.

#### NOTICE OF PROPOSED RULE MAKING

Adopted: January 29, 1988; Released: February 23, 1988

By the Commission:

#### INTRODUCTION

1. The Commission, on its own motion, initiates this proceeding by proposing to designate the algorithm employed in its computer programs as the standard it will use for propagation calculations in the FM and TV broadcast services. As this algorithm was used to draw the metric curves in the Commission's rules, no changes to the predicted signal strength values represented by the curves will result. Establishing the Commission's algorithm as the official standard for FM and TV propagation calculations will facilitate the resolution of discrepancies that occur when visual readings or other algorithms are used to determine field strength values. Thus, it will further our objective of providing efficient, expeditious service to the public.

#### BACKGROUND

2. A fundamental concern of the Commission and other organizations engaged in spectrum management is the development and utilization of appropriate models of real-world electromagnetic propagation. Through its ongoing propagation analysis program, the Commission collects and studies propagation data, and has been doing so for many years. Generally, radio wave propagation measurement data are gathered, analyzed statistically, and presented in the form of curves drawn on graph paper. This form of presentation has the advantages of compactness, versatility, and ability to readily display relationships among several factors that affect radio wave propagation.

3. The six propagation charts currently contained in our broadcasting rules<sup>1</sup> were developed by a group of engineers from government and industry.<sup>2</sup> They are based on measurement data collected by the Commission and industry over a period of two decades.<sup>3</sup> Each of the charts comprises a set of propagation curves drawn on a linear-logarithmic graph. Three of the charts contain 40 curves each, and the other three contain 50 curves each.

4. Prior to the widespread use of computers, propagation curves were the most practical tool to use for prediction of radio wave propagation for allotment and assignment purposes. Visually reading values from the

curves, however, has always been a laborious task. Today, not unlike the engineer's slide rule, such curves suffer from a relative lack of precision<sup>4</sup> and speed when compared to computer programs. Consequently, many broadcast engineering consultants use computer programs that employ propagation data tables and interpolation algorithms to perform the curve reading function. The Commission's staff also developed and uses such a program.<sup>5</sup>

5. Unfortunately, the various computer programs in use by the consultants do not always agree with each other or with the Commission's program. This happens because they are based on different algorithms, and thus vary with respect to the particular data values, the number of data points used, and the particular interpolation method employed. Because the curves in the rules currently constitute the standard, we have accepted some deviation in submissions based on values taken from the curves.

6. However, we believe that the time has come for a more precise standard. In recent actions, we have created additional classes of FM stations<sup>6</sup>, refined the method we use to classify existing and proposed FM stations and simplified the rule that permits grandfathered short-spaced FM stations to modify their facilities.<sup>7</sup> We have also opened an inquiry into the possible use of directional antennas to permit short-spacing in the FM service.<sup>8</sup> All of these actions place additional importance on calculations involving readings from the propagation curves. The full-power TV service and the Low Power TV service would also benefit from a systematic uniform method for obtaining consistent predictions of coverage and interference.

#### PROPOSAL

7. In the *Notice of Inquiry* looking into the use of directional antennas to permit short-spaced FM assignments, we asked for public comment on the relative advantage of designating the Commission's algorithm as the only computation standard upon which all proposals (for short-spaced FM stations using directional antennas) would be evaluated.<sup>9</sup> A review of the comments received in that proceeding reveals that almost all of those addressing this question favor mathematical methods over the current graphical procedures. These commenters agree with us that the consistent and repeatable determinations of a computer program are preferable to the expenditure of time and other resources to resolve disputes over various readings of the curves. Therefore, we are proposing to designate the Commission's algorithm<sup>10</sup> as the computational standard upon which all proposals in the FM and TV broadcast services will be evaluated.

