REPORT
TO
THE ALLOCATIONS RESEARCH COUNCIL
ON
A MEANS OF REASSIGNING THE LOWEST 7 UHF TV CHANNELS FROM THE TELEVISION TO THE LAND MOBILE SERVICE
BY
MAKING REASONABLE CHANGES IN THE UHF TV MILEAGE SEPARATION STANDARDS

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CONCLUSION

Allocation studies have been made which show that it would be possible to divert the lowest 7 UHF television channels from television to land mobile service and to retain in the remaining channels below channel 70 essentially the present number of total assignments by modifying certain of the UHF separation requirements. All but 14 of the 795 cities listed in the Table of Assignments now in the Rules of the Federal Communications Commission would have the same number of assignments as at present and all but 15 of the 1778 assignments would be available.

An adequate program of testing would provide the factual basis for the Commission to decide that the changes should be made.

In diverting the lowest 7 UHF TV channels, existing stations, now operating on those channels, were reassigned a new channel. Over 85 percent of the reassignments were on channel 40 or below. As a practical matter, no existing station need be required to change channels for a period of years, and it is expected that many, and perhaps most, could continue on their present channel indefinitely.

INTRODUCTION

There has long been a well recognized need for additional channels for the land mobile services. The earlier approaches to satisfy this need have been directed largely to greater use of the band of frequencies allocated for the land mobile services. The frequency band-width assigned for individual channels in this service has been halved and halved again, for the present exhausting the possibilities of this procedure for the forseeable future. The need for additional channels not only still exists but also continues to grow.

In March, 1964, the FCC issued a Notice of Inquiry in Docket 15398 looking toward alleviation of the land mobile problem by the more efficient use of the frequency band 150.8 to 162.0 megahertz and by the sharing of frequencies with the VHF television broadcast service. That notice recognized, but rejected, the possibility of sharing the spectrum with the UHF television broadcast service also because the UHF television assignment system was in a state of flux as a result of considerations in the then pending Docket 14229.

In July, 1966, the Commission issued a Further Notice of Inquiry in Docket 15398 to look further into the possibility of sharing with VHF television. In response to that Further Notice, this firm filed comments with the Commission pointing out that the earlier reason for not considering the possibility of sharing the spectrum with the UHF television band no longer was applicable. Since the proceeding in Docket 14229 has been completed (except for consideration of the uppermost 14 channels), the UHF Table of Assignments was essentially as fixed as the table for VHF assignments. It was also pointed out that there were an average of 45 operating stations on each of the 12 VHF channels and an average of only 2 operating stations on each of 70 UHF channels. As a result, it seemed possible and also necessary to consider sharing the spectrum with the UHF television broadcast band, and reassigning some of the UHF television band for the exclusive use of land mobile facilities.

Not long afterwards, a group of land mobile radio service users and manufacturers of equipment for that service banded together to form the Allocations Research Council, which employed this firm to make studies looking toward obtaining additional frequencies for the land mobile service from the UHF television broadcast band while retaining the same number of assignments in each community as were listed in the Table of Assignments in the Commissions Rules.

PRELIMINARY DISCUSSION AND SUMMARY

This firm was employed by the Allocation Research Council to investigate the technical feasibility of diverting a number of UHF channels from television to land mobile use. In comparison with VHF television channels which, on the average, have been listed as available (assigned) to over 50 cities per channel in the Continental United States, UHF television channels have been assigned to approximately 20 cities per channel. With regard to the use made of the assignments, there are nearly 50 operating stations per VHF channel and fewer than 5 per UHF channel. If applications for construction permit and authorizations to construct are added to the operating UHF stations, the total is still fewer than 10 per channel. The difference in channel utilization is greater than 5 to 1. Thus, space should be available in the UHF television band for all UHF television assignments and some Land Mobile assignments. It was decided to seek Land Mobile assignments at the lower end of the UHF television band since only these frequencies would offer almost immediate relief to the pressing needs of the Land Mobile services, present equipment designed for the frequencies immediately below TV Channel 14 to some extent capable of extension upward in the TV band.

In initial discussions,it was expected that it would be necessary to make changes in the UHF TV mileage separation requirements (taboos) in order to provide for all of the present TV assignments after diverting an adequate number of UHF television channels to Land Mobile use. The alternatives faced were either making a serious investigation of the taboos first, determining which could be modified, and then determining whether those modifications were sufficient to permit diverting the necessary channels from television to land mobile use or, as the other alternative, making engineering judgements as to what taboos might successfully be modified and then determining whether the changes judged to be feasible would permit the desired reallocation, and diversion of channels to land mobile use. It was decided to make judgements about the possibility of modifying taboos and then to determine whether a suitable reallocation could be made.

The basic ground-rules for the investigation were:

A. All existing TV stations were to be maintained on their present channels except those stations which were on channels 14 through 20 and those stations were to be given the lowest possible new channel assignments.

B. Each community listed in the Federal Communications Commission Table of Assignments was to have the same number of assignments as presently listed insofar as possible, and no substantial number of unsatisfied requirements were to be permitted.

C. If possible, the FCC computer program, with its priorities and procedures, was to be used with a minimum of modification.

D. Changes would be proposed in those UHF taboos which seemed most amenable to modification.

E. No changes were to be made in the Canadian or Mexican assignments or in any taboo requirements affecting their assignment.

The taboos considered to be most easily attacked at their present separations were the intermodulation, the picture and sound image, the I.F. beat and the local oscillator taboos.

While it was expected that the present number of UHF TV assignments could be made in fewer TV channels by changing the taboos, there was no basis for judgement as to the effect of any taboo change on the number of channels which might be diverted. As a result, a series of preliminary investigations, considered to be probing or exploratory in nature, were made with the intent of obtaining a basis for judgement as to the trade off between the number of channels diverted and the taboo changes contemplated. All of these preliminary runs considered only the northeastern part of the Continental United States (NEUS) in order to save computer time and cost.

The conclusion drawn from the probing runs was that 7 channels could be diverted if the intermodulation and I.F. beat 20 mile taboos were eliminated and if the picture and sound image taboos were reduced from 75 miles to 60, and from 60 to 50 miles respectively. No other taboo changes would be necessary.

The final computer run, for the entire Continental United States, was made in two parts. The first part considered only existing stations. Stations on channels 14 through 20 were reassigned the lowest possible new channel while stations on channel 21 or above were continued on their existing assignments. During this portion of the run unused assignments were deleted from the Table of Assignments. The second part of the run then filled out the Table of Assignments.

In this investigation, it was considered that operating stations and each assignment for which there was an outstanding construction permit issued in 1965 or later were existing stations and all others were unused assignments. This approach was intended to assure maximum flexibility in making the new assignments and greater chance of success in making the same total number of assignments to each community as in the present table. The cut-off date for existing stations was April 1, 1968.

The results of the nationwide computer run are given in the following appendices.

I. Changes in channel assignments for existing stations on Channels 14 through 20.

II. Comparison of Tables of Assignments, the present table using Channels 14 through 69, and a possible Table of Assignments using Channels 21 through 69.

III. List of communities with unsatisfied assignment requirements.

IV. Table showing use made of modified UHF TV mileage separation requirements (taboos).

REASONS FOR CONSIDERING THE UHF TELEVISION BAND

Some perspective as to the relative use of the VHF and UHF television band may be gained from the facts in the following table:

		VHF CH 2 - 13	UHF CH 14 - 83 (LESS CH 37)	UHF CH 14 - 69 (LESS CH 37)
1.	Number of Channels	12	69	55
2.	Number of Assignments	662	1118	1116
	Per Channel	55.2	16.2	20.3
3.	Number of Operating Stations	577	229	229
	Per Channel	48.1	3.3	4.2
4.	Number of Outstanding Permits	14	206	206
	Per Channel	1.2	3.0	3.7
5.	Number of Pending Applications	50	79	79
	Per Channel	4.2	1.1	1.4
6.	Total (3, 4 and 5)	641	514	514
	Per Channel	53.4	7.4	9.3

The information on operating stations, outstanding permits and pending applications was here taken from the August 12, 1968, Addenda to TV Digest. Pending applications in some cases include multiple applications for the same assignment so that the number of facilities to be expected must be less than the number given. Note also that, elsewhere in this report, the term existing stations has been applied to operating stations and outstanding permits issued in 1965, or later, and thus includes most of the operating stations and outstanding permits.

A closer look at the assignments in the UHF TV band shows that it tends to vary from a high of approximately 50 assignments per channel at the low end of the band to 4 to 8 assignments per channel at the high end of the band. It is to be noted that the co-channel separation requirements on UHF television are, in each zone, some 15 miles less than the corresponding co-channel separation requirements for VHF television stations, a fact which should tend to increase the number of UHF assignments per channel relative to the number of VHF assignments per channel. The UHF situation is complicated by the existence of a number of additional separation requirements making allowance for the possibility of problems with regard to adjacent channel interference, to interference on the sound and picture image frequencies, to interference caused by local oscillator radiation, and to interference caused by various intermodulation products between two stations causing interference to a third station. The various separation requirements imposed are commonly called the "UHF taboos". Since all but one of the taboos operate with respect to channels both above and below the channel under consideration, there will be more impact from the taboos in the middle of the UHF band which should result in a somewhat lesser number of assignments per channel there than at either end of the band. This is not the case, however. Although there are more assignments per channel at the lower end of the band than at midband, there are still fewer assignments at the upper end of the band than at midband. It is thus obvious that the total number of UHF television assignments could be increased by making increased numbers of assignments on the upper channels.

The number of existing stations is very much less than the number of assignments as may be seen from the foregoing table. It was not expected that an excessive number of existing stations would actually be affected, and even those stations might be permitted to continue on their present channels for many years.

REASONS FOR CONSIDERING THE LOWER END OF THE UHF TELEVISION BAND

Once it had been decided that the logical place from which to gain frequencies for the land mobile services was the UHF television broadcast band, the question was raised as to what portion of the UHF television broadcast band could best be used by the land mobile services. With regard to this point, there is only one clear cut answer. The land mobile services now make use of equipment designed to operate in the band of frequencies immediately below the UHF broadcast spectrum. This equipment design can be extended upward into the lower portion of the UHF TV spectrum to some extent. The availability of the lowest portion of the UHF television broadcast spectrum would therefore offer almost immediate relief to the pressing needs of the land mobile services. If the upper end of the UHF TV spectrum were to be made available, it would be found that there is no equipment presently available to use on those frequencies. Use of the upper end of the UHF TV spectrum would be delayed a number of years while suitable equipment was being designed, developed and put to use.

Delay is not the only factor in the decision to consider the lower end of the VHF TV band instead of the upper. Channels 14 through 20 occupy the frequency band from 470 to 512 MHz while channels 70 through 83 occupy the band from 806 to 890 MHz. The ratio of frequency is nearly two to one. This fact results in a difference in propagation characteristics. Attenuation of signals by trees and foliage is greater at the higher frequencies. Propagation losses resulting from hills, buildings or other obstructions in the path are also greater at the higher frequencies. On the other hand, in highly built up areas, there is some filling in of deeply shadowed areas which tends to be more effective at the higher frequencies. Thus, the lower frequencies will better serve a longer range suburban type of service while the higher frequencies may be better for various shorter range urban services, or at least are better suited for the latter than the former. As the Report of the Advisory Committee for the Land Mobile Radio Services said in the Summary of Conclusions to its study of the Suitability of Various Frequency Bands for Land Mobile Radio Use:

> "For short range under high noise environments, the band from 400 to 600 MHz gives the best results;
>
> For very short ranges and for some applications the band from 600 to 1000 MHz is suitable."

In addition, these upper TV channels are the subject of the unfinished part of Docket 14229. As a result of these considerations, the only hope for early relief of the land mobile problem and the best solution to it appeared to lie in the use of these lower UHF television broadcast channels. Although there would be some impact on operating low channel UHF stations, this impact would not be immediate in any area.

THE PLAN FOR PROCEEDING

As a result of the above considerations, our first efforts were devoted to finding what block of channels at the lowest end of the UHF spectrum might be cleared of television broadcast stations over a predetermined period of time and made available for the sole use of the land mobile facilities, and yet maintain essentially the present number of UHF TV assignments per community on the remaining channels.

After preliminary investigation, the Allocation Research Council decided to proceed with studies looking toward the diversion of the lowest 7 UHF TV channels to land mobile use.

ALTERNATIVE APPROACHES TO THE REALLOCATION OF UHF TV ASSIGNMENTS AFTER DIVERTING CHANNELS FOR LAND MOBILE USE

The approach used in the study reported herein was based on the use of the FCC computer program and the decision to maintain existing stations on their currently assigned channels except, of course, where the channels would be diverted from TV use to land mobile use. If consideration were to be given to a reallocation plan which would not require that existing station be maintained on their currently assigned channels, then there are at least two alternatives which would permit the assignment of the same number of channels in each community as are now listed in the Rules of the Federal Communications Commission.

One simple approach would be to slide or translate all the assignments upward by the number of channels diverted. There are presently very few assignments on the upper channels which would, under this scheme, be moved upwards to channel 70 or above. It would, therefore, be a simple matter to find new assignments for the thirty or so assignments which would be affected by the general translation of all assignments if, indeed, that were necessary. There is one additional factor to consider in an approach such as this. Channel 37 is presently free of assignments and the Rules provide that it will be kept free of Assignments for several more years. The translation process would result in the free channel being higher than channel 37 by the same number of channels as would be diverted to land mobile use. This change in the cleared channel may not be practical because of the investment in scientific receiving equipment designed for operation in the presently cleared channel 37. It should not be difficult to find other channels for those facilities which would, under a translation or a sliding upwards of channels, be reassigned to channel 37. There would also be a channel with no assignments corresponding to the channel which is today channel 37 and, after the translation process, would be some higher channel. There is no doubt that further reassignment can be made of any channel which under the translation process would fall on channel 37.

A variation of this approach would tolerate the intrusion of additional assignments on channel 70 and above. This alternative would not require any reallocation effort other than the reassignment from channel 37, if that should be necessary, and the finding of new assignments for those now on a channel which would fall above channel 83.

Another simple procedure would invert channels so that all the assignments on channel 14 now would fall on channel 69 and all assignments on 69 would fall on 14. Channel 15 assignments would then become channel 68 assignments and channel 68 assignments would become channel 15 assignments, etc. The relatively few assignments which are now listed on the upper channels would fall on the lower channels which would be diverted. This fact would make it very much easier to find replacement assignments. Special consideration would have to given to channel 37 in this procedure also since channel 37 would invert to channel 46. Some of these undoubtedly could be accommodated on channel 46 again since there would be no other assignments on that channel. There is no doubt that suitable reassignment could be made of any other assignment falling on channel 37.

Neither of the above schemes is proposed because each has the major disadvantage of causing a change in every operating facility. Either the translation or the inversion scheme could almost certainly be applied without any change in the taboo standards.

The only reason for mentioning these possibilities is to demonstrate that other tables of assignment, which will achieve the objective of assigning the same number of channels to each community as are assigned in the present assignments, can be made with fewer channels while retaining the present taboo separation and thus that the efficiency of use of the spectrum can be improved. It is clear that there is room in the UHF TV band for land mobile services.

The approach which has been followed, that is, to leave all existing stations on their present assignments, except those on channels diverted to land mobile use, and then to make assignments within the framework of the existing stations actually poses a more difficult assignment problem and, in order to achieve the objective of having the same number of assignments in each community as the present Table provides, it is necessary to make changes in certain of the taboo standards.

THE USE OF A COMPUTER FOR THE TV REALLOCATION STUDIES

The Federal Communications Commission had developed the Table of Assignments for UHF television broadcast stations by the use of a computer program which their staff had devised. A request was made on behalf of the Allocation Research Council for access to the Commission's assignment program and it was graciously made available. Discussions were held with various members of the Commission's Staff as to the philosophy behind the program and, when it became necessary, the Commission permitted employment of one of its staff members to actually put the program on an outside computer which was leased for the Allocation Research Council. The employment of the Commission staff member was with the clear understanding that he would not be called upon for any assistance other than the technical programming assistance needed in converting our bases for changes in the allocation structure to computer language so that the Commission's program could be used on the outside computer.

The following ground rules were established for making the computer studies:

A. The FCC computer program would be used retaining the same requirements and procedures as to the following:

   (1) The communities to be considered.

   (2) The number of channels required in each community.

   (3) The selection of the community to be considered at any stage in the program.

   (4) The selection of the channel to be assigned to a community where alternatives were available. 1/

B. Changes in the basic computer program would be made only with regard to:

   (1) The number of channels to be used for the TV allocations.

   (2) The mileage separations required for certain taboos.

C. No changes would be made with regard to Canadian or Mexican assignments or the taboo separation requirements used with respect to them.

D. The channels used by existing United States stations would not be changed except for channels proposed to be diverted from TV to land mobile use.

In making assignments, channel 37 was kept void of all assignments and no new assignments were made on channels 70 through 83 although, where the present Table of Assignments does list assignments in that group of frequencies, those assignments were continued. For example, in efforts to delete the lowest 7 channels from television use, the channels which remained for use were channels 21 through 69, with the exception of channel 37, and any existing assignments on channels 70 to 83.

It was set as an objective that, as assignments were deleted from the lowest group of channels, the lowest possible channel would be found for each presently used assignment. In this connection, a broad meaning for "presently used" was used, including not only operating stations and stations which were actually under construction but also stations which had construction permits with no actual construction underway if the permits were issued since January 1, 1965. Assignments for which there were pending applications or long dormant outstanding construction permits were not, however, considered to have existing stations. There should be little or no cost to the permittee or applicant if required to change frequencies. This evaluation as to existing stations was made as of April 1, 1968. A current evaluation would show some changes.

The basic procedure followed was to delete all assignments in the selected lowest group of channels and to delete all unused assignments whether in the lowest group or not. Then, within the framework of existing stations as defined above, new assignments were found for the existing stations displaced from the cleared group of channels. At this point, the results were examined to be sure that all existing stations had been replaced with the lowest possible channel. The computer was then asked to replace assignments in each community listed in the Table of Assignments until there were the same total number of assignments as in the Table presently in the Rules.

In order to save running time and costs, preliminary studies were limited to an area in the northeast part of the United States which contained approximately half of the total UHF

1/ Displaced existing stations were assigned on the lowest channel.

television assignments. This was the same technique and, as a matter of fact, the very same area which the Commission had used in some of its studies of allocation possibilities.

The first investigation of the northeast part of the United States attempted to delete from television use the lowest UHF TV channels and to make replacement assignments using the table of taboo separations as they now exist in the Rules. This attempt failed to find new assignments for all of the existing stations. This confirmed the judgement that, if we were to have the same total number of assignments in each city, it would be necessary to make changes in some taboos.

GENERAL DISCUSSION OF TABOOS

Regular VHF television broadcasting started after World War II. By 1948, operating experience indicated the need for a revision of the Commission's technical Rules. A freeze on new applications was declared and a hearing, which was not finally decided until 1952, was held. In that hearing, consideration was also given to the use of UHF channels and to the possibility of interference between UHF TV stations. It was decided to cope with interference solely by maintaining specified mileage separation between stations which might cause interference to one another. Very little information was available about UHF propagation or about the characteristics of future UHF receivers. With little in the way of facts, arbitrary judgements had to be made as to propagation and receiver characteristics. Various possible types of interference were considered, each of which involved certain frequency separations between the stations being considered. The resulting separation requirements, relating mileage separation to frequency (channel) separation, became generally known as the "taboos". At mid-band UHF some 21 taboos are considered for each assignment. At VHF only co-channel and adjacent channel interference are recognized by the Commission's Rules, because VHF stations occupy two separated frequency bands, neither of which is sufficiently extensive to permit most of the other types of interference considered.

The following table lists the present UHF taboos.

Taboo	Channel Separation	Mileage Separation
Co-channel	0 channels	155 miles in Northeastern U. S.
		175 miles in most of the U. S.
		205 miles in Gulf Coast area
Adjacent channel	± 1 channel	55 miles in all of U. S.
Intermodulation	± 2, 3, 4, 5 channels	20 miles in all of U. S.
I.F. Beat	± 7, 8 channels	20 miles in all of U. S.
Picture Image	± 15 channels	75 miles in all of U. S.
Sound Image	± 14 channels	60 miles in all of U. S.
Local Oscillator	± 7 channels	60 miles in all of U. S.

The nature of each type of interference and the channel separations are reasonably self explanatory. The use of the ± designation may be made clear by an example. Consider a receiver tuned to channel 40. Its local oscillator operates in channel 47 and, if it radiates, may cause interference to the reception of channel 47 by a nearby receiver. On the other hand, the channel 40 receiver may be subject to interference resulting from radiation of the local oscillator of a nearby receiver tuned to channel 33. Thus channel 40 may cause interference to channel 47 and suffer interference from channel 33, and the taboo requirement is ± 7 channels.

The following table briefly summarizes the importance of the major factors which must be evaluated in considering each taboo.

	Importance of Factors Indicated			
Taboo	Propagation	Receiving Antenna	Receiver Characteristics	Other Comments
Co-channel	Major	Intermediate	No	Frequency offset
Adjacent Channel	Intermediate	Intermediate	Major	-
Intermodulation	Minor	Intermediate	Major	Interference only to particular 3rd stations
I.F. Beat	Minor	Intermediate	Major	-
Picture Image	Intermediate	Intermediate	Major	Attention to individual affected receivers likely
Sound Image	Intermediate	Intermediate	Major	No change has been made although aural power of broadcast stations has been reduced
Local Oscillator	Intermediate	Intermediate	Major	-

The Commission has never given weight to receiving antenna characteristics although one Rule Making proposed to do so.

UHF propagation is the subject of an undecided Rule Making Proceeding, Docket 16004. It is likely that an extensive program of measurement and analysis would be necessary in order to establish a readily applied and generally accepted means of predicting UHF service and interfering signals, although there seem to be preliminary indications, by way of statements in other Rule Making Proceedings, that the Commission might adopt certain curves considered in Docket 16004. It was decided not to propose any change in taboos in which propagation was a major factor and to investigate those in which it was considered a minor factor. As a result, no proposal is made with regard to the co-channel taboos. As discussed later, investigation led to the proposal to change the intermodulation and I.F. beat taboos in which propagation is a minor factor.

