AM ANALYSIS MODEL

Phillip G. Tremper and Gary L. Stanford

Federal Communications Commission

ABSTRACT

An AM analysis model has been developed by the Office of Science and Technology for use by the Broadcast Bureau of the Federal Communications Commission (FCC) as a spectrum planning tool. This model was designed to determine the technical feasibility and the practical desirability of reducing the AM channel spacing from 10 to 9 kHz. Additionally, the model was designed to provide an interference analysis capability for AM station license applications. This paper discusses the model's design, development, and analytical processes, the problems encountered with the testing and use of the model, and the uses of the model as a spectrum management tool.

BACKGROUND

In August 1979 the FCC established the 9 kHz AM Task Force to examine the feasibility of changing the AM channel spacing from 10 kHz to 9 kHz. In December 1979 the FCC recommended that the United States should favor the reduction from 10 to 9 kHz and should make such a proposal at the Region 2 MF Broadcast Conference in Buenos Aires, Argentina in March 1980. This proposal was later adopted by the Department of State and presented as a proposal at the Buenos Aires Conference. Included in the Commission's consideration were estimates of the number of new station assignments which could be assigned on the so called "free" channels. These estimates were derived from several sources and needed to be verified. An analysis model was developed which could compute these numbers more definitively and which could also be used to evaluate the interference problems of AM station license applications in either the 10 or the 9 kHz channel spacing plans.

At Buenos Aires, the 9 kHz proposal was extensively discussed, but the decision was deferred until the Second Session of the Region 2 Conference to be held in November 1981. However, a related item was passed which stipulated that all Region 2 countries must submit their basic AM station inventories to the International Telecommunications Union (ITU) by May 31, 1980. Although, this appeared to be a simple task, the FCC encountered two major problems. One was the present state of the North American Regional Broadcasting Agreement (NARBA). If NARBA were abrogated, then the U.S. clear channel frequencies now protected to the international border by the

agreement would lose this high degree of protection. In essence, the clear channel frequencies of the U.S. would become available to all countries. The second was the inventory had to include only stations that were to be operational by December 31, 1982. This meant the U.S. had to plan its future assignments rather than to follow the existing policy of letting the demand for stations dictate who would receive licenses to operate. When the delegation returned from Argentina, the AM analysis model was augmented to assist in the resolution of these problems.

DESIGN CONSIDERATIONS

The model was designed as an AM assignment and evaluation model with the primary user considerations being flexibility and adaptability. The flexibility was designed into the model by allowing the user the ability to change and vary critical parameters. As an example, all interference tolerance limitations are inputs to the model and can be changed at the user's discretion without changing the logic of the model. Designing adaptability into the model was accomplished by the use of structured and modular programming practices. We were aware of improvements being made to the existing sky-wave and ground-wave curves and when these improvements were finalized we planned to incorporate the changes into the model. Accordingly, changing the propagation curves could be accomplished by the replacement of one program module without a change to other modules. The next design consideration was with respect to the data bases. The data bases required of the model were digitized ground wave propagation curves [1], digitized M3 conductivity data [1], the existing FCC's AM station data base [2], and the Geographic Data File's state/county coordinate and population data base [3]. In October 1979 when the model was first defined, none of these data bases was being used in a highly computational mode of operation. This type of processing would be required in the AM model.

[1] Data base developed by Hammett-Edison, Inc., Consulting Engineers, San Francisco, California, under contract to the FCC.

[2] Data base built and verified by Silliman, Moffet, & Kowalski, Consulting Engineers, Washington, D.C., under contract to the FCC.

[3] Data file purchased from List Processing, Inc., Addison, Illinois

Another consideration was concerned with the specific analytical processes which had to be performed. These analyses were derived from the Broadcast Bureau's existing manual and automated application processing techniques. The computerized elements being used were all processing in an independent, non-continuous mode. These elements had to be reformatted/modified to process in one continuous system.

The final design consideration was how the user communicated with the model. The user needed the ability to define the accuracy of the computations, to examine the detailed computations, to accept those interference levels which exceeded the limits but were tolerable, and to interact with the model.

LOGICAL FLOW OF THE MODEL

The model was developed as a time-sharing program for operation on a Honeywell 6088 computer. The logic of the model is to input proposed station parameters, to analyze the proposed station for interference to and from existing stations, and to output a summary of the analyses. Figure 1 is a functional flow diagram of the model. The inputs to the model are divided into five information groupings: frequency definitions, area definitions, one station definition, interference criteria, and accuracy/reporting definitions. The model steps through each of the input requests via an option selection process. All of the input requests have at least two selectable options, either pre-established data options or user supplied data options. The pre-established data options were set-up to minimize the user's time required to specify standard data such as the use of the existing FCC Rules interference criteria.