8. Our proposal would allow applicants and their consultants to continue to use methods other than the proposed standard algorithm for propagation calculations. Enlarged versions of the charts contained in Sections 73.333 (Figures 1 and 1a) and 73.699 (Figures 9, 9a, 10, 10a, 10b, and 10c) will continue to be available for the convenience of those who prefer to use graphical means to perform field strength predictions. We are also considering whether to produce tables of values generated by the proposed standard algorithm, which could be made available in a Technical Memorandum for purchase through our copy contractor or through NTIS to those who wish to use tabular methods.<sup>11</sup> However, in any case where a discrepancy arises, we propose to consider the determinations of our computer programs using the designated algorithm to be deciding. We are proposing to add a

paragraph to each of the rule sections governing prediction of coverage to state this policy. See proposed Sections 73.313, 73.333, 73.509, 73.684, 73.699, 74.705, 74.707, and 74.709 in the Appendix.

9. We recognize that some individual station licensees may evaluate this proposal primarily on the basis of how, if at all, their particular station would be affected. Therefore, at the outset, we emphasize that our intent is not to reclassify or modify any existing station. We are seeking only to codify the more consistent method for propagation prediction calculations that we have been using for more than a decade. Because of the limitations in printing resolution and human visual acuity, it is not unusual for different persons to obtain slightly different results when reading values from the propagation charts. Consequently, there may be some FM stations licensed with a combination of HAAT and ERP that we found acceptable when the values were obtained from the charts, but which we would reject under this proposal because they would exceed (by a small amount) the values obtained using the computer algorithm. Likewise, in the TV broadcast service, some minor variations in the precise locations of Grade A and B contours determined by the computer algorithm as compared to the charts can be expected. We ask for comment on any unintended effects that usage of the more precise computer algorithm may have and suggestions on how to minimize any such effects. We propose to use "grandfather" provisions to prevent hardships to any stations that would otherwise be adversely affected and request comment addressing whether such provisions are needed, and if so, what form they should take.

10. In the comments to another proceeding, it was suggested that a different computer algorithm be established as the standard for propagation calculations.<sup>12</sup> We realize that many consultants are currently using computer programs that they have developed over the years, that these programs usually produce sufficiently precise results, and that they undoubtedly produce more consistent results than one would obtain by simply reading the propagation charts. However, we have more than ten years of experience with our algorithm, and have found it to be more than adequate for our purposes. It is consistent with the curves (in fact, it was used to draw the metric curves), and we already have a considerable amount of developed, debugged, and running software based on it that is an integral part of our licensing processes. In addition, we have provided copies of the software to a number of consulting engineers who have asked to see the algorithm. Therefore, we find that using this algorithm is preferable to using any other.

#### COMMENT PROCEDURE

11. Under procedures set out in Section 1.415 of the rules and regulations, 47 CFR § 1.415, interested persons may file comments on or before April 18, 1988 and reply comments on or before May 3, 1988. All relevant and timely comments will be considered by the Commission before final action is taken in this proceeding. In reaching its decision, the Commission may take into consideration information and ideas not contained in the comments, provided that such information or a writing indicating the nature and source of such information is placed in the public file, and provided that the fact of the Commission's reliance on such information is noted in Report and Order.

12. In accordance with the provisions of Section 1.419 of the Rules and Regulations, 47 CFR § 1.419, formal participants shall file an original and 5 copies of their comments and other materials. Participants wishing each Commissioner to have a personal copy of their comments should file an original and 11 copies. Members of the general public who wish to express their comments are given the same consideration, regardless of the number of copies submitted. All documents will be available for public inspection during regular business hours in the Commission's Public Reference Room at its headquarters in Washington, D.C.

#### EX PARTE CONSIDERATIONS

13. For purposes of this non-restricted notice and comment rule making proceeding, members of the public are advised that *ex parte* presentations are permitted except during the Sunshine Agenda period. See generally Section 1.1206(a). The Sunshine Agenda period is the period of time which commences with the release of a public notice that a matter has been placed on the Sunshine Agenda, and terminates when the Commission (1) releases the text of a decision or order in the matter; (2) issues a public notice stating that the matter has been deleted from the Sunshine Agenda; or (3) issues a public notice stating that the matter has been returned to the staff for further consideration, whichever occurs first. Section 1.1202(f). During the Sunshine Agenda period, no presentations, *ex parte* or otherwise, are permitted unless specifically requested by Commission or staff for the clarification or adduction of evidence or the resolution of issues in the proceeding. Section 1.1203.