It was judged that a serious investigation of receiver characteristics would justify changes in taboos other than the co-channel. It was reasoned and confirmed in the study that the taboos requiring greater distance separations would have greater impact on the allocation structure than those requiring shorter separations. This led to investigation of the image taboos and the proposal that they be modified. The computer studies led to the conclusion that it would not be necessary to modify other taboos to achieve the desired objective. The local oscillator taboo was investigated in the preliminary stages but did not greatly improve the ability to assign channels and is not proposed to be changed. The adjacent channel taboo was not seriously investigated.

In summary, it is suggested that the changes in taboos listed in the following table be thoroughly investigated, since they would permit diversion of 7 channels to Land Mobile use.

Taboo Changed	Present Mileage Separation	Proposed Mileage Separation
Intermodulation (± 2,3,4,5 channels)	20 Miles	0 Miles
I.F. Beat (± 7, 8 channels)	20 Miles	0 Miles
Picture Image (± 15 channels)	75 Miles	60 Miles
Sound Image (± 14 channels)	60 Miles	50 Miles

It is emphasized that the suggestion to change the above taboos were based in part on the engineering judgement that a thorough investigation of the pertinent receiver characteristics would establish facts which would justify the change suggested.

No other taboo changes are proposed although it is believed that investigation would justify changes in some, if not all, of the remaining taboos.

DISCUSSION OF TABOOS PROPOSED TO BE INVESTIGATED

The series of taboos arising from consideration of the possibility of intermodulation interference and resulting in a 20 mile separation requirement between stations separated 2, 3, 4, or 5 channels are believed to have minimum justification, and therefore to be most vulnerable to change. The nature of intermodulation is that two strong signals on channels X and Y (= X + N) interacting in the input circuits of a receiver may cause spurious signals on other channels as indicated by the following table.

Carriers			Intermodulation Product	
Channel X	Channel Y	(Y = X + N)	No. of Channels Above Y	No. of Channels Below X
1. Picture	Picture		N (0)*	N (0)*
2. Picture	Sound		N + 1 (3)*	N + 1 (1.5)*
3. Sound	Picture		N - 1 (1.5)*	N - 1 (3.0)*
4. Sound	Sound		N (4.5)*	N (4.5)*

( )* indicates frequency in MHz above affected channel picture carrier.

Of these, the first, picture carrier beating with picture carrier, is the most important, dealing with the highest signal levels. Tests made at the Commission's Laboratory 1/ indicate that when two strong spurious signals, each 94 dB above one microvolt were fed into a number of receivers the equivalent voltage at the spurious frequency had a median value of 46 dB above one microvolt, or 48 dB below the input levels. The input signals correspond to a very high field intensity such as can be found only in the vicinity of transmitters.

1/ See FCC Laboratory Division Report No. L-6201 of October 19, 1962.

If there were two stations in a community operating on channels 26 and 28, the major spurious signals generated in receivers in the areas where both visual signals were exceptionally strong, i.e. very near the two transmitters, would fall in channels 24 and 30. Thus, if service were to be provided in that area by channel 24 or by channel 30, that service might theoretically suffer interference in the vicinity of the transmitters on channel 26 and 28. The intermodulation interference caused by the strong channel 26 and 28 signals does not affect either channel 26 or 28, but only a third channel. The number of instances in which this type of interference will exist and will affect an actual service must be relatively low since there is a very low probability that all of the circumstances needed for this type of interference will occur together. In addition, only a very small area is affected so that case to case treatment would not present a great task. As a result, the 20 mile intermodulation interference taboos were proposed to be deleted.

The remaining 20 mile separation taboo, that for IF beat interference, was also deleted on the same general basis that it occured only when two very strong signals separated by 7 or 8 channels got into the front end of the receiver and, by beating in the initial circuits of the receiver, caused a spurious signal which fell within the intermediate frequency band. This problem is in one sense more serious than the intermodulation problem for the reason that all receivers in the area of intensely strong signals from the two stations may be affected, not just receivers tuned on two channels. On the other hand, receivers tuned to most channels will exhibit appreciable discrimination against one or both of the IF beat signals so the magnitude of the problem is more apparent than real. In any event, the area in which it is likely to occur is quite small. (Consideration of receiving antenna characteristics will further reduce the area). It was therefore considered that there was a reasonable prospect of justifying also the deletion of the 20 mile IF beat taboos.

It was noted that propagation factors were minor in considering intermodulation and IF beat taboos. Within short distances of the transmitter there will be a higher than normal percentage of locations with line of sight transmission and signal levels approximating free space, i.e. very strong signals. This will be true whatever is done about developing average propagation curves. Of course, on the average, signals will be lower and the possibility of interference reduced.

The image taboos, with separations of 75 miles in the case of the picture image interference between stations separated by 15 channels and of 60 miles for sound image interference between stations separated by frequencies corresponding to 14 channels, are, because of the relatively great separation, two taboos which have a serious effect upon the allocation structure.

Image interference is a function of receiver design and the ability of the receiver to reject signals on image frequencies. Tests made by the Commission's Laboratories in 1962 [1/] indicate that the median rejection ratio is approximately 40 dB. Since the area where image interference may occur lies generally between the two stations involved and at a relatively great distance

1/ See FCC Laboratory Division Report No. L-6201 of October 19, 1962.

from either station, rather good antennas will be used and they will be directed toward the desired station, and away from the undesired station. Thus, some antenna discrimination can be counted on. Using 10 dB for this figure, the total rejection, by antenna and receiver, is 50 dB which is the desired to undesired signal ratio proposed in Docket 18261. Thus, interference should result when there is less than a 0 dB desired to undesired signal ratio. On this basis, a substitution of service would be possible. (This is the same standard and reasoning which led the Commission, in Docket 8736 et al, to adopt a 55 mile adjacent channel separation. A 0 dB ratio was used and consideration was given to the substitution of service concept. By this argument, a reduction in the present 75 mile picture image taboo seems amply justified.)

Consideration of the propagation factors in Docket 16004 makes it clear that the actual service of the UHF television stations will be less than was contemplated when the standards were adopted or proposed. This means that the area where one station might suffer image interference from another would be closer to the desired station and farther from the undesired station. In addition, the signal of the undesired station would be reduced, both because of the greater separation to the area of interference and because the signals would be lower than were originally expected, at any distance. To illustrate this, a brief study has been made to compare the service of UHF stations where image interference exists using, for the present condition, the propagation curves included now in the Commission's Rules for the desired signal, the F(50,10) curves proposed in Docket 13340 for the undesired signal and the separations now required and, for the changed condition, the propagation curves of TRR 6602, as suggested in Docket 18261, for the desired and undesired signals, F(50,50) and F(50,10) respectively, and separations of 60 miles for picture image and 50 miles for sound image. The following table shows the result.

	Picture Image		Sound Image	
	Rules	TRR 6602	Rules	TRR 6602
1. Facility - Power (kW)	1000	1000	1000	1000
Height (feet)	1000	1000	1000	1000
2. Separation (Miles)	75	60	60	50
3. Grade B Area (sq. mi.)	10,568	6,082	10,082	6,082
4. Area within interference free contour (% of Grade B)				
D/U ratio of 0 dB	85.2	86.4	77.9*	80.5*
10 dB	72.7	73.3	62.5*	64*

*The same desired to undesired ratios have been used for sound images as for picture image. Actually, the undesired sound carrier is reduced 7 to 10 dB with respect to the picture carrier and a correspondingly lower D/U ratio could be used where, as here, the signal levels are those of peak visual carrier.

The table shows there to be a small increase in the percentage of Grade B area served free of image interference under the two conditions despite the reduced separation. The Table has also considered the possibility that the desired to undesired signal ratio should be 10 dB, as it might, if antenna rejection were ignored. Here, too, the percentage service increased slightly. All of these considerations led to the decision to reduce the image separation requirements from 75 to 60 miles for picture image and from 60 to 50 miles for sound image in the computer studies of UHF TV allocations.

DISCUSSION OF OTHER TABOOS

It seems likely there is justification for reducing the co-channel separation taboos. Nevertheless, it is not proposed to reduce the co-channel separations or to change from those in the Rules. This problem is related to the overall problem of the actual coverage of the UHF television stations involving the propagation of desired and interfering signals which is now under consideration in Docket 16004. The propagation curves the Commission proposed to be used for predicting UHF television service in that Docket (and in Docket 18261) indicate substantially lesser service radii than the curves used at the time the Rules were adopted. With the proposed curves, lesser separations could be employed without increasing the proportion of the Grade B service area which might suffer from co-channel interference. The following table compares the interference-free service as determined by use of the curves presented in Technical Research Report 6602 and proposed in Docket 16004 with the interference free service as determined by use of the curves in the Rules and the interfering signal, F(50,10), curves previously proposed in Docket 13340. A desired to undesired signal ratio of 28 dB is used to denote the limit of interference-free service.

	Rules	TRR 6602
1. Facility - Power (kW)	1000	1000
Height (feet)	1000	1000
2. Separation (miles)	155	145 (assumed)
3. Grade B Area (sq. mi.)	10,568	6,082
4. Area within Interference Free Contour (% of Grade B)	81.2%	83.4%

This table illustrates the possibility of reducing the co-channel taboos while causing less interference than was considered acceptable when the present standard was set. The present standards have also been based on the assumption that there would be absolutely no ability of a receiving antenna to discriminate against unwanted signals which is the most improbable assumption that could have been made.

Another taboo involving a relatively long separation, 60 miles, is the taboo associated with local oscillator interference. Here, the basic problem is that a receiver tuned to one station has its local oscillator operating on a frequency corresponding to the seventh channel above the station to which the receiver is tuned. Radiation from that local oscillator might cause interference to a nearby receiver tuned to the seventh channel above. The area affected lies within a small radius, probably not over 100 feet, of the offending receiver. The problem is greater if the two receiving antennas are "looking" at one another; and decreases as they look away. The offending receiver may be anywhere within the service area of the station to which it is tuned. In this type of interference, there is a substitution of service also. It appeared likely that a reduction of the local oscillator taboo could be justified. However, the preliminary computer runs showed little gain in allocation efficiency in making a change here if changes were made in the image taboos. As a result, it was decided to make no change in the local oscillator taboo.

For similar reasons it was decided not to change the adjacent channel taboo, although modern experience indicates receiver performance is much better than was determined when the standard was set.

CONCLUSIONS FROM ANALYSIS OF THE NATIONWIDE RUN

An analysis has been made to show the new channels to which the existing stations now using Channels 14 through 20 would be assigned in the computer developed Table of Assignments. The details are given in Appendix I. The results may be summarized as follows:

66 Channels, or 64.08 percent, were diverted to the group between Channel 21 and 30.

22 Channels, or 21.36 percent, were diverted to the group between Channel 31 and 40.

11 Channels, or 10.68 percent, were diverted to the group between Channel 41 and 50.

2 Channels, or 1.94 percent, were diverted to the group between Channel 51 and 60.

2 Channels, or 1.94 percent, were diverted to the group Channel 61 and above.

The results of the second part of the run are given in a computer developed Table of Assignments which is included in Appendix II, along with the present Table 1/. Examination of the Table shows that the assignment requirements were satisfied with 7 fewer channels in all but 14 communities.

An analysis has been made of the unsatisfied assignments. There is attached, as Appendix III, a list of the cities involved, showing the reduction in assignments to each city and the number of other services available to that city.

Of these 14 cities, 8 were reduced from 1 to no assignments. The largest of these cities had a population by the 1960 Census of 114,167, but had 20 potential services available. The minimum total number of services available (assuming UHF assignments serve to 40 miles and VHF to 60 miles) was 5 and the maximum number was 20.

No cities were reduced from 2 to 1 assignments.

3 other cities were reduced from 3 to 2 assignments. The largest of these cities had a population of 174,463, but had 9 potential services available. These cities had a minimum of 9 services available and a maximum of 11.

2 cities were reduced from 4 to 3 assignments. The largest had a population of 186,587, but had 19 potential services available. These cities had a minimum of 4 services available and a maximum of 19.

1/ The Table in Appendix II was not completely developed by the computer. Through an error an excessive number of assignments were made in a few communities and caused a deficiency in other communities. This situation was resolved by manual investigation and, in fact, all unsatisfied assignments were so investigated and some resolved.

1 city was reduced from 7 to 5 assignments. It had a population of 476,258, but had 7 potential services available.

It would appear that the number of unsatisfied assignments is within tolerable limits and that adequate service opportunities exist so that the communities affected need not lack for adequate television service.

A separate computer print-out listed all the assignments which were short spaced under the present taboo requirements. This print-out actually was available twice, the first time after assignment of existing stations with no unused assignments, and the second time after the Nationwide Table was developed. The first print-out showed some short spaced assignments where no changes had been made either in the taboos involved or the station locations, thus pointing up the fact that some derogations had been permitted in the past. One additional co-channel derogation of one mile was made in order to permit a significantly better reassignment. The station now on channel 16 at Providence, Rhode Island, was reassigned to channel 28 at a separation of 154 miles from the co-channel station at Rutland, Vermont, instead of to channel 33, in order to make possible the reassignment of channel 34 instead of 66 for channel 14 at Worcester, Massachusetts. The derogation is minimal and within the range of others permitted in the past, and is further justified by the nature of the terrain near Rutland.

An analysis has been made to determine the use made of the taboo changes considered in developing the nationwide table. This analysis, which is presented as Appendix IV, shows that the reduction of the taboos resulted in permitting the following number of assignments.

TABOO CHANGED	NUMBER OF ASSIGNMENTS PERMITTED	
Intermodulation (from 20 to 0 miles)		152
2 Channel separation	48	
3 Channel separation	28	
4 Channel separation	49	
5 Channel separation	27	
I.F. Beat (from 20 to 0 miles)		57
Sound Image (from 60 to 50 miles)		34
Picture Image (from 75 to 60 miles)		42
Total		285

A further analysis was made to determine those instances where the intermodulation taboo changes permitted assignments of three channels, each less than 20 miles from the other two, with channel separations of 2 or 4, 3 or 6, 4 or 8 and 5 or 10 channels between any of the three assignments. These channel separations are the only ones in which intermodulation interference is reasonably to be expected. This anaylsis showed the following number of situations where 3 assignments were made within 20 miles of one another and with the indicated channel separation.

CHANNEL SEPARATION	
2 or 4 Channels	2 Instances
3 or 6 Channels	0 Instances
4 or 8 Channels	3 Instances
5 or 10 Channels	1 Instance

Actual interference thus might occur in 6 of 152 instances. This confirms the belief, stated earlier, that the number of instances in which this type of interference will exist and will affect an actual service must be relatively low.

The majority of cases where advantage was taken of the changes in intermodulation and I.F. beat taboos involved assignments in the same city. The great number of all such cases, 209, sharply points out the need for serious examination of those taboos. The 285 cases, including assignments made by using the changed image taboos, calls for a careful examination of these and other taboos. The fact that all but 15 assignments in the present Table can be made in 7 fewer channels is a further basis for judgement that efficient use is not being made of the UHF television spectrum. It points up the need for serious investigation of the UHF TV taboos.

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Consulting Engineers
Dallas, Texas

November 15, 1968

By: Thomas A. Wright

CHANGES IN CHANNEL ASSIGNMENTS
FOR EXISTING STATIONS
ON CHANNELS 14 THROUGH 20

CITY	STATE	CHANNEL ELIMINATED	CHANNEL SUBSTITUTED
Florence	Alabama	15	28
Huntsville	Alabama	19	21
Montgomery	Alabama	20	22
Phoenix	Arizona	15	27
Little Rock	Arkansas	16	22
Bakersfield	California	17	25
Modesto	California	19	28
San Bernardino	California	18	50
San Diego	California	15	69
San Francisco	California	20	34
San Mateo	California	14	62
Santa Barbara	California	20	42
Ventura	California	16	36
Hartford	Connecticut	18	51
Waterbury	Connecticut	20	27
Washington	D. C.	14	22
Jacksonville	Florida	17	25
Miami	Florida	17	21
Tampa	Florida	16	32
Atlanta	Georgia	17	27
Chatsworth	Georgia	18	22
Cochran	Georgia	15	33
Pelham	Georgia	14	31
Wrens	Georgia	20	31
Champaign	Illinois	15	41
Chicago	Illinois	20	38
Decatur	Illinois	17	22
Jacksonville	Illinois	14	29
Joilet	Illinois	14	34
Olney	Illinois	16	28
Peoria	Illinois	19	21
Rockford	Illinois	17	29
Springfield	Illinois	20	27
Evansville	Indiana	14	27
Ft. Wayne	Indiana	15	25
Lafayette	Indiana	18	29
South Bend	Indiana	16	48
Davenport	Iowa	18	30
Des Moines	Iowa	17	29
Dubuque	Iowa	16	22

CITY	STATE	CHANNEL ELIMINATED	CHANNEL SUBSTITUTED
Sioux City	Iowa	14	28
Lexington	Kentucky	18	40
Louisville	Kentucky	15	50
Owensboro	Kentucky	19	22
Lafayette	Louisiana	15	21
New Orleans	Louisiana	20	22
Salisbury	Maryland	16	30
North Adams	Massachusetts	19	35
Worcester	Massachusetts	14	34
Bay City	Michigan	19	21
Detroit	Michigan	20	22
Jackson	Michigan	18	36
Mount Pleasant	Michigan	14	29
Minneapolis/St. Paul	Minnesota	17	21
St. Cloud	Minnesota	19	30
Jackson	Mississippi	16	32
Joplin	Missouri	16	22
Kansas City	Missouri	19	25
Poplar Bluff	Missouri	15	28
Norfolk	Nebraska	19	25
Omaha	Nebraska	15	22
Hanover	New Hampshire	15	31
New Brunswick	New Jersey	19	47
Albany/Schenectady	New York	17	29
Buffalo	New York	17	29
Elmira	New York	18	36
Ithaca	New York	14	30
Charlotte	North Carolina	18	34
Hickory	North Carolina	14	30
Linville	North Carolina	17	41
Athens	Ohio	20	29
Canton	Ohio	17	31
Cincinnati	Ohio	19	42
Dayton	Ohio	16	45
Oxford	Ohio	14	24
Zanesville	Ohio	18	32
Oklahoma City	Oklahoma	14	22
Johnstown	Pennsylvania	19	25
Lancaster	Pennsylvania	15	38
Philadelphia	Pennsylvania	17	57
Pittsburgh	Pennsylvania	16	30
Scranton	Pennsylvania	16	26
Providence	Rhode Island	16	28
Allendale	South Carolina	14	28
Columbia	South Carolina	19	22

CITY	STATE	CHANNEL ELIMINATED	CHANNEL SUBSTITUTED
Florence	South Carolina	15	21
Kingsport	Tennessee	19	28
Nashville	Tennessee	17	33
Houston	Texas	20	22
Longview	Texas	16	22
Midland	Texas	18	21
Nacogdoches	Texas	19	30
Victoria	Texas	19	21
Ogden	Utah	18	22
St. Johnbury	Vermont	20	30
Hampton	Virginia	15	21
Roanoke	Virginia	15	43
Pasco	Washington	19	21
Tacoma	Washington	20	22
Parkersburg	West Virginia	15	35
Wheeling	West Virginia	14	26
Madison	Wisconsin	15	31
Milwaukee	Wisconsin	18	42

Summary

Channel Group	New Assignments Number	Percent
21-30	66	64.08
31-40	22	21.36
41-50	11	10.68
51-60	2	1.94
61 and Up	2	1.94
Total	103	100.00