From these inputs the model begins processing the proposed station at each of the locations on each of the frequencies. The order of processing is established by the user's assignment of a priority to each location and frequency entered. The night-time and the day-time theoretical interference limits are then computed to and from all applicable existing stations in the AM data base. If the interference values computed exceed the interference limitations, the model rejects the proposed station frequency and tries the next frequency entered. If the model rejects all of the entered frequencies, the site location is defined as unassignable and the next site is processed, re-initializing the frequency list. If the model finds a frequency at a location which passes all the interference criteria tests, the location is assignable on that particular frequency. This assignment is then recorded into a temporary data base for consideration as an existing station in the next analysis. The model continues with the next location in the list. Again, the frequency list is re-initialized. When all sites have been processed, yielding 0 or 1 assignment per site, the model asks if the sites should be analyzed again. If the user responds positively, the entire process is repeated for all sites having one assignment. This second and

succeeding passes will attempt to find other frequencies which can be assigned at the sites.

Standard printouts are generated to inform the user which frequency and site is being processed, when interference limits have been exceeded, and which frequency and site assignment has been made by the model. The user may request detailed and intermediate printouts in addition to the standard printouts. The detailed printouts present at least one print line per program module called; whereas, the intermediate printouts are more structured and concise. As an example, for a night-time analysis

the intermediate printouts would be a line for each existing station's combined root-sum-square (RSS) limit followed by the RSS limit to the proposed station. The detailed printouts would be multiple lines of printout showing such computations as the sky-wave field factor, the unattenuated field at a mile, and the RSS contributing limit of each existing station in the data base. At the conclusion of the processing, a summary table (Table 1) is printed identifying the number of assignments made at each site and on each frequency defined.

TABLE 1
SAMPLE FINAL OUTPUT REPORT

Evaluation Statistics

Frequency (kHz)	New Station Assignments
585	20
675	12
765	8
855	9

Totals 4 Frequencies
49 New Station Assignments

Area Identification	New Station Assignments
City 1	1
City 2	3
City 3	1
.	.
.	.
City n	4

Totals 200 Areas
49 New Station Assignments

FEATURES OF THE MODEL

As an assignment model, the user has the ability to examine multiple sites and multiple frequencies within one analysis. Specifically, the model can process up to 300 sites and 125 frequencies within one analysis. It can process this combination of sites and frequencies for as many times as there are assignments still to be made or until the computer time runs out. Once a theoretical assignment is made, the model considers this assignment as included in the existing AM station data base, i.e. these assignments are protected from interference as if they were existing stations. Although theoretical interference limitations are the bases for channel assignments and channel rejections, the user has the option of overruling the rejection if the user wishes to

accept the interference. The standard separation and interference criteria used by the model are shown in Figure 2. Any or all of these values may be changed at the user's option. This option is particularly important from a political standpoint, because of the cases where having a station in a special area is more important than the amount of area coverage a proposed station has.

FIGURE 2
AM ANALYSIS MODEL
STANDARD SEPARATION AND INTERFERENCE CRITERIA

DAY-TIME CO-CHANNEL LIMITATIONS					
STATION CLASS	EXISTING STATION		PROPOSED STATION		MAXIMUM PROTECTION DISTANCE
	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	
CLASS I-A	0.100	0.005	0.100	0.005	1300.00
CLASS I-B	0.100	0.005	0.100	0.005	1300.00
NON CLASS I	0.500	0.025	0.500	0.025	1000.00
DAY-TIME ADJACENT CHANNEL LIMITATIONS					
ADJACENT CHANNEL	EXISTING STATION		PROPOSED STATION		MAXIMUM PROTECTION DISTANCE
	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	
ADJACENT CHANNEL 1	0.500	0.500	0.500	0.500	500.00
ADJACENT CHANNEL 2	2.000	25.000	2.000	25.000	300.00
ADJACENT CHANNEL 3	25.000	25.000	25.000	25.000	50.00
NIGHT-TIME CO-CHANNEL LIMITATIONS					
STATION CLASS	EXISTING STATION		PROPOSED STATION		CALCULATION METHOD
	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	PROTECTED CONTOUR (MV/M)	INTERFERING CONTOUR (MV/M)	
CLASS I-A	0.500	20.0:1	0.500	20.0:1	50% SW - 10% SW
CLASS I-B	0.500	20.0:1	0.500	20.0:1	50% SW - 10% SW
CLASS II	2.500	20.0:1	2.500	20.0:1	GW - 10% RSS SW
CLASS III-A	2.500	20.0:1	2.500	20.0:1	GW - 10% RSS SW
CLASS III-B	4.000	20.0:1	4.000	20.0:1	GW - 10% RSS SW
CLASS IV					NONE

The model has the ability to select sites by state, county, and population within the county and the ability to transpose the existing station data base from the standard 10 kHz spacing to any other defined spacing. These latter features were essential in determining the number of new assignments which could be made using the 9 kHz channeling plan.