14. In general, an *ex parte* presentation is any presentation directed to the merits or outcome of the proceeding made to decision-making personnel which (1) if written, is not served on the parties to the proceeding, or (2), if oral, is made without advance notice to the parties to the proceeding and without opportunity for them to be present. Section 1.1202(b). Any person who submits a written *ex parte* presentation must provide on the same day it is submitted a copy of same to the Commission's Secretary for inclusion in the public record. Any person who makes an oral *ex parte* presentation that presents data or arguments not already reflected in that person's previously-filed written comments, memoranda, or filings in the proceeding must provide on the day of the oral presentation a memorandum to the Secretary (with a copy to the commissioner or staff member involved) which summarizes the data and arguments. Each *ex parte* presentation described above must state on its face that the Secretary has been served, and must also state by docket number the proceeding to which it relates. Section 1.1206.

#### INITIAL REGULATORY FLEXIBILITY ANALYSIS

15. In accordance with Section 605(b) of the Regulatory Flexibility Act of 1980 (Pub. L. 96-354), an Initial Regulatory Flexibility Analysis has been prepared:

### I. Reason for Action

Advancement in computer technology has changed many of the procedures used in the practice of broadcast engineering. One such procedure, the visual reading of curves plotted on graph paper, was widely used in the past to perform radio wave propagation calculations and predict probable signal strengths for FM and TV broadcast facilities. Today this procedure has largely given way to the use of computers to perform the same function more rapidly and precisely. Recent actions affecting the FM and TV broadcast services have increased the importance of precision and repeatability in propagation calculations. Recognizing this, the Commission is proposing to designate a standard computer algorithm that will be used to resolve discrepancies that may occasionally arise from the use of the older graphical method or other computer methods.

### II. Objective

The action proposed is intended to facilitate allotment and assignment procedures in the FM and TV broadcast services, and thus further the Commission's objective of providing efficient, expeditious service to the public.

### III. Legal Basis

The legal basis for the proposed action is contained in Sections 4(i) and 303(r) of the Communications Act of 1934, as amended.

### IV. Description, Potential Impact, and Number of Small Entities Affected

There are approximately 200 small entities (consulting businesses) and a few larger entities that provide engineering services to broadcasters on a contract basis. Some of the small entities already use the Commission's algorithm -- however, many do not. Although the proposed rules would designate the Commission's algorithm as the official computational standard, these rules would not mandate use of the designated algorithm by the aforementioned small entities. Nevertheless, if the Commission ultimately adopts its proposal to designate its algorithm as the official computational standard, some of these small entities may feel compelled for competitive or other reasons to obtain the capability to perform propagation calculations using the designated algorithm. This could involve the purchase of additional computer hardware and software, depending on the small entity's current computer facilities.

### V. Recording, Record Keeping, and Other Compliance Requirements

The subject proposal does not entail any recording, record keeping, or other compliance requirements.

### VI. Federal rules that Overlap, Duplicate, or Conflict with the Proposed Rules

The proposed rules would replace existing rules that specify procedures for visual reading of propagation curves as the computational standard. Consequently, no federal rules would overlap, duplicate, or conflict with the proposed rules.

### VII. Any Significant Alternatives Minimizing Impact on Small Entities and Consistent with Stated Objective

A few of the small entities have developed and are using various algorithms other than the Commission's algorithm for propagation calculations in the FM and TV services. Any one of these might be suitable to accomplish the stated objective and could be designated as the computational standard instead of the Commission's algorithm. However, no matter which algorithm is designated, many of the small entities will not be using that algorithm and some may feel compelled to change to it although the proposed rule would not mandate such a changeover. Furthermore, because the Commission has been using the same algorithm for more than ten years and has made the algorithm available to the small entities and others during this time, it is quite possible that more small entities are already using the Commission's algorithm than any other single algorithm. If this is the case, the Commission's proposal is the course of action having the minimum impact on the small entities.