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS 14 THROUGH 83	POSSIBLE CHANNELS 21 THROUGH 83	COMMENT
Alabama			
Andalusia	2	2	-
Anniston	40	40	-
Birmingham	6,10,13,21,42,62,68	6,10,13,42,44,60,68	-
Decatur	23	23	-
Demopolis	41	27	-
Dothan	4,18,39,60	4,39,47,55	-
Florence	15,26,36	26,28,36	-
Gadsden	44,60	56,62	-
Huntsville	19,25,31,48	21,25,29,31	-
Louisville	43	43	-
Mobile	5,10,15,21,31,42	5,10,21,34,42,54	-
Montgomery	12,20,26,32,45	12,22,26,32,45	-
Munford	7,16	7,34	-
Selma	8,29	8,53	-
Tuscaloosa	17,33,39	33,39,55	-
Tuscumbia	47	32	-
Arizona			
Ajo	23	41	-
Douglas	3,28	3,39	-
Flagstaff	9,13,16	9,13,22	-
Globe	14	30	-
Holbrook	18	28	-
Kingman	6,14	6,32	-
McNary	22	32	-
Mesa	12	12	-
Nogales	11,16	11,32	-
Page	17	21	-
Parker	17	28	-
Phoenix	3,5,8,10,15,21,33,39	3,5,8,10,21,23,27,45	-
Prescott	7,19	7,26	-
Safford	23	29	-
Tucson	4,6,9,13,18,27,40	4,6,9,13,28,34,44	-
Yuma	11,13,16	11,13,22	-
Arkansas			
Arkadelphia	9	9	-
Batesville	17	21	-
El Dorado	10,18,30	10,28,47	-
Fayetteville	13,36	13,25	-
Fort Smith	5,24	5,28	-
Harrison	14	36	-
Hot Springs	20,26	43,46	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Arkansas -- Continued			
Jonesboro	8,19	8,32	-
Little Rock	2,4,7,11,16,29	2,4,7,11,22,41	-
Pine Bluff	25,38	33,44	-
Russellville	28	38	-
California			
Alturas	13	13	-
Anaheim	56	56	-
Bakersfield	17,23,29,39	23,25,29,33	-
Barstow	35	41	-
Bishop	14	26	-
Blythe	22	40	-
Brawley	26	26	-
Chico	12,18	12,30	-
Coalinga	27	21	-
Corona	52	52	-
Cotati	22	50	-
El Centro	7,9	7,9	-
Eureka	3,6,13	3,6,13	-
Fort Bragg	17	25	-
Fresno	18,24,30,47,53	24,30,47,49,53	-
Hanford	21	59	-
Indio	19	31	-
Los Angeles	2,4,5,7,9,11,13,22, 28,34,58	2,4,5,7,9,11,13,22, 28,34,64	-
Modesto	19,23	28,52	-
Palm Springs	36,42	42,47	-
Pittsburg	42	42	-
Redding	7,9,16	7,9,21	-
Ridgecrest	25	32	-
Riverside	40,46	40,46	-
Sacramento	3,6,10,15,40	3,6,10,29,40	-
Salinas-Monterey	8,46,56,67	8,33,46,67	-
San Bernardino	18,24,30	24,30,50	-
San Diego	8,10,15,39,51	8,10,39,51,69	-
San Francisco	2,4,5,7,9,20,26,32, 38,44,60	2,4,5,7,9,26,32,34, 38,44,60	-
San Jose	11,36,48,54	11,36,54,64	-
San Luis Obispo	6,15	6,50	-
San Mateo	14	62	-
Santa Ana	50	58	-
Santa Barbara	3,14,20	3,26,42	-
Santa Cruz	16	58	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
California -- Continued			
Santa Maria	12	12	-
Santa Rosa	50,62	55,63	-
Stockton	13,31,58	13,31,48	-
Susanville	14	26	-
Tulare	26	27	-
Ventura	16	36	-
Visalia	43	43	-
Watsonville	25	23	-
Yreka City	20	29	-
Colorado			
Alamosa	3,16	3,27	-
Boulder	12,14	12,21	-
Colorado Springs	11,13,21	11,13,28	-
Craig	16	28	-
Denver	2,4,6,7,9,20,31,41	2,4,6,7,9,26,29,31	-
Durango	6,20	6,31	-
Fort Collins	22	30	-
Glenwood Springs	19	36	-
Grand Junction	5,18	5,21	-
Gunnison	17	43	-
La Junta	22	30	-
Lamar	12,14	12,21	-
Leadville	15	32	-
Montrose	10,22	10,30	-
Pueblo	5,8,26,32	5,8,22,25	-
Salida	23	35	-
Sterling	3,18	3,36	-
Trinidad	24	29	-
Connecticut			
Bridgeport	43,49	43,49	-
Hartford	3,18,24,61	3,24,51,61	-
New Britain	30	30	-
New Haven	8,59,65	8,33,59	-
New London	26	57	-
Norwich	53	53	-
Waterbury	20	27	-
Delaware			
Dover	34	49	-
Seaford	22	36	-
Wilmington	12,61	12,59	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
District of Columbia			
Washington	4,5,7,9,14,20,26,32,50	4,5,7,9,22,26,28,32,63	-
Florida			
Boca Raton	14	27	-
Bradenton	19	48	-
Clearwater	22	22	-
Cocoa	18,52	55,61	-
Daytona Beach	2,26	2,43	-
Fort Lauderdale	51	51	-
Fort Meyers	11,20,30	11,30,54	-
Fort Pierce	21,34	34,36	-
Gainesville	5,20	5,46	-
Jacksonville	4,7,12,17,30,47,59	4,7,12,25,30,47,59	-
Key West	16,22	22,26	-
Lake City	41	41	-
Lakeland	32	26	-
Leesburg	45,55	29,45	-
Madison	36	36	-
Marianna	16	30	-
Melbourne	31,43	31,52	-
Miami	2,4,6,7,10,17,23,33,39,45	2,4,6,7,10,21,23,29,33,39	-
New Smyrna Beach	15	53	-
Ocala	29,51	33,51	-
Orlando	6,9,24,35	6,9,24,35	-
Palatka	42	27	-
Panama City	7,13,22,28	7,13,28,33	-
Pensacola	3,23,33,44	3,23,29,46	-
St. Petersburg	10,38,44	10,38,44	-
Sarasota	40	40	-
Sebring	27	42	-
Tallahassee	11,27,40	11,34,40	-
Tampa	3,8,13,16,28	3,8,13,28,32	-
West Palm Beach	5,12,25,42,53	5,12,25,46,59	-
Georgia			
Albany	10,19,31	10,21,42	-
Ashburn	23	29	-
Athens	8,34	8,32	-
Atlanta	2,5,11,17,30,36,46,57	2,5,11,27,30,36,46,55	-
Augusta	6,12,26,54	6,12,26,50	-
Chatsworth	18	22	-
Cochran	15	33	-

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Georgia -- Continued			
Columbus	3,9,28,38,54	3,9,28,38,54	-
Dawson	25	25	-
Draketown	27	58	-
Macon	13,24,41,47	13,24,41,44	-
Pelham	14	31	-
Rome	14	52	-
Savannah	3,9,11,22	3,9,11,34	-
Thomasville	6	6	-
Toccoa	32	48	-
Valdosta	33,44	52,58	-
Vidalia	18	39	-
Warm Springs	22	57	-
Waycross	8	8	-
Wrens	20	31	-
Idaho			
Boise	2,4,7,14	2,4,7,21	-
Burley	17	33	-
Caldwell	9	9	-
Coeur d'Alene	26	28	-
Grangeville	15	29	-
Idaho Falls	3,8,20,33	3,8,29,35	-
Filer	19	41	-
Lewiston	3	3	-
Moscow	12	12	-
Nampa	6,12	6,12	-
Preston	28	36	-
Pocatello	6,10,15,25,31	6,10,25,27,31	-
Sandpoint	16	34	-
Twin Falls	11,13	11,13	-
Weiser	17	31	-
Illinois			
Aurora	60	60	-
Bloomington	43	43	-
Carbondale	8	8	-
Champaign	3,15	3,41	-
Chicago	2,5,7,9,11,20,26,32, 38,44	2,5,7,9,11,26,32, 38,44,68	-
Danville	68	35	-
Decatur	17,23	22,45	-
DeKalb	48	40	-
Edwardsville	18	36	-

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Illinois -- Continued			
Elgin	66	66	-
Freeport	23,65	23,59	-
Galesburg	63	42	-
Harrisburg	3	3	-
Jacksonville	14	29	-
Joliet	14	34	-
Kankakee	54	54	-
LaSalle	35	58	-
Macomb	22	26	-
Moline	8,24	8,52	-
Olney	16	28	-
Peoria	19,25,31,47,59	21,25,31,53,69	-
Quincy	10,16,27	10,28,44	-
Rockford	13,17,39	13,29,35	-
Rock Island	4	4	-
Springfield	20,49,55,65	27,33,49,55	-
Streator	64	63	-
Urbana	12,27	12,39	-
Vandalia	21	32	-
Indiana			
Anderson	67	69	-
Bloomington	4,30,63	4,30,34	-
Elkhart	28	28	-
Evansville	7,9,14,25,44	7,9,25,27,44	-
Fort Wayne	15,21,33,39,55	21,25,33,61,67	-
Gary	50,56	50,56	-
Hammond	62	62	-
Indianapolis	6,8,13,20,40,59,69	6,18,13,40,57	-2
Kokomo	29	23	-
Lafayette	18,24	29,52	-
Madison	60	60	-
Marion	31	31	-
Muncie	23,49,61	49,51,53	-
Richmond	43	43	-
South Bend	16,22,34,46	22,46,48	-1
Terre Haute	2,10,26,66	2,10,38,59	-
Vincennes	22	46	-
Iowa			
Ames	5,23,34	5,25,31	-
Burlington	26,58	34,62	-
Carroll	18	39	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Iowa -- Continued			
Cedar Rapids	2,9,28	2,9,66	-
Council Bluffs	32	45	-
Davenport	6,18,30,36	6,30,36,64	-
Decorah	14	42	-
Des Moines	8,11,13,17,43,63,69	9,11,13,29,47,57,63	-
Dubuque	16,29,40	22,28,33	-
Estherville	28	44	-
Fort Dodge	21	21	-
Iowa City	12,20	12,32	-
Mason City	3,24	3,45	-
Ottumwa	15,33	27,35	-
Red Oak	36	34	-
Sioux City	4,9,14,27	4,9,28,30	-
Waterloo	7,22,32	7,26,43	-
Kansas			
Chanute	30	26	-
Colby	4	4	-
Columbus	34	32	-
Dodge City	6,21	6,27	-
Emporia	25	49	-
Garden City	11,13	11,13	-
Goodland	10	10	-
Great Bend	2	2	-
Hays	7,14	7,28	-
Hutchinson	8,12,36	8,12,30	-
Lakin	3	3	-
Lincoln Center	9	9	-
Manhattan	21	31	-
Oakley	15	35	-
Phillipsburg	22	26	-
Pittsburg	7	7	-
Pratt	32	33	-
Salina	18,34,44	22,34,42	-
Sedan	28	38	-
Topeka	11,13,27,43,49	11,13,27,36,44	-
Wichita	3,10,15,24,33,42	3,10,24,35,43,48	-
Kentucky			
Ashland	25,61	21,25	-
Bowling Green	13,40,53	13,36,53	-
Covington	54	54	-
Elizabethtown	23	23	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Kentucky			
Hazard	35,57	32,35	-
Hopkinsville	51	47	-
Lexington	18,27,46,62	27,40,46,62	-
Louisville	3,11,15,21,32,41,68	3,11,21,32,41,50,63	-
Madisonville	35	35	-
Morehead	38	38	-
Murray	21	21	-
Owensboro	19,31	22,31	-
Owenton	52	52	-
Paducah	6,29	6,29	-
Pikeville	22,51	22,66	-
Somerset	16,29	29,34	-
Louisiana			
Alexandria	5,25,31,41	5,31,42,44	-
Baton Rouge	2,9,27,33	2,9,43,45	-
De Ridder	23	25	-
Houma	11	11	-
Lafayette	3,10,15,24	3,10,21,53	-
Lake Charles	7,18,29	7,29,38	-
Monroe	8,13,14,39	8,13,26,39	-
Morgan City	14	27	-
Natchitoches	28	36	-
New Iberia	36	40	-
New Orleans	4,6,8,12,20,26,32,38	4,6,8,12,22,26,35,39	-
Shreveport	3,12,24,33	3,12,45,53	-
Tallulah	19	35	-
Maine			
Augusta	10	10	-
Bangor	2,5,7	2,5,7	-
Calais	13	13	-
Fort Kent	46	62	-
Fryeburg	18	27	-
Houlton	25	25	-
Kittery	34	26	-
Lewiston	8,35	8,51	-
Millinocket	44	22	-
Orono	12	12	-
Portland	6,13,26,51	6,13,29,35	-
Presque Isle	8,10	8,10	-
Rumford	43	43	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Maryland			
Baltimore	2,11,13,24,45,54,67	2,11,13,24,45,51,67	-
Cumberland	36,52,65	42,46,52	-
Frederick	62	34	-
Hagerstown	25,68	40,62	-
Salisbury	16,28	30,58	-
Waldorf	56	55	-
Massachusetts			
Boston	2,4,5,7,25,38,44,56,68	2,4,5,7,25,38,44,56,60	-
Greenfield	32	32	-
New Bedford	6,28,47	6,64,68	-
North Adams	19,35	35,58	-
Pittsfield	51	48	-
Springfield	22,40,57	22,40	-1
Worcester	14,27,48,66	34,66,69	-1
Michigan			
Alpena	6,11	6,11	-
Ann Arbor	58	60	-
Bad Axe	15	51	-
Battle Creek	41	41	-
Bay City	5,19,61	5,21,53	-
Cadillac	9,27	9,46	-
Calumet	5,22	5,35	-
Cheboygan	4	4	-
Detroit	2,4,7,20,50,56,62	2,4,7,22,50,56,62	-
East Lansing	23,69	58,64	-
Escanaba	3	3	-
Flint	12,31,66	12,31,66	-
Grand Rapids	8,13,17,35	8,13,35,63	-
Iron Mountain	8,14	8,31	-
Ironwood	15	29	-
Jackson	18	36	-
Kalamazoo	3,52	3,57	-
Lansing	6,36,53	6,39,68	-
Manistee	21	38	-
Manistique	15	29	-
Marquette	6,13,19	6,13,21	-
Mount Clemens	22	44	-
Mount Pleasant	14	29	-
Muskegon	54	54	-
Parma	10	10	-
Petoskey	23	28	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Michigan -- Continued			
Port Huron	44	48	-
Saginaw	25,42	25,42	-
Sault Ste. Marie	8,10,32	8,10,42	-
Traverse City	7,29	7,30	-
West Branch	24	34	-
Minnesota			
Alexandria	7,24	7,28	-
Appleton	10	10	-
Austin	6,15	6,40	-
Bemidji	9,26	9,42	-
Brainerd	22	34	-
Crookston	33	33	-
Duluth	3,8,10,21,27	3,8,10,22,27	-
Ely	17	26	-
Fairmont	16	27	-
Hibbing	13,18	13,36	-
International Falls	11,35	11,41	-
Mankato	12,26	12,22	-
Marshall	30	42	-
Minneapolis-St. Paul	2,4,5,9,11,17,23,29	2,4,5,9,11,21,29,31	-
Rochester	10,47	10,34	-
St. Cloud	19,25,41	30,39,47	-
St. James	38	35	-
Thief River Falls	10	10	-
Wadena	20	25	-
Walker	12	12	-
Willmar	14	26	-
Winona	35	36	-
Worthington	20	32	-
Mississippi			
Biloxi	13,19,25	13,25,31	-
Booneville	18	45	-
Bude	17	46	-
Cleveland	31	42	-
Columbia	34	33	-
Columbus	4	4	-
Greenville	15,21	25,34	-
Greenwood	6,23	6,31	-
Hattiesburg	22,28	36,41	-
Jackson	3,12,16,29,40	3,12,29,32,40	-
Laurel	7,18	7,28	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Mississippi -- Continued			
Meridian	11,14,24,30	11,24,30,47	-
Senatobia	22	38	-
State College	2	2	-
Tupelo	9	9	-
Vicksburg	35	27	-
Yazoo City	32	21	-
Missouri			
Birchtree	20	44	-
Bowling Green	35	41	-
Cape Girardeau	12,23,39	12,34,45	-
Carrollton	18	42	-
Columbia	8,17	8,31	-
Flat River	22	26	-
Hannibal	7	7	-
Jefferson City	13,25,36	13,21,39	-
Joplin	12,16,22	12,22,30	-
Kansas City	4,5,9,19,41,50,62,68	4,5,9,25,28,41,50,62	-
King City	28	43	-
Kirksville	3	3	-
LaPlata	21	22	-
Lowry City	15	29	-
Poplar Bluff	15,26	28,31	-
Rolla	28	33	-
St. Joseph	2,16,22	2,30,33	-
St. Louis	2,4,5,9,11,24,30,40	2,4,5,9,11,24,30,40	-
Sedalia	6	6	-
Springfield	3,10,21,27	3,10,27,35	-
Montana			
Anaconda	2	2	-
Billings	2,8,11,14,20	2,8,11,21,29	-
Bozeman	9	9	-
Butte	4,6,7,18,24	4,6,7,26,34	-
Cut Bank	14	34	-
Dillon	14	21	-
Glendive	5,16	5,21	-
Great Falls	3,5,16,26,32	3,5,28,30,36	-
Hardin	4	4	-
Havre	9,11,18	9,11,26	-
Helena	10,12,15	10,12,22	-
Kalispell	9,29	9,21	-
Lewiston	13	13	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Montana -- Continued			
Miles City	3,6,10	3,6,10	-
Missoula	8,11,13,17,23	8,11,13,27,35	-
Wolf Point	17	26	-
Nebraska			
Albion	8,21	8,27	-
Alliance	13	13	-
Bassett	7	7	-
Grand Island	11,17	11,21	-
Hastings	5,29	5,33	-
Hayes Center	6	6	-
Hap Springs	4	4	-
Kearney	13	13	-
Lexington	3	3	-
Lincoln	10,12,45,51	10,12,32,48	-
McCook	8	8	-
Merriman	12	12	-
Norfolk	19	25	-
North Platte	2,9	2,9	-
Omaha	3,6,7,15,26,42,48	3,6,7,22,26,42,61	-
Scottsbluff	10	10	-
Superior	4	4	-
Nevada			
Boulder City	5	5	-
Elko	10,14	10,22	-
Ely	3,6	3,6	-
Fallon	25	22	-
Goldfield	2	2	-
Las Vegas	3,8,10,13,21	3,8,10,13,27	-
McGill	8	8	-
Reno	2,4,5,8,21,27	2,4,5,8,25,33	-
Tonopah	9,17	9,28	-
Winnemucca	7,15	7,30	-
Yerington	16	27	-
New Hampshire			
Berlin	40	40	-
Concord	21	62	-
Durham	11	11	-
Hanover	15,31	31,39	-
Keene	52	52	-
Littleton	49	49	-
Manchester	9,50,60	9,21,50	-
Portsmouth	17	54	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
New Jersey			
Asbury Park	58	58	-
Atlantic City	18,53	53,62	-
Burlington	48	48	-
Glen Ridge	77	77	-
Newark	13,68	13,60	-
New Brunswick	19,47	47,52	-
Paterson	41	41	-
Trenton	52	-	-1
Vineland	65	65	-
Wildwood	40	40	-
New Mexico			
Alamogordo	18	21	-
Albuquerque	4,5,7,13,14,23,32	4,5,7,13,22,28,30	-
Carlsbad	6,15,25	6,30,36	-
Clayton	17	28	-
Clovis	12	12	-
Deming	16	33	-
Farmington	12,15	12,29	-
Gallup	3,8,10	3,8,10	-
Hatch	12	12	-
Hobbs	29	26	-
Las Cruces	22	22	-
Lovington	19	22	-
Portales	3	3	-
Raton	18	26	-
Roswell	8,10,21,27,33	8,10,27,33,35	-
Santa Fe	2,9,11,19	2,9,11,36	-
Silver City	6,10	6,10	-
Socorro	15	34	-
Tucumcari	15	21	-
New York			
Albany-Schenectady	6,10,13,17,23,29,45	6,10,13,23,29,45,67	-
Amsterdam	39,55	25,54	-
Binghamton	12,34,40,46	12,34,40,46	-
Buffalo	2,4,7,17,23,29,49	2,4,7,23,29,31,49	-
Carthage	7	7	-
Corning	30	32	-
Elmira	18,36	36,42	-
Glens Falls	58	64	-
Ithaca	14,52	30,52	-
Jamestown	26,46	26,62	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
New York -- Continued			
Kingston	63	65	-
Lake Placid	5,34	5,47	-
Levittown	21	21	-
Massena	18	-	-1
New York	2,4,5,7,9,11,25,31	2,4,5,7,9,11,25,31	-
Oneonta	15,42	57,66	-
Patchogue	67	-	-1
Plattsburg	57	57	-
Poughkeepsie	54	62	-
Riverhead	55	55	-
Rochester	8,10,13,21,31,61	8,10,13,21,38,50	-
Syracuse	3,5,9,24,43,62	3,5,9,24,43,55	-
Utica	2,20,33,59	2,27,49,53	-
Watertown	16,50	59,65	-
North Carolina			
Asheville	13,21,33,62	13,21,33,57	-
Burlington	16	38	-
Chapel Hill	4	4	-
Charlotte	3,9,18,36,42	3,9,34,36,42	-
Columbia	2	2	-
Concord	58	58	-
Durham	11,28	11,28	-
Fayetteville	40,62	31,40	-
Franklin	56	38	-
Goldsboro	17	41	-
Greensboro	2,48,61	2,48	-1
Greenville	9,14,25	9,36,58	-
Hickory	14	30	-
High Point	8,32	8,50	-
Jacksonville	19	25	-
Kannapolis	64	69	-
Lexington	20	26	-
Linville	17	41	-
Morganton	23	39	-
New Bern	12	12	-
Raleigh	5,22,34	5,22,63	-
Rocky Mount	47	30	-
Washington	7	7	-
Waynesville	59	49	-
Wilmington	3,6,29,39	3,6,43,51	-
Wilson	30	46	-
Winston-Salem	12,26,45	12,32,61	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
North Dakota			
Bismarck	3,5,12,17,26	3,5,12,21,26	-
Devils Lake	8,22	8,25	-
Dickinson	2,4,7	2,4,7	-
Ellendale	19	29	-
Fargo	6,11,13,15	6,11,13,22	-
Grand Forks	2,14,27	2,21,27	-
Jamestown	7,23	7,30	-
Minot	6,10,13,14,24	6,10,13,22,31	-
Pembina	12	12	-
Valley City	4	4	-
Williston	8,11,15	8,11,30	-
Ohio			
Akron	23,49,55	23,51,64	-
Ashtabula	15	63	-
Athens	20	29	-
Bowling Green	70	70	-
Bryan	27	27	-
Canton	17,67	31,67	-
Chillicothe	53	39	-
Cincinnati	5,9,12,19,48,64	5,9,12,42,48,64	-
Cleveland	3,5,8,19,25,61	3,5,8,25,41,61	-
Columbus	4,6,10,34,47,56	4,6,10,34,36,63	-
Dayton	2,7,16,22,45	2,7,22,45,66	-
Defiance	65	65	-
Hillsboro	24	58	-
Lima	35,44,57	35,47,59	-
Lorain	43	43	-
Mansfield	31	69	-
Marion	68	38	-
Newark	28,52	28,40	-
Oxford	14	24	-
Portsmouth	30,36,42	30,49,61	-
Sandusky	51	49	-
Springfield	26,66	26,55	-
Steubenville	9,62	9,50	-
Toledo	11,13,24,30,54,60	11,13,24,30,52,54	-
Woodsfield	44	66	-
Youngstown	21,27,33,45,58	21,27,33,55,59	-
Zanesville	18	32	-
Oklahoma			
Ada	10,22	10,26	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Oklahoma -- Continued			
Altus	19	29	-
Ardmore	12,17	12,32	-
Bartlesville	17	21	-
Elk City	8,15	8,21	-
Enid	20,26	28,36	-
Guymon	16	22	-
Hugo	15	36	-
Lawton	7,16,36	7,34,40	-
McAlester	32	42	-
Miami	18	34	-
Muskogee	19	39	-
Oklahoma City	4,5,9,13,14,25,34,43	4,5,9,13,22,25,27,30	-
Tulsa	2,6,8,11,23,29,35,41	2,6,8,11,23,29,31,33	-
Woodward	17	26	-
Oregon			
Astoria	21	21	-
Bend	15,21	26,31	-
Brookings	14	30	-
Burns	18	22	-
Corvallis	7	7	-
Eugene	9,13,16,28	9,13,22,25	-
Klamath Falls	2,22	2,35	-
La Grande	13,16	13,30	-
Medford	5,8,10,18	5,8,10,27	-
North Bend	11,17	11,21	-
Portland	2,6,8,10,12,24,30	2,6,8,10,12,24,32	-
Roseburg	4	4	-
Salem	3,22,32	3,28,36	-
The Dalles	17	40	-
Pennsylvania			
Allentown	39,69	39,69	-
Altoona	10,31,47,57	10,60,65,68	-
Bethlehem	60	-	-1
Clearfield	3	3	-
Erie	12,24,35,54,66	12,24,35,46,54	-
Greensburg	40	47	-
Harrisburg	21,27,33	21,27,33	-
Hazleton	56	-	-1
Johnstown	6,19,28	6,25,36	-
Lancaster	8,15	8,38	-
Lebanon	59	64	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Pennsylvania -- Continued			
Philadelphia	3,6,10,17,23,29,35,57	3,6,10,23,29,35,57,61	-
Pittsburgh	2,4,11,13,16,22,53	2,4,11,13,22,30,53	-
Reading	51	-	-1
Scranton	16,22,38,44,64	22,26,44,50,63	-
State College	55	41	-
Wilkes-Barre	28	28	-
Williamsport	66	53	-
York	43,49	43,54	-
Rhode Island			
Providence	10,12,16,36,64	10,12,28,36,47	-
South Carolina			
Aiken	44	52	-
Allendale	14	28	-
Anderson	40	40	-
Beaufort	16	36	-
Charleston	2,4,5,7	2,4,5,7	-
Columbia	10,19,25,35,57	10,22,25,27,35	-
Conway	23	29	-
Florence	13,15,21,33	13,21,33,49	-
Georgetown	41	32	-
Greenville	4,16,29	4,29,59	-
Greenwood	38	56	-
Rock Hill	30,55	46,67	-
Spartanburg	7,49	7,51	-
Sumter	27	44	-
South Dakota			
Aberdeen	9,16	9,27	-
Brookings	8	8	-
Eagle Butte	13	13	-
Huron	12	12	-
Lead	5,11	5,11	-
Mitchell	5	5	-
Pierre	4,10	4,10	-
Rapid City	3,7,9,15,21	3,7,9,22,30	-
Reliance	6	6	-
Seneca	2	2	-
Sioux Falls	11,13,17,23,36	11,13,29,34,40	-
Vermillion	2	2	-
Watertown	3	3	-
Tennessee			
Athens	24	69	-