PROBLEMS ENCOUNTERED

With the development of this model, and for that matter any model, problems will be encountered. There were two main problem areas experienced with the development of this model: data accuracy and criteria formulation. Data accuracy caused many problems in verifying the model accuracy and correctness. As examples, the AM data base was not complete or accurate during the development period making the testing of the model extremely difficult. The digitized M3 conductivity data base had inconsistencies in it which kept appearing at inopportune times. Finally, the digitized propagation curves had discontinuities which caused the model to either error off when the discontinuity was encountered or to produce erroneous results. Both caused problems.

The criteria formulation problem areas were the most difficult to resolve. Let us first define what is meant by criteria formulation. Criteria formulation is the process of defining the assumptions used by the model.

The first criteria formulation problem arose with the definition of the 9 kHz channeling plan. Typical questions were:

1. How does the 9 kHz plan interact with the 10 kHz plan?
2. What propagation curves should be used for those 9 kHz channels which fall between sets of ground wave curves?
3. Where should the 9 kHz plan start to produce the minimum impact on existing stations?

If an engineer were to manually analyze the problem, he would simply do what seemed to be reasonable, possibly write down his assumption, and go on with the analysis. The model on the other hand can not determine at run time what is reasonable, therefore all the rules must be established prior to the running of the model, i.e. the assumptions had to be documented. The assumptions made in this example were:

1. The model would only operate in one channeling plan at a time.
2. The 10 kHz propagation curves closest in frequency to the 9 kHz frequency will be used for the between channels.
3. The standard 9 kHz plan will start with center frequency at 540 kHz; however, the user can specify any starting point via inputs.

Another criteria formulation problem was when to reject a proposed station due to interference received from the existing stations. Interference caused by the proposed to the existing stations was adequate rejection criteria, but interference received by the proposed station was not. One solution was to use the same criteria for both, but this was too restrictive and not consistent with the way the Commission processes applications. Another solution was not to protect proposed stations at all. This was not restrictive enough. The solution agreed upon and incorporated into the model was to establish standard interference limitations to the proposed stations the same as those to the existing stations and to give the user the ability to change them during the input process or to overrule the proposed stations rejected for this reason. Some other criteria formulation problems were:

1. What accuracy was required of the model and how could the accuracy be measured or defined?
2. When could the night/day time interference computations be skipped without any adverse affect on the results of the model?
3. When should applications be included in the protection analyses and when shouldn't they be included?
4. What priority scheme should be used for assignment?

It should be noted here that each assumption affects the results and the accuracy of the results. The job of the model developer should be to identify the assumptions made in the model and

to quantify the effect these assumptions have on the model. There are no perfect models and all model results should be qualified with accuracy or confidence statements.

SAMPLE USE OF THE MODEL

The first use of the model was in the preparation of the FCC's inventory submission, due May 31, 1980. As mentioned above in the background section, the FCC was faced with the decision of determining where the United States needed AM broadcast stations, what type of stations could be accommodated, and how many stations could be operational by December 31, 1982? The solutions were partially analytical and partially political. The FCC wanted, if possible, to utilize the Class 1A station frequencies to plan for new stations. The FCC knew of approximately 300 to 400 cities which needed AM service. The FCC was able to prioritize the 300 to 400 cities and proceeded to make the analyses. The first result from the model was a matrix of those cities which were not excluded by the existing Class 1A stations. The second result was another matrix of those cities which also passed the co-channel and adjacent channel ground wave interference checks against the existing AM data base. The third and final result was the list of proposed sites which additionally passed the sky-wave interference checks. Approximately twenty-five of these sites were incorporated into the May 31, 1980 inventory. The reason for the three step process was primarily budgetary, in that the computer resources were limited and expensive.

The next planned use of the model will be in support of the second U.S. inventory submission to the ITU, due May 31, 1981. This inventory will include any 9 kHz change-over station assignments.

CONCLUSIONS

The FCC now has the capability to automatically evaluate proposed AM station applications for potential interference, to analyze the impact of different channeling plans and allocation schemes, and to analyze the impact of different interference criteria. This capability did not exist previously.