### OTHER MATTERS

16. The proposal contained herein has been analyzed with respect to the Paperwork Reduction Act of 1980 and found to contain no new or modified form, information collection and/or record-keeping, labeling, disclosure, or record retention requirements; and will not increase or decrease burden hours imposed on the public.

17. IT IS PROPOSED, pursuant to authority contained in Sections 4(i) and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. 154 and 303, That Parts 73 and 74 of the Commission's Rules be AMENDED as set forth in the Appendix below.

### FEDERAL COMMUNICATIONS COMMISSION

H. Walker Feaster, III  
Acting Secretary

### APPENDIX

It is proposed to amend 47 CFR Part 73 as follows:

1. The authority citation for Part 73 would continue to read as follows:

Authority: 47 U.S.C. 154 and 303.

2. 47 CFR 73.313 would be amended by adding an introductory text to read as follows:

§ 73.313 *Prediction of coverage.*

For evaluation of FM propagation calculations based on the field strength curves contained in § 73.333, Figures 1 and 1a, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

\*\*\*\*\*

3. 47 CFR 73.333 would be amended by revising the introductory text, as follows:

**§ 73. 333 Engineering charts.**

This section consists of the following Figures 1 (with sliding scale), 1a, 2, 4 and 5. For evaluation of FM propagation calculations based on the field strength curves contained in Figures 1 and 1a, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

\*\*\*\*\*

4. 47 CFR 73.509 would be amended by adding a new paragraph (c)(4), to read as follows:

**§ 73. 509 Prohibited overlap.**

\*\*\*\*\*

(c) \* \* \*

(4) For evaluation of FM propagation calculations based on the field strength curves contained in § 73.333, Figures 1 and 1a, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

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5. 47 CFR 73.684 would be amended by adding an introductory text, to read as follows:

**§ 73. 684 Prediction of coverage.**

For evaluation of TV propagation calculations based on the field strength curves contained in § 73.699, Figures 9, 9a, 10, 10a, 10b and 10c, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

\*\*\*\*\*

6. 47 CFR 73.699 would be amended by revising the introductory text, as follows:

**§ 73. 699 TV engineering charts.**

This section consists of the following Figures 1-5, 5a, 6-10, 10a-e, 11-12 and 13-16. For evaluation of TV propagation calculations based on the field strength curves contained in § 73.699, Figures 9, 9a, 10, 10a, 10b and 10c, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

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7. A new section, 47 CFR 73.4240, would be added:

**§ 73. 4240 Field strength computer algorithm.**

See paper entitled "Algorithm for Computing Field Strength for FM and TV Broadcast Stations", available from the Commission's copy contractor.

It is proposed to amend 47 CFR Part 74 as follows:

1. The authority citation for Part 74 would continue to read as follows:

**Authority: 47 U.S.C. 154 and 303.**

2. 47 CFR 74.705 would be amended by adding an introductory text to read as follows:

**§ 74. 705 TV broadcast station protection.**

For evaluation of TV, low power TV and TV translator propagation calculations based on the field strength curves contained in § 73.699, Figures 9, 9a, 10, 10a, 10b and 10c, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

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3. 47 CFR 74.707 would be amended by adding an introductory text to read as follows:

**§ 74. 707 Low power TV and TV translator station protection.**

For evaluation of low power TV and TV translator propagation calculations based on the field strength curves contained in § 73.699, Figures 9, 9a, 10, 10a, 10b and 10c, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

\*\*\*\*\*

4. 47 CFR 74.709 would be amended by adding an introductory text to read as follows:

**§ 74. 709 Land mobile station protection.**

For evaluation of low power TV and TV translator propagation calculations based on the field strength curves contained in § 73.699, Figures 9, 9a, 10, 10a, 10b and 10c, values produced by the Commission's computer algorithm (see § 73.4240) shall be considered definitive.