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Tennessee -- Continued			
Chattanooga	3,9,12,45,61	3,9,12,45,61	-
Cookeville	22	60	-
Crossville	20,55	39,42	-
Fayetteville	28	54	-
Greeneville	39	31	-
Jackson	7,16,32	7,22,27	-
Johnson City	11,41	11,44	-
Kingsport	19	28	-
Knoxville	6,10,15,26,43	6,10,26,43,47	-
Lexington	11	11	-
Memphis	3,5,10,13,14,24,30	3,5,10,13,30,35,46	-
Murfreesboro	39	46	-
Nashville	2,4,5,8,17,30,42	2,4,5,8,30,33,38	-
Sneedville	2	2	-
Texas			
Abilene	9,15,26,32	9,22,30,35	-
Alpine	12	12	-
Amarillo	2,4,7,10,14	2,4,7,10,27	-
Austin	7,18,24,36,42	7,24,36,40,42	-
Bay City	27	33	-
Beaumont	6,12,21,34	6,12,32,35	-
Big Spring	4,14	4,27	-
Boquillas	8	8	-
Brady	13	13	-
Brownsville	23	26	-
Bryan	3,15	3,44	
Childress	21	33	-
Corpus Christi	3,6,10,28,38	3,6,10,27,31	-
Dallas	4,8,13,27,33,39	4,8,13,29,33,39	-
Del Rio	10,24	10,22	-
Denton	2	2	-
El Paso	4,7,9,13,14,26,38	4,7,9,13,26,38,50	-
Fort Stockton	5	5	-
Fort Worth	5,11,21,31	5,11,21,41	-
Galveston	16,22	34,47	-
Harlingen	4,44,60	4,44,52	-
Houston	2,8,11,13,14,20,26,39	2,8,11,13,22,26,28,39	-
Laredo	8,13,27,39	8,13,39,66	-
Longview	16	22	-
Lubbock	5,11,13,28,34	5,11,13,28,34	-
Lufkin	9	9	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Texas -- Continued			
McAllen	48	64	-
Marfa	3	3	-
Marshall	22,35	34,40	-
Midland	2,18	2,21	-
Monohans	9	9	-
Nacogdoches	19,32	27,30	-
Odessa	7,24,30,36	7,25,29,31	-
Port Arthur	4	4	-
Presidio	7	7	-
Richardson	23	23	-
Rosenberg	45	45	-
San Angelo	3,6,8,21	3,6,8,26	-
San Antonio	4,5,9,12,23,29,41	4,5,9,12,29,32,41	-
Sherman	20,26	35,43	-
Sonora	11	11	-
Sweetwater	12	12	-
Temple	6,46	6,34	-
Texarkana	6,17,34	6,21,32	-
Tyler	7,14,38	7,26,38	-
Victoria	19,25	21,25	-
Waco	10,25,34,44	10,25,31,47	-
Weslaco	5	5	-
Wichita Falls	3,6,18,24	3,6,31,44	-
Utah			
Cedar City	4,16	4,22	-
Logan	12,22	12,34	-
Moab	14	22	-
Monticello	16	28	-
Ogden	9,18,24,30	9,22,26,28	-
Price	6,15	6,27	-
Provo	11,16	11,21	-
Richfield	13,19	13,29	-
Salt Lake City	2,4,5,7,14,20,26	2,4,5,7,24,30,32	-
St. George	18	28	-
Vernal	3,17	3,29	-
Vermont			
Burlington	3,22,33	3,22,33	-
Rutland	28	28	-
St. Johnsbury	20	30	-
Windsor	41	41	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE / CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
Virginia			
Blacksburg	43	49	-
Bluefield	63	45	-
Bristol	5,28	5,60	-
Charlottesville	29,41,64	29,41,64	-
Courtland	52	45	-
Danville	24,44,56	56,59	-1
Fredericksburg	53	66	-
Front Royal	42	50	-
Hampton	13,15	13,21	-
Harrisonburg	3	3	-
Kenbridge	31	44	-
Lynchburg	13,21,33	13,25,47	-
Norfolk-Portsmouth-Newport News	3,10,27,33,49,55	3,10,27,33,43,49	-
Norton	47	55	-
Onancock	25	42	-
Petersburg	8	8	-
Richmond	6,12,23,35,57,63	6,12,23,35,48,57	-
Roanoke	7,10,15,27	7,10,27,43	-
Staunton	51	51	-
West Point	46	31	-
Washington			
Bellingham	12,24,34,64	12,24,34,65	-
Centralia	15	26	-
Everett	16	28	-
Kennewick	42	33	-
Pasco	19	21	-
Pullman	10	10	-
Richland	25,31	25,31	-
Seattle	4,5,7,9,22,28	4,5,7,9,33,38	-
Spokane	2,4,6,7,22,28	2,4,6,7,22,26	-
Tacoma	11,13,20,56,62	11,13,22,56,62	-
Vancouver	14	30	-
Walla Walla	14	41	-
Wenatchee	18,27	27,39	-
Yakima	23,29,35,47	23,29,35,47	-
West Virginia			
Beckley	4	4	-
Bluefield	6,40	6,40	-
Charleston	8,23,29,49	8,23,31,42	-
Clarksburg	12,46	12,58	-

COMPARISON OF TABLES OF ASSIGNMENTS

STATE CITY	PRESENT CHANNELS	POSSIBLE CHANNELS	COMMENT
West Virginia -- Continued			
Fairmont	66	45	-
Grandview	9	9	-
Huntington	3,13,67	3,13,67	-
Martinsburg	44	44	-
Morgantown	24	24	-
Parkersburg	15,39,57	35,62,68	-
Weirton	50	-	-1
Weston	5	5	-
Wheeling	7,14,41	7,26,48	-
Williamson	31	64	-
Wisconsin			
Appleton	32	26	-
Colfax	28	38	-
Eau Claire	13,18	13,25	-
Fond du Lac	34	34	-
Green Bay	2,5,11,26,38	2,5,11,32,56	-
Janesville	57	57	-
Kenosha	55	-	-1
LaCrosse	8,19,25,31	8,39,44,52	-
Madison	3,15,21,27,47	3,21,27,31,49	-
Manitowoc	16	22	-
Milwaukee	4,6,10,12,18,24,30,36	4,6,10,12,24,36,42,55	-
Oskosh	22	43	-
Racine	49	30	-
Rhinelander	12	12	-
Sheboygan	28	45	-
Superior	6,40	6,32	-
Wausau	7,9,20,33	7,9,28,30	-
Wyoming			
Casper	2,6,14,20	2,6,21,29	-
Cheyenne	5,17,27,33	5,22,27,35	-
Lander	4	4	-
Laramie	8	8	-
Rawlins	11	11	-
Riverton	10	10	-
Rock Springs	13	13	-
Sheridan	7,12	7,12	-

COMMUNITIES WITH UNSATISFIED ASSIGNMENT REQUIREMENTS

STATE CITY	DEFICIENCY	OTHER SERVICES
Indiana		
Indianapolis	2	7
South Bend	1	4
Massachusetts		
Springfield	1	9
Worcester	1	19
New Jersey		
Trenton	1	20
New York		
Massena	1	7
Patchogue	1	14
North Carolina		
Greensboro	1	10
Pennsylvania		
Bethlehem	1	5
Hazleton	1	8
Reading	1	9
Virginia		
Danville	1	11
West Virginia		
Weirton	1	12
Wisconsin		
Kenosha	1	14

Further information about these communities is given in the following pages of this Appendix.

Indianapolis, Indiana

A. Total Assignments

1)	In present Table of Assignments	7
2)	In computer Table of Assignments	5

B. Population (1960 Census) 476,258

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Anderson, Indiana	34 Mi.	69
2)	Bloomington, Indiana	45 Mi.	4

D. Total Service Available

1)	From Same City	5
2)	From Nearby Cities	2
3)	Total	7

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

South Bend, Indiana

A. Total Assignments

1) In present Table of Assignments — 4

2) In computer Table of Assignments — 3

B. Population (1960 Census) — 132,445

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Elkhart, Indiana	14 Mi.	28

D. Total Service Available

1) From Same City — 3

2) From Nearby Cities — 1

3) Total — 4

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Springfield, Massachusetts

A. Total Assignments

1) In present Table of Assignments — 3

2) In computer Table of Assignments — 2

B. Population (1960 Census) — 174,463

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Hartford, Connecticut	23 Mi.	3,24,51,61
2)	New Britain, Connecticut	32 Mi.	30
3)	New Haven, Connecticut	58 Mi.	8
4)	Greenfield, Massachusetts	33 Mi.	32

D. Total Service Available

1) From Same City — 2

2) From Nearby Cities — 7

3) Total — 9

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Worcester, Massachusetts

A. Total Assignments

1)	In present Table of Assignments	4
2)	In computer Table of Assignments	3

B. Population (1960 Census) 186,587

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Manchester, New Hampshire	52 Mi.	9
2)	Hartford, Connecticut	56 Mi.	3
3)	Providence, Rhode Island	37 Mi.	10,12,28,36,47
4)	Boston, Massachusetts	39 Mi.	2,4,5,7,25,38, 44,56,60

D. Total Services Available

1)	From Same City	3
2)	From Nearby Cities	16
3)	Total	19

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Trenton, New Jersey

A. Total Assignments

1) In present Table of Assignments — 1

2) In computer Table of Assignments — 0

B. Population (1960 Census) — 114,167

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	New York City, New York	52 Mi.	2,4,5,7,9,11
2)	Philadelphia, Pennsylvania	21 Mi.	3,6,10,23,29, 35,57,61
3)	Newark, New Jersey	48 Mi.	13
4)	Asbury Park, New Jersey	39 Mi.	58
5)	Burlington, New Jersey	11 Mi.	48
6)	New Brunswick, New Jersey	25 Mi.	47,52
7)	Wilmington, Delaware	54 Mi.	12

D. Total Service Available

1) From Same City — 0

2) From Nearby Cities — 20

3) Total — 20

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Massena, New York

A. Total Assignments

1)	In present Table of Assignments		1
2)	In computer Table of Assignments		0

B. Population (1960 Census) 15,478

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Ottowa, Ontario	51 Mi.	4,9,13
2)	Cornwall, Ontario	9 Mi.	8,36,56,68

D. Total Service Available

1)	From Same City	0
2)	From Nearby Cities	7
3)	Total	7

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Patchogue, New York

A. Total Assignments

1)	In present Table of Assignments	1
2)	In computer Table of Assignments	0

B. Population (1960 Census) 8,838

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Bridgeport, Connecticut	30 Mi.	43,49
2)	New Haven, Connecticut	37 Mi.	8,33,59
3)	New York City, New York	50 Mi.	2,4,5,7,9,11
4)	Riverhead, New York	21 Mi.	55
5)	Newark, New Jersey	59 Mi.	13
6)	Levittown, New York	26 Mi.	21

D. Total Service Available

1)	From Same City	0
2)	From Nearby Cities	14
3)	Total	14

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Greensboro, North Carolina

A. Total Assignments

1)	In present Table of Assignments	3
2)	In computer Table of Assignments	2

B. Population (1960 Census) 119,574

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Chapel Hill, N. C.	41 Mi.	4
2)	Burlington, N. C.	19 Mi.	38
3)	Durham, North Carolina	49 Mi.	11
4)	High Point, North Carolina	15 Mi.	8,50
5)	Winston Salem, N. C.	26 Mi.	12,32,61

D. Total Services Available

1)	From Same City	2
2)	From Nearby Cities	8
3)	Total	10

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Bethlehem, Pennsylvania

A. Total Assignments

1) In present Table of Assignments	1
2) In computer Table of Assignments	0

B. Population (1960 Census) 75,408

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Allentown, Pennsylvania	7 Mi.	39,69
2)	Philadelphia, Pennsylvania	46 Mi.	3,6,10

D. Total Services Available

1) From Same City	0
2) From Nearby Cities	5
3) Total	5

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Hazleton, Pennsylvania

A. Total Assignments

1) In present Table of Assignments	1
2) In computer Table of Assignments	0

B. Population (1960 Census) 32,056

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Allentown, Pennsylvania	35 Mi.	39,69
2)	Scranton, Pennsylvania	35 Mi.	22,26,44,50,63
3)	Wilkes Barre, Pennsylvania	19 Mi.	28

D. Total Services Available

1) From Same City	0
2) From Nearby Cities	8
3) Total	8

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Reading, Pennsylvania

A. Total Assignments

1)	In present Table of Assignments	1
2)	In computer Table of Assignments	0

B. Population (1960 Census) 98,177

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Allentown, Pennsylvania	30 Mi.	39,69
2)	Lancaster, Pennsylvania	28 Mi.	8,38
3)	Lebanon, Pennsylvania	25 Mi.	64
4)	Philadelphia, Pennsylvania	51 Mi.	3,6,10
5)	Wilmington, Delaware	45 Mi.	12

D. Total Service Available

1)	From Same City	0
2)	From Nearby Cities	9
3)	Total	9

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Danville, Virginia

A. Total Assignments

1)	In present Table of Assignments	3
2)	In computer Table of Assignments	2

B. Population (1960 Census) 46,577

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Lynchburg, Virginia	58 Mi.	13
2)	Roanoke, Virginia	56 Mi.	7,10
3)	Burlington, North Carolina	35 Mi.	38
4)	Chapel Hill, North Carolina	51 Mi.	4
5)	Durham, North Carolina	50 Mi.	11
6)	Greensboro, North Carolina	41 Mi.	2
7)	High Point, North Carolina	54 Mi.	8
8)	Winston Salem, N. Carolina	56 Mi.	12

D. Total Service Available

1)	From Same City	2
2)	From Nearby Cities	9
3)	Total	11

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Weirton, West Virginia

A. Total Assignments

1)	In present Table of Assignments	1
2)	In computer Table of Assignments	0

B. Population (1960 Census) 28,201

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Wheeling, West Virginia	26 Mi.	7,26,48
2)	Steubenville, Ohio	6 Mi.	9,50
3)	Pittsburgh, Pennsylvania	34 Mi.	2,4,11,13
			22,30,53

D. Total Services Available

1)	From Same City	0
2)	From Nearby Cities	12
3)	Total	12

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

Kenosha, Wisconsin

A. Total Assignments

1)	In present Table of Assignments	1
2)	In computer Table of Assignments	0

B. Population (1960 Census) 67,899

C. Other Assignments Capable of Providing Service 1/

	City	Distance	Computer Assignments
1)	Chicago, Illinois	50 Mi.	2,5,7,9,11
2)	Milwaukee, Wisconsin	33 Mi.	4,6,10,12 24,36,42,55
3)	Racine, Wisconsin	9 Mi.	30

D. Total Service Available

1)	From Same City	0
2)	From Nearby Cities	14
3)	Total	14

1/ UHF assignments within 40 miles and VHF assignments within 60 miles.

USE MADE OF MODIFIED TABOOS IN
DEVELOPING TABLE OF ASSIGNMENTS

I. Change in Intermodulation Taboos (20 Miles to 0)

A. 2 Channel Separation

Mileage Separation	Assignments Made
1. 0 to 4 Miles	28
2. 5 to 9 Miles	12
3. 10 to 14 Miles	2
4. 15 to 19 Miles	6
5. Total	48

B. 3 Channel Separation

1. 0 to 4 Miles	15
2. 5 to 9 Miles	4
3. 10 to 14 Miles	2
4. 15 to 19 Miles	7
5. Total	28

C. 4 Channel Separation

1. 0 to 4 Miles	31
2. 5 to 9 Miles	7
3. 10 to 14 Miles	6
4. 15 to 19 Miles	5
5. Total	49

D. 5 Channel Separation

1. 0 to 4 Miles	18
2. 5 to 9 Miles	6
3. 10 to 14 Miles	3
4. 15 to 19 Miles	0
5. Total	27

E. Total for all Intermodulation 152

II. Change in I.F. Beat Taboo (20 Miles to 0)

A. 8 Channel Separation

Mileage Separation	Assignments Made
1. 0 to 4 Miles	37
2. 5 to 9 Miles	10
3. 10 to 14 Miles	3
4. 15 to 19 Miles	7
5. Total	57

III. Change in Sound Image Taboo (60 Miles to 50)

A. 14 Channel Separation

Mileage Separation	Assignments Made
1. 50 to 54 Miles	5
2. 55 to 59 Miles	29
3. Total	34

IV. Change in Picture Image Taboo (75 Miles to 60)

A. 15 Channel Separation

Mileage Separation	Assignments Made
1. 60 to 64 Miles	5
2. 65 to 69 Miles	20
3. 70 to 74 Miles	17
4. Total	42

V. Total Changes

A.	Intermodulation	152
B.	I.F. Beat	57
C.	Sound Image	34
D.	Picture Image	42
E.	Total	285

VI. Assignments Made With 2 or 4 Channel Separation

		Channels
A.	Tulsa, Oklahoma	29,31,33
B.	Muncie, Indiana	49,51,53

VII. Assignments Made With 3 or 6 Channel Separation

		Channels
A.	None	None

VIII. Assignments Made With 4 or 8 Channel Separation

		Channels
A.	Huntsville, Alabama	21,25,29
B.	Midland, Odessa, Odessa, Texas	21,25,29
C.	Florence, Tuscumbia, Florence, Alabama	28,32,36

IX. Assignments Made With 5 or 10 Channel Separation

		Channels
A.	Duluth, Duluth, Superior, Wisconsin	22,27,32

Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D. C. 20554

In the Matters of:

Amendment of Parts 2, 89, 91 and 93; Geographic Reallocation of UHF-TV Channels 14 through 20 to the Land Mobile Radio Services for Use Within the 25 Largest Urbanized Areas of the United States	)	DOCKET NO. 18261
Petition filed by the Telecommunications Committee of the National Association of Manufacturers to Permit Use of TV Channels 14 and 15 by the Land Mobile Stations in the Los Angeles Area	)	RM-566

REPLY COMMENTS OF THE LAND MOBILE COMMUNICATIONS COUNCIL

Max Guiberson, President
Land Mobile Communications Council
7810 East Martin Way
Olympia, Washington 98501

April 24, 1969

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REPLY COMMENTS OF THE
LAND MOBILE COMMUNICATIONS COUNCIL

The Land Mobile Communications Council (hereinafter referred to as "LMCC"), by its President, respectfully submits these Comments in Reply to those filed in this proceeding on behalf of the Association of Maximum Service Telecasters, Inc., (hereinafter referred to as "MST"). 1/ Reply Comments

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1/ . The principal points raised in the Comments of other broadcast interests were, very largely, redundant to those covered in the MST Comments. Thus, these Reply Comments are also responsive to the Comments filed by the broadcast interests other than MST.

in this proceeding were originally due on March 31, 1969, but the filing date was extended by Commission Order at the request of MST until April 30, 1969. (FCC 69-223, No. 27940, March 13, 1969).