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## FOOTNOTES

<sup>1</sup> These propagation charts establish a correspondence between the effective radiated power (ERP) and antenna height above average terrain (HAAT) of an FM or TV station and the predicted median strength of the signal as a function of distance from the transmitting antenna. The charts are used to determine, among other things, the distance to various field strength contours. Such contour distances are used in FM station application processing to classify stations, determine allowable HAAT/ERP combinations, perform interference calculations for NCE-FM stations, and for other purposes. In the television service, the Grade A and B service contours are determined using the propagation charts.

<sup>2</sup> The curves were published first in "Report of the Working Group for the Engineering Conference in Docket No. 16004, on the Development of New FM and TV Propagation Curves," dated April 12, 1966.

<sup>3</sup> The data and a brief history of the development of the curves may be found in FCC Report R-6502, "Development of New VHF and UHF Propagation Curves for Television Broadcasting," April 26, 1965, and its successor FCC Report R-6602, "Development of VHF and UHF Propagation Curves for TV and FM Broadcasting," September 7, 1966.

<sup>4</sup> We recently adopted a classification system for FM broadcast stations that relies primarily on power and antenna height limitations and secondarily on the rounded distance to the station's 1 mV/m contour or "reference distance." We stated at that time our reluctance to adopt a classification system based solely on field strength contour distances because of the reasonable variations that may occur when different persons read values from the propagation charts in the rules. See *Second Report and Order*, in FCC 87-296, MM Docket 86-144, released September 25, 1987, 2 FCC Rcd 5693 (1987).

<sup>5</sup> The Commission's program, written in FORTRAN, utilizes six data tables and a bivariate interpolation routine. Interested persons should consult the following references for further information on it: (1) FCC/OCE REPORT NO. RS 76-01 "Field Strength Calculation for TV and FM Broadcasting (Computer Program TVFMFS)", by Gary S. Kalagian, January 1976, (2) "A Method of Bivariate Interpolation and Smooth Surface Fitting based on Local Procedures", by Hiroshi Akima, U.S. Department of Commerce, Office of Telecommunications, March 1973, and (3) "Algorithm 474, Bivariate Interpolation and Smooth Surface Fitting Based on Local Procedures"; *Communications of the ACM*, January 1974, Volume 17, Number 1, page 26.

<sup>6</sup> See *Report and Order* in FCC 83-259, BC Docket 80-90, released June 14, 1983, 94 FCC 2d 152 (1983).

<sup>7</sup> See *Second Report and Order*, FCC 87-296, MM Docket 86-144, released September 25, 1987, 2 FCC Rcd 5693 (1987).

<sup>8</sup> See *Notice of Inquiry*, FCC 87-152, MM Docket No. 87-121, released May 26, 1987, 2 FCC Rcd 3141 (1987).

<sup>9</sup> *Id.*, at paragraph 11.

<sup>10</sup> Copies of a comprehensive description of the Commission's algorithm may be obtained from the Commission's copy contractor. This description includes the relevant data tables, boundary conditions, methodology and mathematical formulas. In addition, a U.S. Department of Commerce report describing the bivariate interpolation method (see footnote 5, reference 2) is reproduced in its entirety.

<sup>11</sup> For example, the Commission could create a table of distances to specific contours, as a function of antenna height above average terrain and effective radiated power. If such a table contained a sufficiently large number of distances, relatively simple interpolation methods, such as linear interpolation, could be used to find intermediate values.

<sup>12</sup> The firm of Hammett & Edison, Inc., Consulting Engineers, (H&E) submitted an extensive description of its curve reading and interpolation algorithm to the record established by the *Notice of Proposed Rule Making* in MM Docket 86-144. H&E's algorithm utilizes six data tables and a combination linear/logarithmic interpolation method. It was written in reverse Polish notation for execution on a Hewlett-Packard HP-41CX hand-held calculator. H&E claimed that its method is precise and accurate, and urged that it be adopted instead of the index method of FM station classification then under consideration. H&E also provided source code for BASIC and FORTRAN computer language programs employing the same algorithm.