I

PRELIMINARY STATEMENT

A. Proposals In This Docket Should Be Adopted As First Step In Meeting Land Mobile Requirements

1. The proposals advanced by the Commission in this Docket are a very important and integral part of the overall plan of relief needed to meet present and future land mobile frequency requirements. As a reading of the original LMCC Comments reveals, LMCC believes it is very important that as an interim step, and preliminary to the exclusive allocation of the lower seven UHF-TV frequencies to the Land Mobile Services, the Commission should promptly issue a First Report and Order in this proceeding adopting the rule changes looking toward the geographic sharing of these frequencies between Land Mobile Services and Broadcast Services.

2. LMCC assumes, however, that in adopting the proposals in this Docket the Commission will take into consideration the constructive criticism offered by LMCC with respect to certain limitations found in the original proposals and that the Commission will make such adjustments or modifications to the proposed restrictions on the shared land mobile use of these frequencies so that during the interim "sharing stage", land mobile users will be able to make maximum practical use of these frequencies to the degree that is possible under any kind of frequency sharing arrangement. For example, a modification of the originally proposed antenna height, power and mileage separation requirements could result in more land mobile licensees making better or more meaningful use of these frequencies.2/ Also, since these factors have no relationship to the urbanized area

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2/ The technical details of these modifications will be covered in the Reply Comments of the Land Mobile Section of Electronics Industries Association and those of individual equipment manufacturers.

boundaries and since mobile unit areas of operation are normally limited by the location of the base station and its operating characteristics, it would seem that the artificial 1960 urbanized area boundary concept could be eliminated.[3/]

B. Commission Should Immediately Move Forward With Further Steps To Reallocate Lower Seven UHF-TV Channels To Land Mobile Services

3. Although the modification of these restrictions would mean that more land mobile licensees will be able to make greater use of these shared frequencies than would be possible under the original proposals, LMCC must stress, again, that the adoption of these rule proposals, even with modifications of the restrictions, can only be considered as a first interim step and it is necessary for the Commission to go forward immediately with the further studies and steps necessary to more fully meet the existing land mobile congestion problem and also to provide, in a more meaningful way, for the near future requirements.

3/ During the interim sharing period, the operating areas of "mobile only" systems could be handled on a case-by-case basis taking into consideration the mobile operating requirements and co-channel and possibly adjacent channel TV operations.

4. The fact that the proposals advanced in this Docket by the Commission, even with the proposed restrictions modified, are still inadequate to fully meet all existing land mobile frequency requirements, does not mean that the proposals should be abandoned. Rather, since these proposals will afford some immediate relief to land mobile licensees, they should be adopted, in modified form, as the first, or interim, step in meeting the land mobile congestion problem.

II

REPLY COMMENTS

A. Contentions On Growth Projections For Land Mobile Services

5. MST argues that the need for additional frequencies to meet land mobile requirements is founded upon faulty land mobile transmitter growth projections. MST contends that the transmitter growth projections used by both the Commission's Land Mobile Advisory Committee and the Commission's Land Mobile Frequency Relief Committee were overstated. MST contends that there will be only 2.9 million land mobile transmitters in service by 1980 instead of the 7.3 million projected by the Commission's Land Mobile

Frequency Relief Committee. MST goes on to argue that there is a decline in the growth rate of the Land Mobile Services which is not caused by frequency congestion but, rather, by mismanagement of the use of existing land mobile frequencies. MST concludes that there should be no saturation of existing land mobile frequencies for the foreseeable future, even in the most heavily populated areas.

6. The attached Exhibit No. 1, which is a critique of the MST growth projections and a verification of the validity of the projections made by the Commission's Land Mobile Advisory Committee and its Land Mobile Frequency Relief Committee, demonstrates that the Land Mobile Frequency Relief Committee projections of 7.3 million land mobile transmitters by 1980 instead of being "grossly in error" as contended by MST, are, in fact, ultra-conservative. Based upon the formula used in attached Exhibit No. 1, (which, LMCC submits is more realistic

in making forecasts on such matters as land mobile transmitter growth than the Gompertz curve used by MST,) it will be seen that the number of transmitters installed in 1980, if free land mobile growth is permitted through adequate frequency allocations, would amount to 10.8 million.

7. While the use of different formulae and different methods of forecasting result in diverse projections of the number of transmitters which might possibly be in use at the end of the next decade, the fact remains that there has been and continues to be growth in the use of land mobile radio and the number of land mobile transmitters on the air. The fact also remains that even with the existing number of land mobile operations there is, admittedly, intolerable congestion in most of the major metropolitan areas. Thus, any growth in the number of transmitters on the air will only serve to worsen the congestion situation unless effective means of relief are taken. LMCC submits that the growth

projections arrived at by the Commission through the activities of its Land Mobile Frequency Relief Committee and those set forth in the attached Exhibit No. 1 are accurate and are, in fact, more realistic than the projections contrived by MST.

B. Contention That Land Mobile Congestion Is Not Caused By A Shortage Of Frequencies But Rather Because Of Deficiencies In Methods Of Allocation, Coordination, Management and Usage Of Frequencies and That This Congestion Could Be Solved By A Series Of Reforms

8. MST argues that although congestion may, in fact, exist, there are in reality sufficient frequencies to meet land mobile requirements for the foreseeable future even in the metropolitan areas, since the existing congestion is not caused by any lack of frequencies, but rather, by mismanagement in the use and licensing of the land mobile frequencies. MST contends that this congestion can be solved by a combination of approaches and reforms of land mobile spectrum licensing, management, coordination and engineering practices. Among the principal "reforms"

suggested by MST is to modify the "block" allocation system and encourage sharing to minimize uneven channel loading; modify the coordination and licensing processes to include determinations of needs in relation to spectrum availability in a particular area and develop a range of technical system parameters for use in the licensing process; implement such technical approaches as multiplexing, trunking, time sharing, use of non-voice systems, and geographic space sharing; and, apparently, simply to deny the use of mobile radio to most new prospective users once an area becomes congested, even under MST's definition of congestion. Also, MST suggested that the "primary" police radio communications activity be consolidated in the 150 MHz band by moving what MST referred to as "low priority" commercial and industrial users to the 450 MHz band and to the "new" band <u>above</u> 900 MHz.

9. At the outset, LMCC must note that all of the "problems" which MST cites as the reasons for land mobile congestion and most of the "reforms" advocated by MST as solutions to these problems, have been thoroughly reviewed, first by the Land Mobile Advisory Committee and then by the Commission and its

Staff. In fact, some of the "reforms" suggested by the Land Mobile Advisory Committee have already been implemented, at least in part, by the Commission.

10. For example, Working Group C-2 of the Land Mobile Advisory Committee made an exhaustive study of the various methods of allocation of the existing land mobile spectrum and recommended to the Commission that the present block allocation system be revised to permit, under appropriate conditions, a radio service suffering frequency channel over-crowding in a given locale to share the frequency channels of another service which is making less intensive use of its channels in that area. The report of this Working Group also demonstrated, however, that in the major metropolitan areas, this would not result in great benefit because substantially all frequency channels in all allocation blocks are already crowded. Although the Commission has only implemented this inter-service sharing recommendation in part, even if it were immediately fully implemented

as to all land mobile bands, it would do little more than quite temporarily relieve congestion in the Land Mobile Services as was demonstrated in the studies made by Working Group C-2.

11. Also, the Land Mobile Advisory Committee made an exhaustive study of the then existing frequency coordination practices to determine where improvements and efficiencies through uniformity could be accomplished. As a result of these studies, and the necessity for improved inter-service coordination practices resulting from the inter-service sharing of frequencies already accomplished by the Commission, many of the improvements in this area recommended by the Land Mobile Advisory Committee have been implemented. In addition, studies and pilot projects are already underway in certain of the Land Mobile Services with a view towards further efficiencies and improvements in frequency coordination and assignment techniques through the use of computers.

12. As to the "technical" approaches or reforms suggested by MST, while time-sharing of channels and geographic space sharing, already widely used, result in varying degrees, of more efficient use of the existing land mobile spectrum, the Land Mobile Advisory Committee reports demonstrated that their expanded use would not result in any substantial relief to the Land Mobile Services. The same Land Mobile Advisory Committee reports also considered, at length, trunking, multiplexing, random access and other techniques, and found conclusively that their use, even in the aggregate, would not substantially increase the efficient use of existing land mobile spectrum, "efficient use" being the accommodation of the maximum number of users per channel and the transmission and reception of the maximum amount of information per channel.

13. LMCC recognizes, as did the Land Mobile Advisory Committee, that while the expansion of the use of any or all of these techniques would be

beneficial, it cannot result in such greater utilization of the existing land mobile spectrum as to meet even the present requirements in the major centers of population. On the other hand, LMCC certainly believes that these and any other promising proposals should be seriously considered and implemented, when found to be practical, particularly with respect to any additional frequency space which is made available to the Land Mobile Services.

14. With respect to the MST suggestion of consolidating all police requirements in the 150 MHz band by moving what MST refers to as "low priority" licensees to the 450 MHz band or above, LMCC submits that all Land Mobile Services, police or otherwise, need frequencies in various bands to meet different operating requirements. It is neither realistic nor efficient to confine given services to specific frequency bands and such action would not conform to sound engineering practices. For this reason alone, and apart from the economic burden which

the MST proposal would thrust upon many local and state governments, this particular MST proposal is without any merit. LMCC submits that the present land mobile allocations, which provide, in most cases, availability of frequencies across the land mobile spectrum, reflects the recognition by the Commission that land mobile licensees need access to channels, which are as interference free as possible, in all bands.

C. Contention That Allocation Of Any UHF-TV Channels To Land Mobile Services Should Be Rejected Because Of A Requirement For 82 Channels For Television Use

15. In its Comments, MST has contended that the allocation of UHF-TV channels to the Land Mobile Services should be rejected because all the 82 channels now allocated for television use will be required if the goal of an adequate educational and commercial television system is to be achieved.

16. In raising the question of the necessity for 82 channels, MST has touched upon what is, in reality, the most important consideration

in meeting in a meaningful and adequate way the land mobile congestion problem. By adopting "reforms" in the present UHF-TV separation requirements ("taboos") (which is analogous to the "channel splitting" which the Land Mobile Services has been undergoing since the early 1950s), the goal of an adequate educational and commercial television system can still be achieved, but on substantially less than 82 channels. LMCC submits that the "Cullum Study" (Exhibit 4 to Comments of the Land Mobile Communications Council in Docket No. 18261) quite clearly shows that it is possible and practical to divert the lowest seven UHF television channels from the Broadcast Services to the Land Mobile Services, and, at the same time, to retain in the remaining channels <u>below Channel 70</u>, essentially the same number of total assignments by modifying certain of the UHF taboos.

17. LMCC further submits that the findings and conclusions in the Cullum Study warrants the Commission promptly launching the program of testing recommended in the Cullum

Study as a preliminary step to implement the needed changes in the taboos. However, LMCC submits that the conduct of any such program of testing should not, in any way, delay the prompt implementation of the interim sharing proposals advanced in this Docket. As LMCC indicated in its original Comments, the conduct of this testing program is only one of the steps the Commission should take in arriving at the ultimate goal of the total reallocation of the lower seven UHF channels to the Land Mobile Services.

18. If, as the Cullum Study demonstrates, substantially the same number of UHF-TV assignments can be retained on fewer channels by modifying certain of the UHF taboos, thereby making more efficient use of this portion of the spectrum, the frequencies which were yielded through this improvement in spectrum utilization could be used to meet land mobile requirements. In this connection, it must be stressed that communications with moving vehicles and persons can only be met through the use of radio spectrum as opposed

to the situation in the Broadcast Services where the requirements can be and are met by metallic circuits as well as by the use of radio spectrum, in some cases, more efficiently. Thus, when MST speaks of the Commission requiring the land mobile licensees to demonstrate a "need" for the use of radio spectrum, it should recognize that the same guidelines must also be applied to the Broadcast interests. Unlike a receiver in a vehicle which can only be reached through radio transmission, a television receiver can be reached just as effectively by a metallic circuit.

III

SUMMARY

19. LMCC submits that the MST contentions concerning the land mobile growth projections are without merit and that if anything, the projections previously advanced by the Land Mobile Advisory Committee and expanded upon by the Commission's Land Mobile Frequency Relief Committee, are at the most, ultra-conservative.

20. It will also be seen that based upon these projections, as well as those advanced in Exhibit No. 1 of these Reply Comments, even if all of the "reforms" suggested by MST (most of which have already been considered by the Land Mobile Advisory Committee and the Commission) were implemented as to existing land mobile frequency spectrum, it still would not be sufficient to meet even existing congestion in the major metropolitan areas.

21. Similarly, the arguments advanced by the Broadcast interests that land mobile relief should not be effected through the allocation of broadcast frequencies in order to avoid eliminating the present inefficiencies in broadcast usage of the UHF-TV spectrum are without merit when it is recognized that when "reforms" in the broadcast operating methods, such as those suggested by the Cullum Report are implemented, an adequate commercial and educational television system can still be developed, but on substantially fewer channels.

WHEREFORE, THE PREMISES CONSIDERED, the Land Mobile Communications Council respectfully urges that as an interim step the Commission should go forward immediately and issue an Order adopting the sharing proposals in this Docket but with such modifications as would permit maximum utilization of these shared channels by land mobile users. However, since even under the most favorable operating conditions the relief proposed in this Docket will not meet the immediate requirements of all land mobile users in the major metropolitan areas, LMCC urges that the Commission should immediately take the further steps necessary for the exclusive allocation to the Land Mobile Services of the frequencies now occupied by TV Channels 14 through 20.

Respectfully submitted,

LAND MOBILE COMMUNICATIONS COUNCIL

(s) Max Guiberson

By____________________________

Max Guiberson, President
Land Mobile Communications Council
7810 East Martin Way
Olympia, Washington 98501

April 24, 1969

VERIFICATION

STATE OF WASHINGTON)
) SS:
COUNTY OF THURSTON)

Max Guiberson, being first duly sworn, deposes and says:

That he is President of the Land Mobile Communications Council, that he has read the foregoing Reply Comments, and that to the best of his knowledge, information and belief the matters stated therein are true and correct.

(s) Max Guiberson

Max Guiberson, President
Land Mobile Communications Council
7810 East Martin Way
Olympia, Washington 98501

Subscribed and sworn to before me this 24th day of April 1969.

(s) Paul E. Krauss

Notary Public in and for the
County of Thurston

My Commission Expires: July 20, 1971

EXHIBIT NO. 1

LMCC REPLY COMMENTS
DOCKET NO. 18261

CRITIQUE OF MST LAND MOBILE GROWTH PROJECTIONS AND VERIFICATION OF THE VALIDITY OF PROJECTIONS MADE BY LAND MOBILE ADVISORY COMMITTEE AND LAND MOBILE FREQUENCY RELIEF COMMITTEE

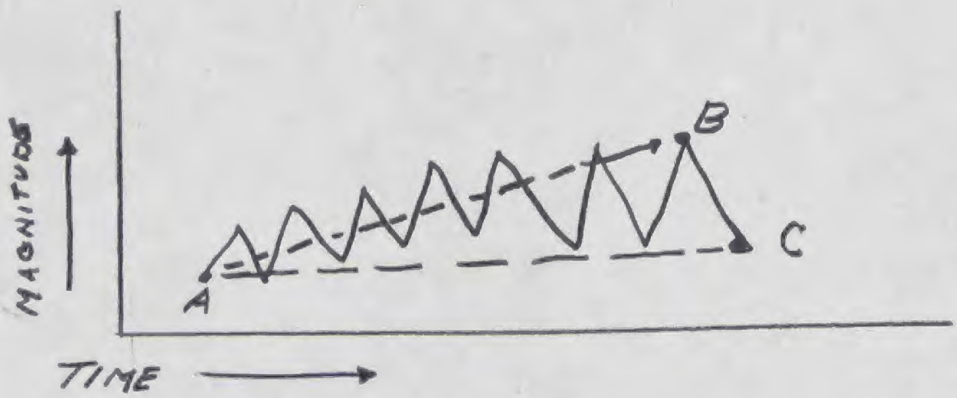
EXHIBIT NO. 1

CRITIQUE OF MST LAND MOBILE GROWTH PROJECTIONS AND VERIFICATION OF THE VALIDITY OF PROJECTIONS MADE BY LAND MOBILE ADVISORY COMMITTEE AND LAND MOBILE FREQUENCY RELIEF COMMITTEE

The reasoning behind the MST and Kelly filing which associates the number of land mobile radio transmitters with the gross national product is specious. Because the number of land mobile transmitters in use is not free to increase to meet a need or demand it does not merit serious response. However, the logic may become valid at some future date when all of the pent-up demand for land mobile communications has been satisfied and the need to be satisfied becomes one of meeting year-to-year growth requirements.

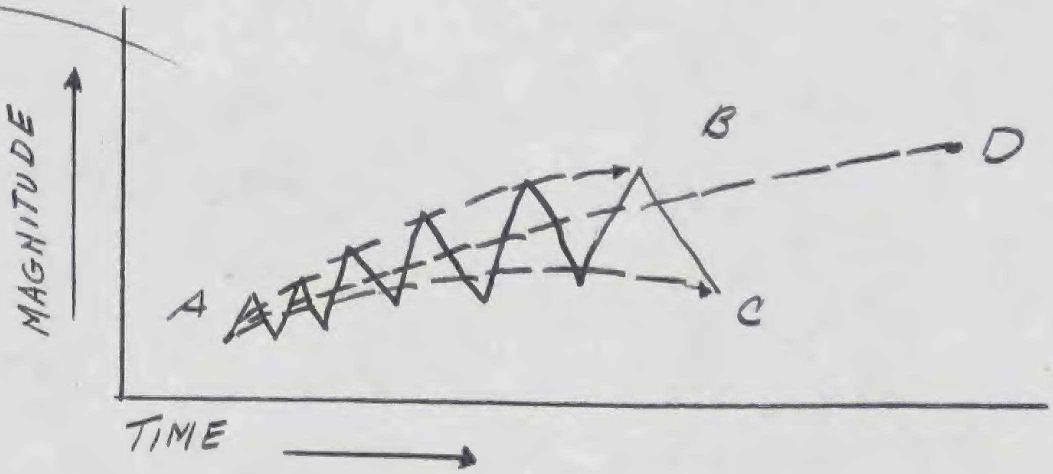
The formula $r = \sqrt[N]{\frac{P_n}{P_o}} - 1$ utilized in the MST filing to determine the rate of decline in land mobile growth percentages is analogous to the straight line annual rate of increase with which we are all familiar.

For example, consider the following sketch:



The annual rate of growth between points A to B and A to C are clearly different with that between A to B being somewhat greater.

If, instead of straight line increase, a curve is plotted as shown in the following sketch, the formula $r = \sqrt[N]{\frac{P_n}{P_o}} - 1$ could be used to estimate the annual rate of decline in succeeding years. Here again, the curve from A to B is clearly higher than that from A to C. To estimate the decline from a preceeding year on an average basis, the best way to make the estimate would be to input trend line values from a curve with a high index of determination (r^2 value), i.e. A to D:



The trend line methodology given above may be applied to each individual land mobile service. Most will show a decline in transmitters in use beginning when frequencies became crowded. However, experience with the Business Radio Service shows that businessmen want and need mobile communications and that they will license in any service for which they are eligible. It is questionable that anything can be proven by such an analysis on a service-by-service basis as was attempted by MST, other than that a service stops growing when it runs out of available frequencies in the populated areas where they are required to serve human needs.

However, a mathematically sound estimate and forecast of land mobile transmitters in use each year from 1950 through 1980 can be developed from three publicly available data inputs. The first input is from the MST filing and is selected primarily to eliminate further contention on the question of the ratio of transmitters in use to transmitters licensed. The Kelly Scientific Corporation reports from a survey of a small sample (7391 names from a universe of approximately 225,000 stations, or approximately 3.2%) that transmitters in use as a percent of those licensed is 66%.[1/] For convenience and

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1/ Kelly goes on to state that that percentage is high due to non-responses, etc. While it is true that a certain number of licensees have moved or gone out of business since licenses were secured, it should be noted that the wording of the Kelly Survey introduced a bias which more than offsets the items cited by Kelly. A spot check among respondents listed in the MST filing found that the Kelly questionnaire was so worded that in the minds of the respondents portable or personal two-way radios (which are certainly transmitters) were excluded as were radios not actually in use at the time. As a result, respondents with large numbers of personal two-way radios reported only a small number in vehicular use. Additionally, other respondents with seasonal businesses requiring a fleet of trucks equipped with two-way radio reported only those which were actually active at the time of the survey. The remainder, both of trucks and radios, were awaiting use later in the year.

for the purpose of calculating a trend line of transmitters installed, we are willing to accept the 66% reported by Kelly although objective market research studies suggests that the number is low by several percentage points.

The second input is the number of transmitters in use as a percentage of those licensed in 1955. An FCC Report of Survey published as a Public Notice, Number 16187, dated February 18, 1955, shows transmitters in service as a ratio to those authorized to be 57.5%.

The third input is the number of mobile transmitters authorized as shown in the FCC's Annual Report. The effect of a change in reporting date which took place in 1958 and which the MST filing spent considerable time in recalculating is negligible in an 18-year trend line calculation.

The results of combining these three inputs cited above is shown in the following table:

YEAR	TRANSMITTERS LICENSED FROM FCC ANNUAL REPORT	PERCENT IN SERVICE2/	ACTUAL NUMBER OF LAND MOBILE TRANSMITTERS INSTALLED
1950	154529	57.5	88854
1951	234829	57.5	135027
1952	295489	57.5	169906
1953	377712	57.5	217184
1954	433627	57.5	249336
1955	521345	57.5	299773
1956	697799	57.5	401234
1957	768500	57.5	441888
1958	937744	57.5	539203
1959	1100522	57.5	632800
1960	1271025	57.5	719339
1961	1513352	58.56	886219
1962	1702260	59.62	1014887
1963	1902799	60.68	1154618
1964	2067516	61.74	1276484
1965	2276617	62.80	1429715
1966	2443733	63.86	1560568
1967	2680800	64.92	1740375
1968	2895581	66.00	1911083

2/ The distribution of increase in percent of transmitters installed as a percent of those licensed from 57.5% in 1954-4 to 66% in 1968 was assumed to occur in the period 1961 through 1968. An alternate assumption of straight line increase from 1955 to 1968 meakes very little difference in the 1980 trend projection.

Given a series such as this a forecaster will seek a mathematical formula which describes the curve of best fit, i.e. that which has the highest index of determination, where the index of determination is the familiar r^2, or the square of the degree of correlation. By definition a perfect fit is 1.0. It follows that for a given series, the highest index of correlation is that which most nearly approaches 1.0.

Most statistical texts deal at some length with the subject of correlation. However, it is convenient in this case to input the data series, "Transmitters Installed" into a computer program which will calculate the index of determination between the given data and the general equations which describe the six most commonly met regular curves.[3/] This was done with the

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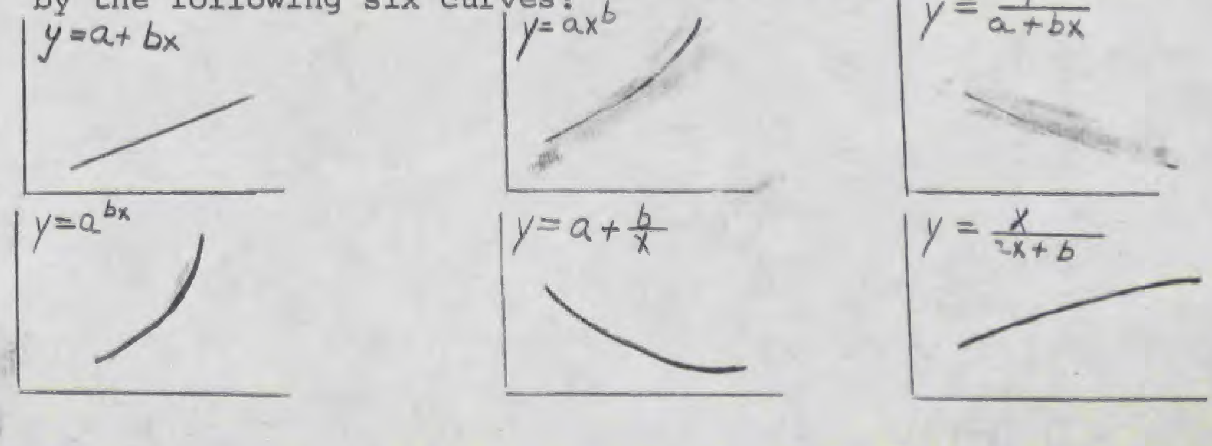
3/ The families of most regular curves may be described by the following six curves:



results shown below:

CURVE TYPE	INDEX OF DETERMINATION	A	B
1. Y=A+(B*X)	.95462	-5.19172E+06	101259.
2. Y=A*EXP (B*X)	.976596	36.9607	.163018
3. Y=A*(X↑B)	.986986	5.54585E-12	9.61061
4. Y=A+(b/X)	.914148	6.56843E+06	-3.38405E+08
5. Y=1/(A+B*X)	.723982	2.80743E-05	-4.29201E-07
6. Y=X/(A+B*X)	.787458	1.52869E-03	-2.33854E-05

These are all first quadrant curves which may be drawn in other quadrants with suitable transformation of sign.

Curve number 3, $y=ax^b$ is a power function, in this case, with an index of determination (r^2) of .987. The power function is the formula for a curve which on rectilinear graph paper rises at a steadily increasing rate while on logarithmic graph paper the curve rises at a steadily but at something less than a constant rate. The curve may be projected for as many years as one wishes. In this case, the computer was directed to extend the curve to 1980 with the results shown on the following page:

EXHIBIT NO. 1
Page Nine

$Y = A*(X^B)$ is a power function. The results of a least-squares fit of its linear transform are as follows:

X-ACTUAL	Y-ACTUAL	Y-CALC	DIFFERENCE	PCT DIFFER
1950	88854	118059.	-292204.9	-24.7
1951	135027	142808.	-7780.71	-5.4
1952	169906	172107.	-2201.38	-1.2
1953	217184	206682.	10501.6	5.
1954	249336	247355.	1980.63	.8
1955	299773	295058.	4714.89	1.5
1956	401234	350844.	50390.2	14.3
1957	441888	415900.	25988.1	6.2
1958	539203	491563.	47640.1	9.6
1959	632800	579333.	53466.8	5.6
1960	719339	680892.	38446.5	11.
1961	886219	798122.	88097.4	8.7
1962	1014887	933121.	81766.4	6.1
1963	1154618	1.08823E+06	66388.4	.8
1964	1276484	1.26605E+06	10432.	-2.7
1965	1429715	1.46948E+06	-39764.1	-8.2
1966	1560568	1.70172E+06	-141149.	-11.4
1967	1740375	1.96631E+06	-225939.	-15.7
1968	1911083	2.26719E+06	-356110.	
1969		2.60873E+6		
1970		2.99561E+6		
1971		3.43313E+6		
1972		3.92705E+6		
1973		4.48371E+6		
1974		5.11005E+6		
1975		5.81367E+6		
1976		6.60289E+6		
1977		7.48677E+6		
1978		8.47522E+6		
1979		9579036		
1980		10.809947		

(NOTE: In this program E+6= $1x\ 10^6$)

The number of transmitters installed in 1980, if free growth were permitted, would amount to 10.8 millions. This data shows the number of transmitters which would be in use if spectrum for the use of Land Mobile radio was made available to would-be users at the rate it was made available during the period 1950 through 1962. That is, if enough spectrum were made available to let the nation utilize mobile radio in a freely competitive climate rather than in the artificially restricted climate which has prevailed in the past and which has restricted growth from 1963 onward.

Returning to the LMFRC forecast of 7.3 million transmitters by 1980, it would appear that the forecast was ultra-conservative and justifiable only on the assumption that sorely needed spectrum would not be available to the Land Mobile Services prior to 1970.

CERTIFICATE OF SERVICE

This is to certify that I have, this 30th day of April, 1969, mailed a copy of the foregoing "Reply Comments of the Land Mobile Communications Council" in Docket No. 18261 to the following, via First Class Mail, with proper postage shown thereon:

Ernest W. Jennes, Esquire
Covington & Burling
701 Union Trust Building
Washington, D. C. 20005
Attorneys for Association of
Maximum Service Telecasters, Inc.

/s/ Catherine R. Ferguson

By______________________________

Catherine R. Ferguson

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

In the Matters of

Amendment of Parts 2, 89, 91, and 93: geographic reallocation of UHF TV channels 14 through 20 to the land mobile radio services for use within the 25 largest urbanized areas of the United States.	DOCKET NO. 18261

Comments of the Land Mobile Communications
Section of the Industrial Electronics
Division of Electronic Industries Association

Respectfully submitted,

John Sodolski

John Sodolski
Secretary
Land Mobile Communications Section

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Exhibits

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

In the Matters of

Amendment of Parts 2, 89, 91, and 93: geographic reallocation of UHF TV channels 14 through 20 to the land mobile radio services for use within the 25 largest urbanized areas of the United States.	DOCKET NO. 18261

Comments of the Land Mobile Communications Section of the Industrial Electronics Division of Electronic Industries Association.

The Land Mobile Section (Hereinafter referred to as the Section) is pleased to submit the following comments on the above entitled proceeding.

I. INTRODUCTION

1. The Section wishes to commend the Commission for its recognition that the Land Mobile Radio Services require additional spectrum now. This problem has been the subject of Congressional Reports, and speeches, of blue ribbon Government Advisory Panels, and of members of the Commission's staff itself (Exhibit 1 lists these sources). Perhaps, the Commission has expressed the current state of land mobile spectrum usage most graphically:

> "The condition is not unlike that of a main highway on a summer weekend, so overcrowded with vehicles that traffic has come to a standstill. Getting it moving again becomes a problem of gigantic proportions." (p. 48, 1966 FCC Annual Report)

2. Thus, this concrete action proposing to make additional spectrum available is encouraging. The last reallocation proceeding was completed by 1949, twenty years ago, and the spectrum between 25 and 890 MHz has been more or less fixed ever since. No one at that time visualized the fantastic growth of the land mobile services which would occur in the future. While in Docket 11997, however, EIA and others did point out that significant continued growth would require accomodation, the fact remains that in roughly 4.7% of this spectrum there are now crammed more than two and a half million transmitters endeavoring to serve

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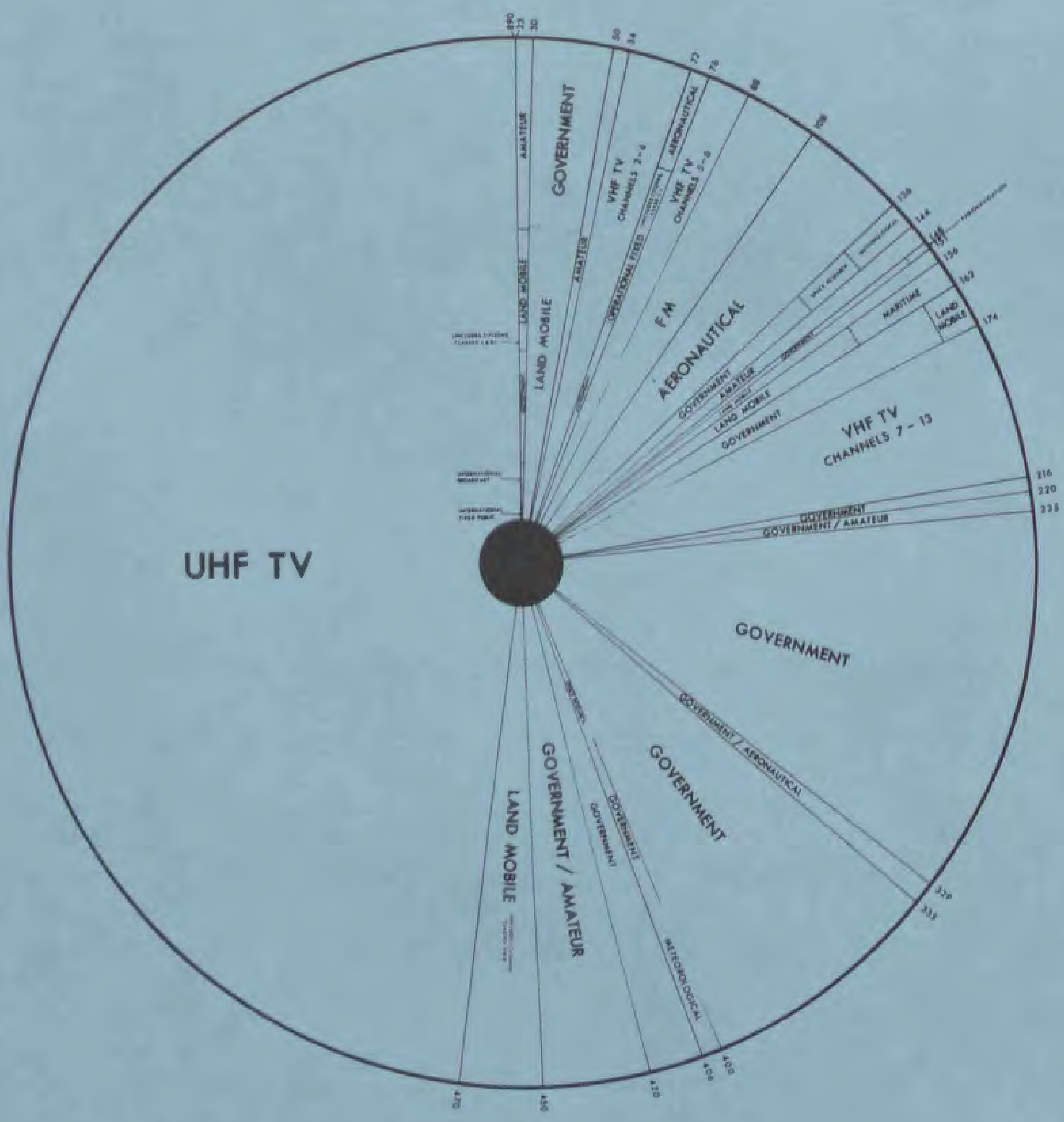
the public by providing more efficient protection of life and property, more efficient production and delivery of goods, and quicker availability of all kinds of services (see Figure 1 which depicts the current spectrum allocations.)



CURRENT SPECTRUM ALLOCATION FROM 25-890 MHz

FIGURE 1

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As discussed later, there is no indication that the public needs, which can be served better by land mobile radio, will slacken. Furthermore, as a result of continuing technological development, there is expected to be a myriad of new uses which will merit additional requirements for more spectrum.

3. The Commission also has justifiably recognized that the spectrum between 470 and 512 MHz represents the best practical location in the spectrum for this additional land mobile relief. While it is recognized from a technical point of view that the 150 MHz band is optimum for base-mobile communications, it is conceded that this spectrum is already so heavily occupied by a wide range of users, including VHF television, that providing the needed spectrum here is not likely to be done. Conversely, the Commission has properly taken cognizance of some of the problems of the 900 megahertz band when it stated in this docket that:

"propagation vagaries and other considerations label possibilities for effective use of this part of the spectrum by the land mobile services largely speculative and in any event strictly a long-range possibility outside the time frame within which relief is being sought." (paragraph 5)

4. There does, however, seem to be a body of opinion, as expressed by Commissioner Lee in his dissent in this proceeding that the 900 MHz portion of the spectrum not only could be made

usable for mobile communications in the near-term future, but also that this band would provide relief equivalent to the 470-512 MHz band. This contention overlooks the serious and fundamental physical characteristics and limitations of the upper end of the spectrum for land mobile use as compared with lower frequency bands. (Figure 2 shows the impact of these differences in a typical large city in Table form and Exhibit 2 analyzes the differences with regard to range, system design, and equipment factors.)

FIGURE 2

COMPARISON OF 150, 450, and 900 MHz BANDS

	150 MHz	450 MHz	900 MHz
Transmitter Power	110 W.	60 W.	35 W.
Receiver Sensitivity	0.5 uv.	0.8 uv.	1.2 uv.
Antenna Gain	6 db.	10 db.	13 db.
City Factor or Foliage Loss	10 db.	28 db.	34 db.
Noise Degradation	15 db.	6 db.	1 db.
Environment	City Residential or Industrial District		
Terrain	Flat		

5. Further, the Section recognizes the Commission's stated objective: to provide relief to the Land Mobile Radio Services with a minimum impact on television broadcasting. Since both types of spectrum usage are designed to benefit the public, a

solution designed to allow both to serve all of the people in the public interest, convenience and necessity must have minimum impact on both. As an example, permitting land mobile to utilize spectrum now occupied by television in such a way so as to cause significant interference to TV viewers would not be satisfactory to anyone. Similarly, a proposal which would result in TV interference to land mobile operations would deprive the public of safety, property and economic benefits. Whatever the solution, to be meaningful, it must provide needed frequencies for both land mobile and television to whatever extent a valid need exists.

II. Land Mobile Need

6. It is well-recognized that land mobile has been suffering increasingly from a shortage of frequencies which has reached the critical stage in many services in many areas. The FCC categorized the situation in its 1966 Annual Report:

"The major problem . . . one of the thorniest."

7. In addition, Congressman John D. Dingell of Michigan, a member of the House Select Committee on Small Business, stated on the floor of the House on December 6, 1967, that:

> . . . . . . I and many other members of the House have been trying to get some action by the FCC to resolve that plight of the small businesman, the police, and other users of two-way radio who are desperately in need of an adequate amount of frequency spectrum in order to effectively use their two-way radios. (Congressional Record, December 6, 1967, p. H16422)

8. In a letter to Congressman Dingell dated August 23, 1967, Police Chief Thomas Reddin and Deputy Chief Noel McQuown of the Los Angeles Police Department stated:

> "The Los Angles Police Department has been plagued with radio frequency shortage problems over the past decade. The situation has become ever-more acute since the Watts Riots in August of 1965."
>
> "That riotous period required total utilization of the Police Department's radio communications system and clearly demonstrated that additional message capacity was essential to the public safety of the City of Los Angeles. (Idem).

9. Mr. Richard A. Pinkston, business manager of the City Cab Company in Detroit, Michigan, told a congressional committee

that:

> "The area we serve now is so large that we should be adding more cabs to our fleet. The reason we don't is that we share our radio channel with five other cab companies, and there is so much frequency congestion I don't dare put any more cabs or any more units on the air." (House Select Committee on Small Business, Report of Subcommittee No. 5, 1968, p. 17)

10. In a report entitled, "Electromagnetic Spectrum Utilization - The Silent Crisis," The Telecommunications Science Panel of the U.S. Department of Commerce aptly depicted the situation:

> "Today, in almost all the major metropolitan areas, there is considerable interference. In Los Angeles, for example, frequencies may be shared by as many as 50 to 60 users, operating 500 or 600 mobile units, all in the same geographical area. A recent FCC inspection trip to New York City confirmed intense congestion there." (p. 13)

11. Quantitatively, the growth in land mobile transmitters has been explosive. From a figure of 86,000 in 1949, there has been an increase to approximately 3 million today. The Commission's Land Mobile Frequency Relief Committee (see infra) predicts a growth to 5.2 million licensed transmitters by 1975 and 7.3 million in 1980, and it cautions that these figures may prove to be a "conservative estimate." EIA has also undertaken a service-by-service market projection and has arrived at a figure reasonably proximate to that of the Commission's (Figure 3 shows the totals while Exhibit 3 demonstrates how each service's growth was derived.) We would also echo that this total is

FIGURE 3

LAND MOBILE LICENSED TRANSMITTERS

1970 - 1990

	1970	1975	1980	1985	1990
POLICE	300,000	380,000	460,000	540,000	630,000
FIRE	170,000	220,000	282,000	340,000	382,000
LOCAL GOV'T	140,000	208,000	275,000	343,000	413,000
HIGHWAY MAINT.	75,000	100,000	130,000	162,000	200,000
FORESTRY CONS.	48,200	52,800	57,500	62,200	67,500
SPEC. EMERGENCY	33,500	45,000	60,000	74,000	90,000
STATE GUARD	416	416	416	416	416
TOTAL SAFETY TOTAL	767,116	1,006,216	1,264,916	1,521,616	1,782,916
SPECIAL IND.	435,000	555,000	680,000	800,000	935,000
BUSINESS	1,150,000	2,100,000	3,300,000	4,500,000	5,720,000
POWER	221,000	269,000	324,000	387,000	450,000
PETROLEUM	110,000	133,000	163,000	192,000	219,000
MANUFACTURERS	90,000	170,000	250,000	320,000	392,000
FOREST PROD.	38,500	50,000	62,000	73,000	84,200
IND. RADIOLOCATION	1,900	2,900	4,000	5,100	6,190
MOTION PICTURE	1,100	1,200	1,310	1,420	1,560
RELAY PRESS	5,000	8,200	11,400	14,000	17,400
TELEP. MAINT.	68,000	119,000	188,000	242,000	290,000
TOTAL INDUSTRIAL	2,120,500	3,408,300	4,983,710	6,534,520	8,115,350
RAILROAD	250,000	300,000	344,000	380,000	412,000
TAXICAB	175,000	190,000	209,000	229,000	248,000
AUTO EMER.	22,500	27,100	30,500	33,100	36,000
INTER URBAN PASS.	1,470	2,250	3,100	3,950	4,890
INTER URBAN PROP.	60,400	71,000	79,000	86,400	94,600
URBAN PASS.	1,793	1,793	1,793	1,793	1,793
URBAN PROP.	42,800	70,000	93,000	110,000	126,000
TOTAL LAND TRANSP.	553,963	662,143	760,393	844,243	923,283
TOTAL LAND MOBILE	3,441,579	5,076,659	7,009,019	8,900,379	10,821,549

FIGURE 3

likely to be conservative, because it does not take into account the potential impact which new technology (which can mean new uses) will have on spectrum requirements. To illustrate, it is recognized that mobile teleprinters will in many cases require more frequencies. The use of scramblers also imposes more demands on the spectrum. However, at this early stage it is difficult to quantify the amount. There are a wide variety of other needs which can be foreseen and for which the technical solutions are near at hand. Translating these needs into frequency requirements would be highly speculative. It is sufficient to recognize that they will occur and they will necessitate more frequencies. It is important to note the nature of these new uses, because they dramatize a discernible evolutionary trend which is enlarging the mode and purpose of land mobile communications. (This emerging concept and some examples of what it will mean are set forth in Exhibit 4).

12. Heretofore, we have discussed need and growth on a nation-wide basis, and with our population and GNP increasing throughout the country, there will be a continuing upsurge in land mobile usage. Obviously, however, the growth does not follow a uniform pattern; saturation has occurred in our major cities already, as typified by the testimony of Seymour Siegal,[1]

[1] Hearings Before Select Committee on Small Business, Feb. 20 and 21, 1968; page 53.

communications director of New York City, that New York needs 185 additional channels. The plight of Los Angeles has been similarly documented (See Exhibit 5), and like cases can be demonstrated for other areas. The 1964 EIA Card Study which was based on FCC License Records as of 1963 showed the correlation between population and land mobile transmitters.

13. Thus, as our population migrates out from urban centers, the need for the benefits of land mobile radio follows right behind. Ten years ago, there was no beltway around Washington; traffic thinned out on Shirley Highway to the south beyond Route 7, and was light past Hyattsville to the north. Today Dale City, Woodbridge and Springfield are burgeoning cities, and Bowie is now the second largest city in Maryland. Schaumburg, located twenty-five miles from the City of Chicago has experienced a population growth of over 1000% in the last nine years. These examples are typical and reflect an incipient need for more police and fire protection, more highway maintenance, more plumbers, more fuel deliveries, more need for diaper deliveries; more of all things which land mobile radio helps to get with greater economy, speed, and efficiency (Exhibit 6 depicts examples of growth outside urban centers in deucation, housing and industry).

14. It is in these locations that the need for additional frequencies will occur tomorrow. It is important to understand that the proximity of these suburbs to the urban centers precludes their use of frequencies which are already being utilized within the

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metropolitan center itself, and as has been demonstrated these cities are already facing critical shortages of frequencies. In essence, then, we are face with a two-pronged growth: a) within the city itself where population, business and industrial growth have caused the mobile communications problems of yesterday and today; and b) progressing out from the city where expanding needs for goods and services not only could lead to tomorrow's spectrum crisis but are resulting in serious frequency shortages today.

15. Land Mobile Radio has endeavored to meet today's needs with roughly 42 MHz of spectrum which was allocated in 1949. As has been shown, this space now accomodates more than three times the number of licensed transmitters, and the resulting congestion is already beginning to take its toll in terms of depriving the public of service. With projections indicating an almost equal increase over the next ten years, it is logical to conclude that a minimum of 42 MHz of additional spectrum will be needed.

16. Doubling the present allocation will not provide anything akin to exclusive channels for land mobile users, even for those who have an operational need for high reliability of communications. All users will continue to have to share channels to some degree. Fortunately, however, the nature of land mobile usage permits frequencies to be assigned to licensees inside and outside the urban center, provided adequate mileage separations are maintained. Thus, although the licensed transmitter growth rate has tripled and is projected to about triple again by 1980, 42MHz

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should provide sufficient frequencies for the reasonably foreseeable future.

III. Analysis of the Commission Proposal

A. Background

17. On April 14, 1967, the Commission organized the Land Mobile Frequency Relief Committee under the chairmanship of the Chief Engineer and consisting of Bureau Chiefs and other key staff personnel. The Committee was directed to study the feasibility of meeting land mobile needs within spectrum space presently allocated to UHF television. It was organized into three groups as follows:

Working Group I -- Study the impact presented by the reallocation of from four to seven low UHF television stations.

Working Group II - (a) Investigate feasibility of land mobile use of channels on a geographic basis so as to minimize the impact on UHF TV and (b) investigate interference problems which might arise by virtue of such sharing.

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<u>Working Group III</u> -- Explore the reallocation of the band 806-960 megahertz in whole or in part to the land mobile services.

18. We will discuss the findings of Working Group I subsequently and since the conclusions of Working Group III form the basis of Docket No. 18262, it is not necessary to discuss its results in this proceeding.

B. <u>WORKING GROUP II</u>

19. Working Group II in determining possibly ground rules for geographic allocation of UHF TV channels by land mobile considered three allocation plans:

Plan 1 - "Equivalent Protection Method." Potential land mobile channels are based upon permitting the land mobile service to cause TV interference to the same extent that the existing TV allocation standards permit mutual interference between TV stations.

Plan 2 - "Grade B Contour Protection Method." TV receiver antenna directivity is assumed for co-channels. Potential land mobile channels are based upon protecting the Grade B TV contours for a 35 db desired to undesired signal strength ratio. TV receiver antennas are assumed to have a 15 db rejection of land mobile signals for reception of desired co-channel TV stations.

Plan 3 - "Grade B Contour Protection Method." TV receiver antennas are considered to have no directivity. Potential land mobile channels are based upon protecting the Grade B TV contours for a 50 db desired to undesired signal strength ratio.

20. This Working Group, in order to provide for adequate separation between land mobile and TV areas of operation assumed that the maximum facilities for the former would be base stations with 400 watts ERP using antennas 200 feet above average terrain. Further, it was assumed that all land mobile systems were located at the post offices of the main stations examined. Also, in Plan 3 the TV propagation curves developed in Report No. R6602 were used. With respect to "taboos" only "co-channel, adjacent-channel and sound and picture image channels" were considered. Although discussed as a "taboo", the adjacent-channel protection ratios assumed by Working Group II and promulgated in the subject docket represent a new concept in spectrum allocation (the adjacent-channel "taboos" in the Commission's Rules being mileage separation). Finally, as the Working Group stated: "the three plans should be considered as rough guides as to the potentials for obtaining additional land mobile channels through geographic sharing with UHF TV." A detailed analysis of the findings of this Working Group, particularly with respect to Plan 3 are set forth in Exhibit 7.

RESTRICTIONS RESULTING FROM USE OF 1960 URBANIZED AREA

21. The use of any arbitrary geographic area as a test of where land mobile needs relief must meet the test of whether it will permit the public to be served. Figure 4 compares the population between 1960 and projections for 1980 in the 25 major metropolitan areas. It also shows the percentage of increase in

FIGURE 4

URBANIZED AREA PROJECTION
1960-1980

URBANIZED AREA	1960 POPULATION (000)	AREA (SQ. MI)	1980 POPULATION (000)	% INC.	AREA (SQ.MI)	% INC.
NEW YORK NORTHEASTERN NEW JERSEY	14,102	1,841	19,255	37.2%	3,292	78%
LOS ANGELES	6,489	1,370	12,744	96%	2,507	84%
CHICAGO-NORTHWESTERN INDIANA	5,840	921	8,083	38.2%	1,470	59.5%
PHILADEPHIA	3,626	566	4,847	34%	875	54%
DETROIT	3,354	616	5,500	64%	1,122	82%
SAN FRANCISCO-OAKLAND	2,455	603	5,332	118%	1,442	134%
BOSTON	2,443	534	3,111	27%	756	42%
WASHINGTON D.C.	1,808	343	3,339	85%	723	112%
CLEVELAND	1,719	413	2,626	53%	725	76%
PITTSBURGH	1,711	374	2,019	18%	472	26%
ST. LOUIS	1,668	324	2,230	34%	457	41%
BALTIMORE	1,419	220	2,098	47%	371	68%
MINNEAPOLIS-ST. PAUL	1,338	573	1,920	43%	851	48%
HOUSTON	1,140	423	2,263	98%	890	110%
MILWAUKEE	1,054	211	1,552	47%	469	122%
CINCINNATI	1,004	251	1,436	43%	407	62%
BUFFALO	936	134	1,370	46%	221	65%
DALLAS	932	464	2,625	182%	1,062	129%
KANSAS CITY	921	282	1,307	42%	445	58%
SEATTLE	864	232	1,495	73%	423	83%
MIAMI	853	183	3,092	262%	783	328%
NEW ORLEANS	837	120	1,224	31%	188	57%
SAN DIEGO	836	278	1,796	115%	563	102%
DENVER	804	164	1,407	75%	303	85%
ATLANTA	768	254	1,573	105%	709	179%
PHOENIX	552	224	1,405	154%	522	134%

DATA SOURCE: "Dimensions of Metropolitanism", Jerome P. Pickard
Urban Land Institute, 1967.

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square miles projected for 1980. (Exhibit 8 illustrates with six examples a comparison of these two land areas.) In light of the substantial differences in land area and population, it is apparent that the Commission is applying a 1960 standard to solve a problem which is steadily increasing geographically.

POWER AND ANTENNA RESTRICTIONS

22. Figure 5 shows the calculations that have been made as to what effect the various power and antenna height limitations would have on the range of land mobile operations.

Figure 5

URBAN AREA UHF LAND MOBILE RANGE
(Base to Mobile)

Effective Radiated Power	Antenna Height Above Average Terrain	Range
400 w	200 ft	17 miles
200 w	200 ft	14 miles
100 w	200 ft	12 miles
50 w	200 ft	10 miles
25 w	200 ft	7 miles
100 w	50 ft	6 miles
50 w	50 ft	5 miles
20 w	50 ft	4 miles
10 w	50 ft	3 miles
5 w	50 ft	2 miles
100 w	6 ft	3 miles
5 w	6 ft	1 mile

These computations are based on an analysis of a complex series of factors; their derivation is set forth in detail in Exhibit 9.

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23. Of course, the presence of buildings in an urban environment as well as trees all tend to make theoretical range predictions maximum rather than reasonable in terms of providing reliable coverage. Thus, for example, when it is computed that at a 50 watt (ERP) level at 50 feet AAT a base station range would be about five miles, while at a 400 watt (ERP) level at 200 feet AAT, a base station range would be approximately seventeen miles, it must be remembered that such ranges should be deemed maximum in the 450-500 MHz band and would not produce consistently reliable communications. Most users have needs which make such reliability mandatory and hence have already installed systems at 450 MHz at power levels and antenna heights well in excess of those proposed, in order to obtain essential range coverage. A discussion of the physical factors characteristic of the 450-470 Mhz band which affect communications reliability in urban environments are discussed in Exhibit 10.

24. The facts of the real world reveal how actually restrictive the proposed antenna height and power limitations are. By contrasting the present permissible usage of the 450-470 Mhz band with the proposed restrictions, it is possible to estimate what percentage of land mobile requirements can be satisfied under the proposal. Since the Commission conceded in the Notice of Proposed Rule Making that land mobile users in Chicago would obtain limited relief, we analyzed the Los Angeles and New York areas. The

results which are discussed fully in Exhibit 11 provide stark testimony to the fact that only a minute number of users in each city will realize any meaningful utility from frequencies encubbered with such severe power and antenna height restrictions.

25. These users comprise that small group whose needs only extend to the nearby neighborhood. The preponderance of users must have the ability to communicate over at least a large portion of their city and frequently beyond the city limits. Proper system design involves the selection of power, antenna height and antenna location to enable the user to serve his customers. While we support the policy expressed in the Commission's Rules that a licensee should use no more power or antenna height than is necessary, the converse is equally valid: he should be permitted to utilize that which is reasonably necessary for reliable communications over the area which his activities require him to cover.

E. EFFECT OF LAND MOBILE - TELEVISION MINIMUM SEPARATION DISTANCES FROM CO-CHANNEL AND ADJACENT CHANNEL TELEVISION ASSIGNMENTS

The appendix contained in the Notice of Proposed Rule Making specifies in part:

> "The distance between a land mobile base station or land mobile operating area and the nearest co-channel or adjacent channel UHF-TV station must equal or exceed the distance indicated in the table."

This indicates that wherever the minimum separation distance falls within an urbanized area, that channel is not

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available to land mobile in the portion of the urbanized area between the television transmitter andthe line of minimum separation.

26. Figure 6 shows the Philadelphia area and the minimum separation distance specified for the available base station frequencies in the bands of Channels 14 and 20. Substantial por tions of the Philadelphia area are closer to television facilities than the minimum required separation distance and thus land mobile base stations could not operate in these areas.

27. Channel 17 in Philadelphia similarly reduces the mobile operating area within the New York urbanized area (Figure 7) to the portion north of Hoboken, New Jersey and above the center of Kings County in New York. Paragraph 10 of the Docket stated:

> "The co-channel land mobile field must be at least 50 db below the established Grade B contour of the TV station which is that point where the field is 64 db above 1 uv/m or 64 dBu. That combination of land mobile effective radiated power and antenna height above average terrain that permits this ratio to be satisfied can be authorized at that point."

28. Hence, the Section tested the assumption that this provision would allow continued use of Channel 17 closer to Philadelphia with reduced power and lower antenna heights. The conclusion was that in order to service the full New York-Northern New Jersey area to its closest approach to the Philadelphia television facility on Channel 17, a reduction of land mobile power below five watts and antenna height of six feet would be required.

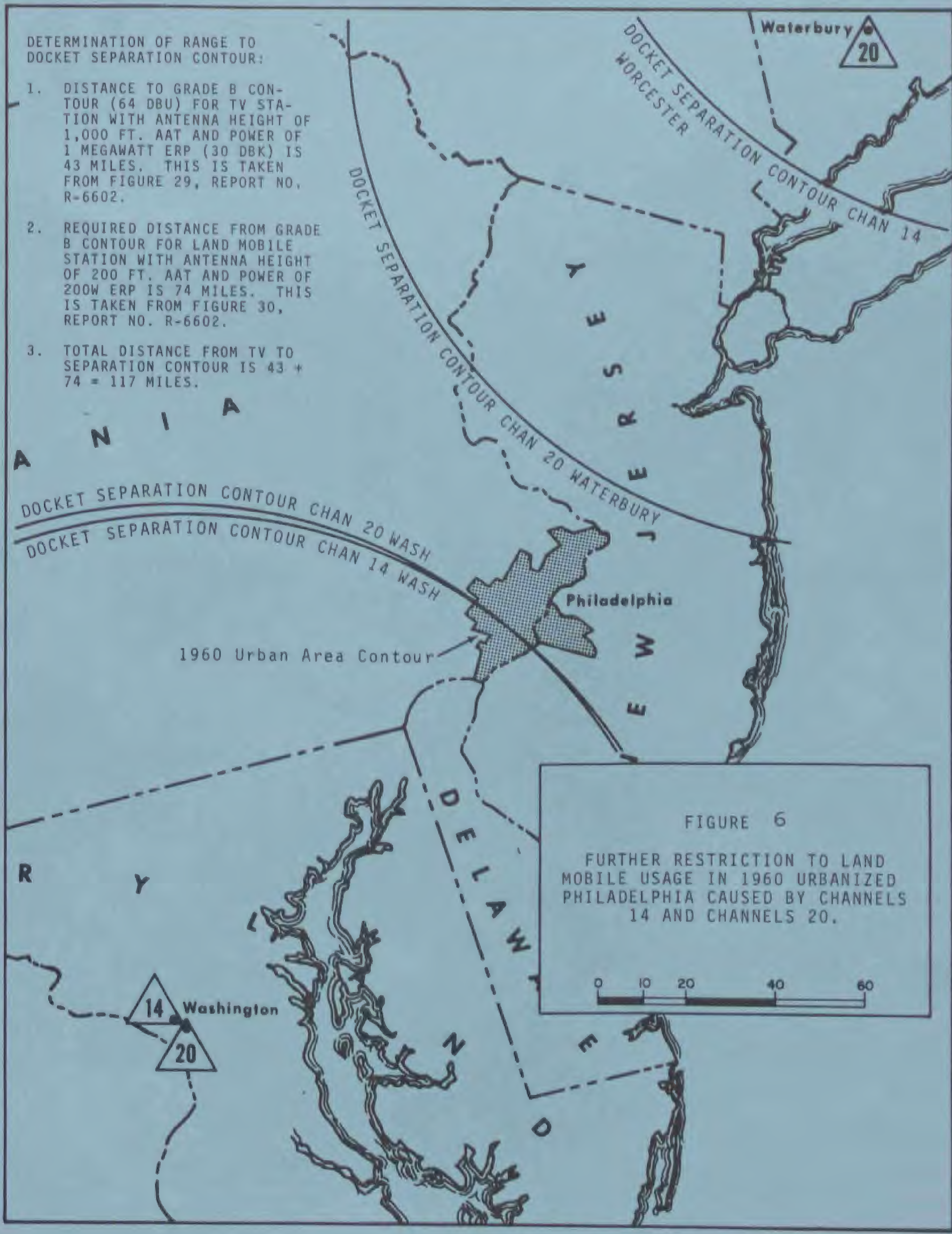

FIGURE 6

FURTHER RESTRICTION TO LAND MOBILE USAGE IN 1960 URBANIZED PHILADELPHIA CAUSED BY CHANNELS 14 AND CHANNELS 20.

CONTOUR	MILES FROM CH. 17	LAND MOBILE ANT. HT. (FT. AAT)*	LAND MOBILE POWER (WATTS ERP)
A	77	50	50
B	70	50	20
C	66	50	10
D	61	50	5
E	56	6	100
F	51	6	5

*FEET ABOVE AVERAGE TERRAIN

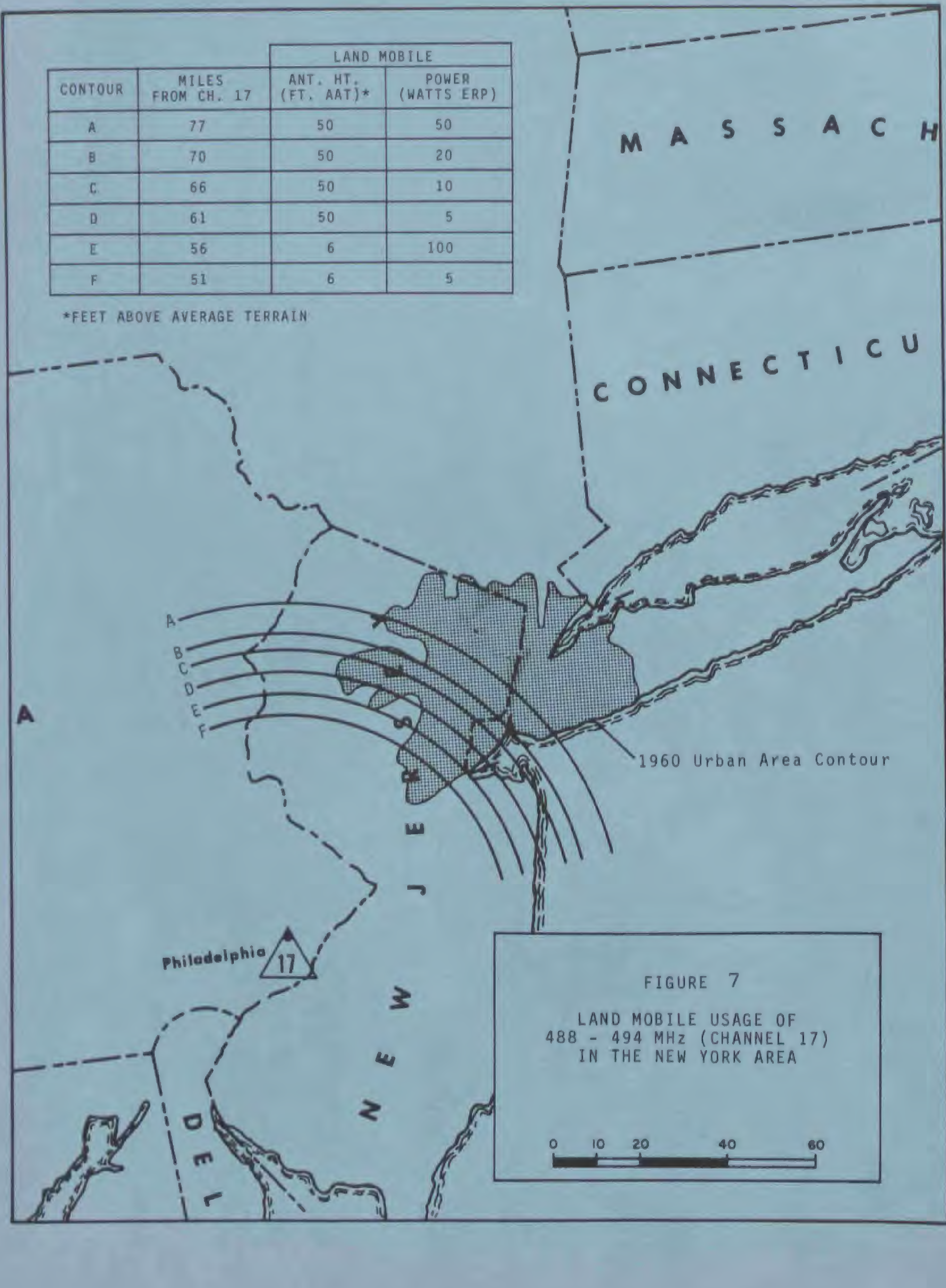

FIGURE 7

LAND MOBILE USAGE OF
488 - 494 MHz (CHANNEL 17)
IN THE NEW YORK AREA

29. Public Safety, land transportation or industrial licensees cannot define or limit their areas of operation to comply with these restrictions. The relief obtained under this proposal, and the portion of the population of the urbanized areas served by land mobile licensees is consequently reduced.

F. LIMITED QUANTITY OF RELIEF

30. It is impossible to assess the specific amount of additional spectrum space which will be made available to any given urban area under this proposal. While on the surface some cities appear to have access to four or more television channels, closer examination reveals that such a number is illusory (See Exhibit 11, supra). The use of a channel with five watts (ERP) and a six foot antenna AAT hardly qualifies as more than token availability. The need for spectrum has been set at 42 megahertz for adequate relief. No city comes even close to that total and in New York, Chicago, and Los Angeles the relief proposed can only be termed "nominal."

G. FURTHER CONSIDERATIONS

31. The Section notes that the Commission has assumed in its proposal that television stations have one MW ERP at a height of 1,000 feet (AAT), 30 DBK. The Commission's rules permit these stations a maximum of five MW ERP and 2,000 feet (AAT 37 DBK.)

If stations are frozen at the suggested levels their opportunity for growth would be severely restricted. Alternatively, if they are allowed to expand to the maximum, even the modest relief now proposed for land mobile will be lessened.

32. Figure 8 compares the approximate mileage separations which would be required under the proposed co-channel criteria of -50db land mobile field strength at the Grade B contour as specified in the docket and for a maximum TV facility.

Figure 8

Zone I Co-Channel Separations (miles
Land Mobile/VHF TV Taboo Tabulation
Grade B Protection Method
No TV Receiver Antenna Directivity

LM Watts (ERP)	400	200	100	50	25	100	50	20	10	100
LM Height (AAT)	200	200	200	200	200	50	50	50	50	6
Grade B Per Docket 18261 Minimum Separation Distance in Miles	127	117	107	97	89	89	77	70	66	61
Grade B At 37 DKB Minimum Separation Distance in Miles	150	140	130	120	110	106	100	93	88	85

33. These greater separations required to protect television reception at the Grade B of a 37 DKB TV facility would essentially eliminate land mobile effective radiated powers above 100 watts. In lieu of this, a television facility in excess of

one megawatt (ERP) and 1,000 feet (AAT) will experience land mobile field strengths in excess of -50 db for a distance up to 23 miles inside its Grade B contour. (assuming from R-6602 a 43 mile Grade B contour for 30 DBK and a 66 mile Grade B contour for 37 DBK).

H. PROPOSED APPLICATION PROCEDURE FOR LAND MOBILE

34. The procedures proposed for land mobile applications in the 470-512 MHz band require extensive engineering and field survey in order to determine the antenna height above average terrain.

35. Figure 9 illustrates the relative field strength of a vertically polarized Land Mobile signal (expressed in db) at the Grade B contour for errors in measurement up to 200 feet. For certain ranges, the field strength will increase as the antenna height increases. However, when the Land Mobile antenna is situated to "look over the top" of nearby TV antennas, the field strength at those TV antennas may decrease as that Land Mobile antenna is raised.

36. Errors of extreme magnitude could produce noticeable interference. However, approximations of height above average terrain within +200 feet produce no perceptible increase in interference. This provision of the proposed rules does not appear justified in view of the additional cost burden required of the land mobile applicant.

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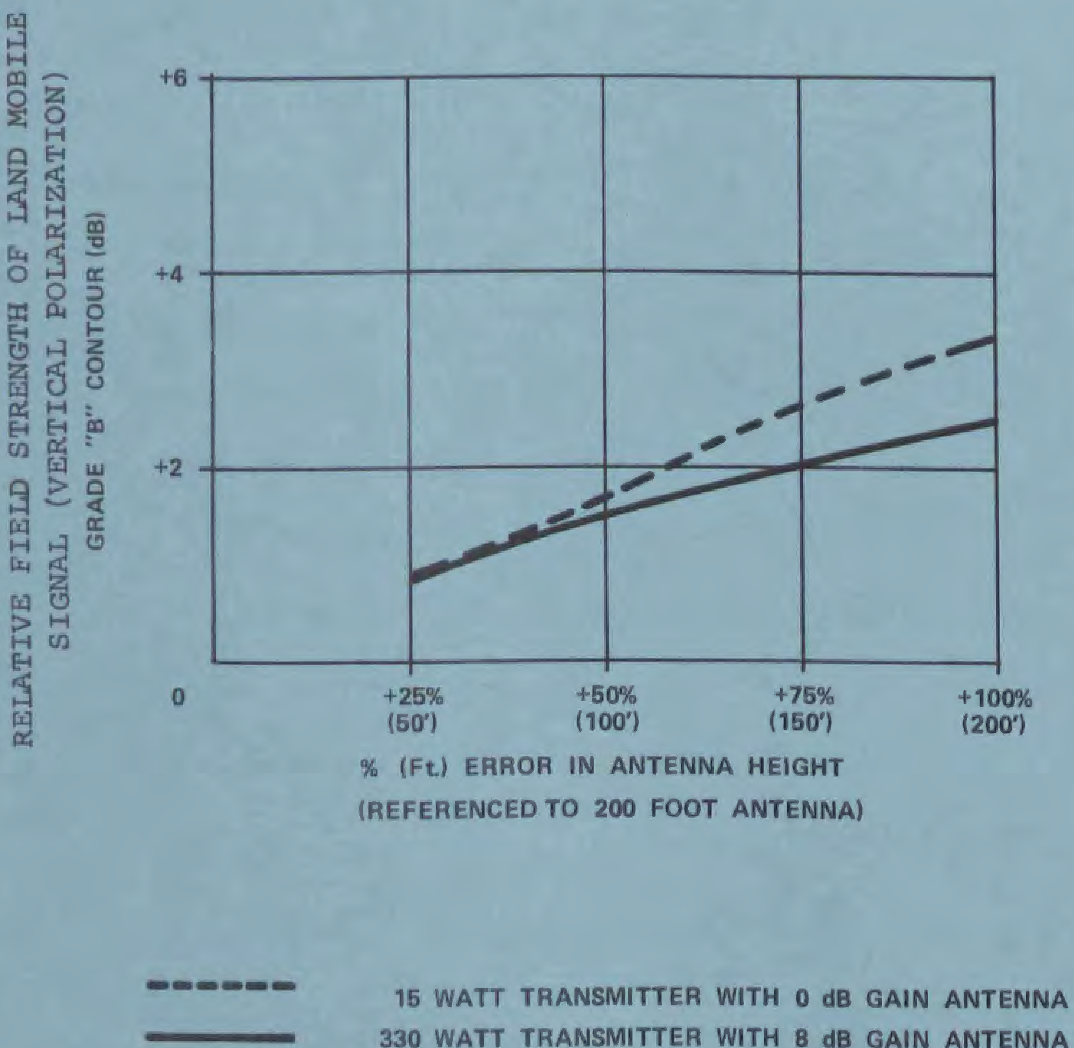
FIGURE 9

RELATIVE FIELD STRENGTH OF LAND MOBILE SIGNAL (VERTICAL POLARIZATION)
AT GRADE "B" CONTOUR
VS. ERROR IN ANTENNA HEIGHT



NOTE: Data extracted from Figure 30, FCC Report R-6602
September, 1966

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37. The docket Appendix, Part II, 2. (d) does not exclude mobile only frequencies from this provision. The requirement to ascertain height above average terrain for a mobile operating area represents a totally unrealistic engineering and cost burden.

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IV. SUMMARY COMMENTS ON THE COMMISSION'S PROPOSAL

38. The Commission merits credit for endeavoring to provide sorely needed additional frequencies for land mobile in a usable portion of the spectrum. However, the proposal fails to meet the relief needed because:

a) relief is restricted to parts of geographic areas that were defined nearly a decade ago

b) Land Mobile operation within the archaic urbanized area is imposed under restrictive power and antenna limitations

c) mileage separations imposed between TV and Land Mobile stations prevent Land Mobile Operation in some urbanized areas

d) relief is not provided either in the inner city or in the rapidly expanding periphery

e) there is a dilemma in the restriction of TV to 1 Mw at 1,000 Ft. AAT (with maximum mobile service area) and the expansion of a TV facility to 5 Mw at 2,000 Ft. AAT (with restricted mobile service area)

f) Land Mobile applicants must provide engineering and field survey data at a cost much out of proportion to the expected ability to predict interference

V. PROPOSAL OF THE LAND MOBILE SECTION

A. Introduction

39. The following resolution was adopted by the Land Mobile Communications Council on March 28, 1968:

> "Resolved that the LMCC Directors recommend to their organizations that they support as the solution for the needs of the land mobile services, the reallocation of channel 14-20; said reallocation to commence on January 1, 1969; to be implemented in accordance with an agreed time table which will provide 42 MHz of relief in the major metropolitan areas of the country; and further, that said Directors recommend to their organizations that they support the reallocation of spectrum at the upper end of the UHF portion of the TV band to provide in the long term for further relief for land mobile, including broad band common carrier use."

40. The Land Mobile Section of EIA as a member of LMCC recorded its support of this resolution as did every other member organization. Hence, the foregoing represents the Section's approach as to what should be done and how it should be done to effectuate the above resolution to provide adequate, appropriate relief.

1. Elements of the Proposal

41. The Section requests that the Commission enlarge the scope of this proceeding to provide for the immediate reallocation of the band 470-512 MHz from the UHF television service to the land mobile service. Further the Commission is requested

to currently initiate proceedings to reassign existing television authorizations in this band to frequencies above 512 MHz in accordance with an established time-frame.

42. The urgency of the land mobile problem requires this immediate action to reallocate the 470-512 MHz to make the needed channels available at the earliest possible date. Land Mobile Radio Service growth rates indicate that the change to a channel above 512 MHz by presently operating TV stations, including CPs, should be accomplished by 1981. This time period, if initiated at once, would minimize and in fact guard against disruption of existing television service.

43. The results of the analysis of reallocation by Working Group 1 of the FCC Frequency Relief Committee indicate that sufficient vacant channels are available above channel 20 to accommodate the operating stations in the area studied. Working Group 1 demonstrated that the 44 operating stations in the Test Area could be accommodated in the vacant assignments above channel 20. One finding of the study was that two stations, WHCT-TV (Channel 18) Hartford, Connecticut and WNED-TV (Channel 17) Buffalo, New York would be required to move above channel 70. This conclusion, however, does not recognize that channels 61 in Hartford and channels 29 and 49 in Buffalo are presently vacant assignments. Thus, these two stations could be accommodated immediately and

the matter of whether new vacant assignments for these cities should be provided for future accommodation could be explored subsequently.

2. <u>Orderly Land Mobile Service Spectrum Occupancy</u>

a. <u>Nation-wide channel assignments</u>

44. The Section strongly urges that full consideration be given to providing an efficient mode of spectrum occupancy so that land mobile service operations can be instituted on a sound technical basis for maximum spectrum utilization. In order to insure orderly development and effective use of this spectrum in the public interest, the reassignment proceedings should vacate the entire 14-20 band throughout the nation. This will permit common usage of similar equipment possessing similar characteristics to satisfy the needs throughout the nation.

45. There is the potential of adjacent channel interference to and from an operating television station that may not have completed its frequency change before or concurrent with the assignment to a land mobile station to operate on an adjacent frequency in the same area. The Section has studied adjacent channel TV and land mobile operation that is currently authorized (Land Mobile contiguous to Channel 14).

46. <u>Exhibit 12</u> contains maps that have been constructed for Oxford, Ohio, Mt Pleasant, Michigan; Worcester, Massachusetts;

Washington, D.C.; and San Mateo, California. These maps show the location of the television station in each of these communities and the location of those land mobile stations that are known to be in operation within the service area of the television station. This investigation found no interference to the reception of television in these communities due to land mobile stations. On the contrary, there is substantial evidence from actual experience indicating that successful land mobile operations can be carried out in close proximity to adjacent channel television stations. Figure 10 summarizes the number of licensed base station and mobile units in the adjacent bands for three of the communities (Washington, D.C., San Mateo, California and Worcester, Massachusetts). Thus, the occupancy and operation of land mobile does not appear to require that operating TV stations on the adjacent channels need be simultaneously changed to new operating frequencies above channel 20 but rather can be moved in accordance with the established schedule.

b. The Occupancy on Uniform Paired Basis

47. The Land Mobile Section in response to Docket No. 13847 addressed the question of uniform pairing of the land mobile channels in the 450-470 MHz band posed by the Commission therein. In the Section's study related to this issue, it was found that significant benefits in terms of spectrum utilization result from

employment of a paired configuration with proper separation. Applying that analysis to consideration of the 470-512 MHz band it is our recommendation that uniform pairing be initiated throughout this band as extensively as possible. Further, the Section's study indicates that a uniform base station-mobile station frequency separation of 12 megahertz would permit use of this frequency band with minimum interference and reduced inter-face considerations. To illustrate, the spectrum of channel 14 would be paired with the spectrum of channel 16, with channel 14 being assigned exclusively for base station use and channel 16 to exclusive mobile station use. This arrangement would create only three interfaces between base station and mobile station frequencies in the entire 470-512 MHz band. (See Figure 11) Channel 19 would be used for other land mobile applications such as one-way, low power operations or unique systems where flexibility of spacing is preferable.

48. This proposed pairing arrangement for orderly use of this spectrum can be readily accomplished, and no more serious disruption nor greater technical problem is involved in instituting land mobile operations on this basis. The parameters are the same in paired channel frequency changes as those for single channel frequency changes. The only difference is that the co-channel reassignment proceedings would also determine if the completion of adjacent channel action must be concurrent. This

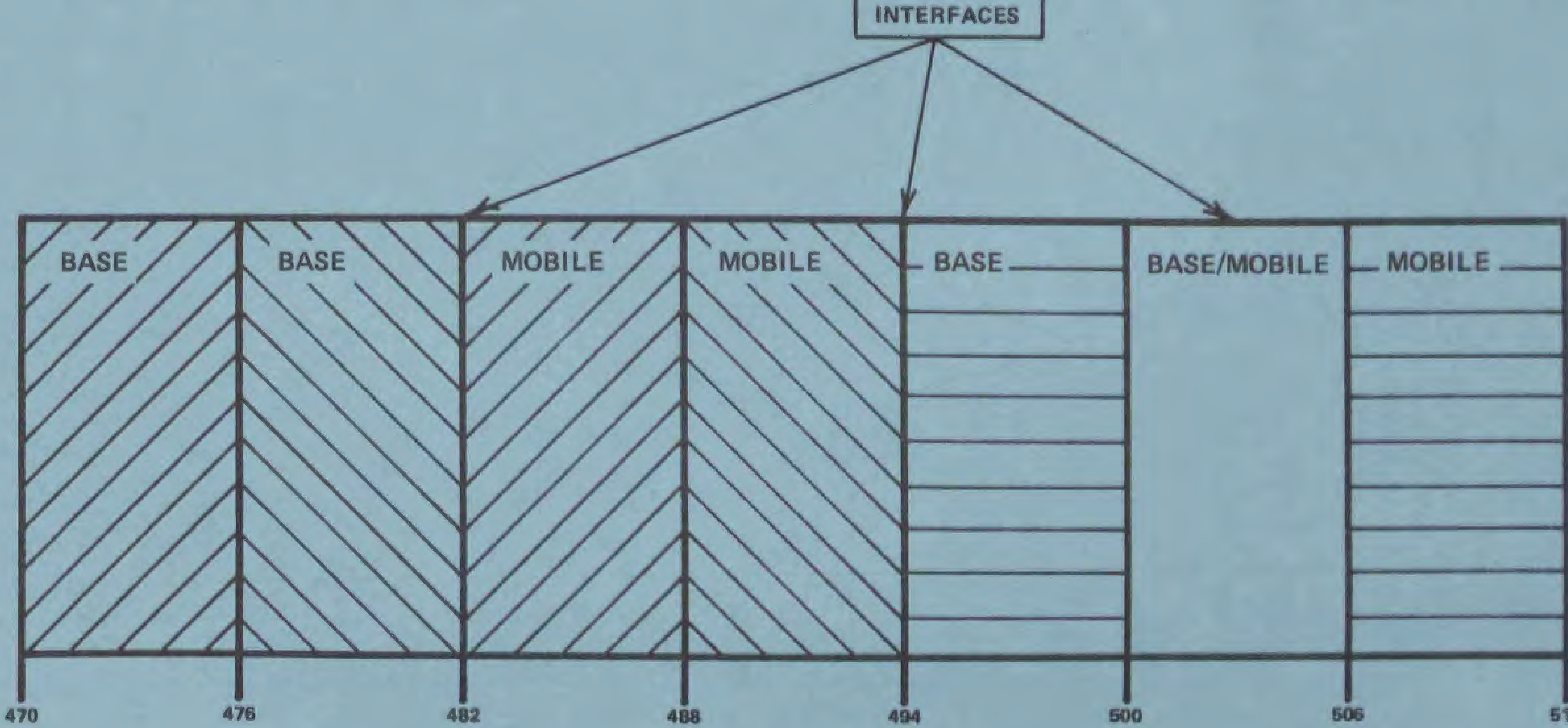
Figure 10

LICENSED LAND MOBILE TRANSMISSION IN

464-470 Mhz Band

City	Mobiles	Base Stations
Washington, D.C.	3312 Units	145
San Mateo Calif.	1214 Units	153
Worcester, Mass.	303 Units	48

FIGURE 11



PROPOSED PAIRING ARRANGEMENT
FOR THE 470 - 512 MHz BAND

involves the considerations discussed above. If there is no evidence which would necessitate the concurrent move of the adjacent channel TV station, then paired operation can be instituted prior to the completion of that station's move to a higher channel.

49. In recommending reallocation of UHF channels 14-20 to Land Mobile, the Section understands that the Television industry will be affected. Some of these issues are discussed now in order to place the effects upon the Land Mobile and Television Industry in perspective.

c. <u>Impact on Television Service</u>

50. Working Group 1 of the FCC Frequency Relief Committee has listed in Appendix II of the Report the operating stations which comprised the major portion of those who would be affected by a reallocation of the 470-512 MHz band. In addition, some stations operating outside the study area analyzed by Working Group 1, those CPs external to the study area and those which were not included because they did not exist at the time of this study (July 25, 1967) would be involved.

51. The Land Mobile Frequency Relief Committee assessed the approximate costs involved in television station relocation. The staff paper by Sidney R. Lines, Assistant Chief, Technical Division,

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estimated that they would average $125,000 per station and we would agree that this figure is generally accurate. The current Table of Assignments provides for 305 assignemtns on Channel 14-20. Existing stations or construction permits issued since January 1, 1965, total 114. According to Television Factbook, 1968-1969 edition, 44 commercial stations (and 26 educational stations) were on the air or expected to commence operating. This list has been brought up-to-date as of December 31, 1968 by first-hand examination of the Commission's records. Figure 12 indicates the dispersal of these stations by channel.

Figure 12

Channel	Commercial Stations	Educations Stations	Total*
14	6	5	11
15	8	6	14
16	8	3	11
17	8	5	13
18	9	2	11
19	9	3	12
20	8	4	12
Total	56	28	84

*Not reflected are formerly operating stations which the Television Factbook indicated have left the air.

52. Comparing the average cost to change frequency on any one station with the actual number of operating station on Channels 14-20 produces the result depicted in Figure13 .

Figure 13

Channel	Number of Operating Stations		Cost to Clear Channel @$125,000/station
14	11		$ 1,375,000
15	14		1,750,000
16	11		1,375,000
17	13		1,625,000
18	11		1,375,000
19	12		1,500,000
20	12		1,500,000
		Total	$ 10,500,000

Of course this entire sum will not have to be expended in one year. In fact, the maximum estimated cost to clear the most heavily occupied channel across the nation is $1.75 million, a cost greater than the expenditure expected in any given year. Instead, channels would be cleared in pairs by moving operating TV stations to higher channels gradually over a period of several years, thus enabling television broadcasting to amortize its cost some years into the future. In some instances, a move might not be necessary for three or more license terms. Contrast this with the Section's estimate that as a result of the new technical standards imposed on 450-470 MHz land mobile users in Docket No. 13847, they will have expended $4.98 million in less than 4 years in the interests of greater spectrum efficiency and utility.

d. Impact on the Land Mobile Services

53. The Section's proposal for national reallocation would yield a higher degree of efficient spectrum utilization. There would continue to be a single interface between the land mobile and television services, at 512 MHz rather than 470 MHz as now exists.

54. The arbitrary confinement of land mobile operations to "urbanized areas" would be eliminated, so that all users would be able to serve all the people.

55. Proposed limitations on land mobile antenna height and effective radiated power designed to protect television rather than to permit land mobile to use radio effectively would be relaxed. Instead, the range and reliability requirements of the user would determine proper system design.

56. A national allocation benefits both urban and ex-urban mobile radio users. Whole categories of users excluded by the proposed rule-making from use of the 470-512 MHz band - and essentially unable to use present land mobile frequencies because of their intensive urban use - would receive relief.

57. Those users whose operations extend beyond a single urban area would be permitted to utilize the same frequency, and hence the same equipment, wherever they have a need to communicate. Inter-city businesses, state and county agencies, metropolitan transit systems, utility pools, and multiple terminal truckers are among those who would benefit from a nation-wide allocation.

58. Historically, shared use between television and land mobile, permitted in the VHF-TV bands prior to the adoption of Docket 8487, has not resulted in optimum spectrum utility. The concern of a potential land mobile user that his operations might cause interference to television transmissions deters his willingness to occupy a channel shared with TV. There is

precedent that when any complaint of interference has been made the burden has fallen on the land mobile licensee to eliminate the cause even if this has required him to vacate the frequency. Experience has also demonstrated that the land mobile user regards shared occupancy of a channel with television as impermanent, and hence there is a reluctance to make the necessary investment to go on a frequency whose utility could well be sharply limited or eliminated at any time in the future.

VI. SUMMARY AND RECOMMENDATIONS

The need for additional frequency spectrum to enable land mobile to serve the public properly has been well-documented. The mere recital of figures: from 86,000 licensed transmitters in 1949 to more than 2,500,000 in 1969 to a conservative projection of over 7,000,000 by 1980; from 4.7% of the spectrum in 1949 to 4.7% today patently demonstrates the need and the fact that inadequate attention has been given to its solution.

It must be borne in mind that if this need is met adequately, everyone will benefit. The Commission's proposal could benefit a few users and the people they serve. However, it will be of little value for most of our public safety agencies, utilities, transportation concerns and businesses which rely on radio to enable them to solve the problems of their citizens and customers who cannot always be found within prescribed urban areas.

Under this proposal, the public will suffer no adverse impact in terms of loss of TV service. They will gain in better services and better products in their daily lives. The impact on those relatively few stations which will be required to change frequency will be minimal, especially since many of them will be able to continue their present operations undisturbed for a period of years.

Therefore, in view of the foregoing, the Section respectfully requests that:

1. No new applications for television assignments for channels 14-20 should be accepted by the Commission.

2. The Commission should immediately undertake a further proceeding proposing to reallocate the frequency band 470-512 MHz to the Land Mobile Radio Services across the nation.

3. Concurrently, the Commission should initiate an appropriate proceeding to provide for new channel assignments above Channel 20 for operating TV stations and for those currently holding construction permits, establishing the dates by which these licensees must vacate their existing channel assignments.

4. This latter proceeding should take into account the advantages of making the frequency band 470-512 MHz available to the Land Mobile Services on a uniformly-paired basis and, where feasible, channel reassignments should be scheduled in accordance therewith.

Exhibit 1 - Sources Describing Land Mobile Congestion

1) Report of the Advisory Committee for the Land Mobile Radio Services, Nov. 1967

2) The Joint Technical Advisory Committee, Spectrum Engineering- The Key to Progress

3) Report of the Land Mobile Frequency Relief Committee, Federal Communications Commission, January 19, 1968

4) Electromagnetic Spectrum Utilization--The Silent Crisis, U.S. Department of Commerce, Telecommunication Science Panel of the Commerce Technical Advisory Board, October, 1966

5) House of Representatives, Select Committee on Small Business, Report of Subcommittee No. 6, 89th Congress, 2nd Session, pursuant to H. Res. 13, House Report No. 2344, 1966

----------------------, Select Committee on Small Business, Report of Subcommittee No. 5, 90th Congress, 2nd Session, pursuant to H. Res. 53, Dec. 23, 1968

6) Hon. Laurence J. Burton, Congressional Record, September 17, 1968, E8029

7) Hon. Silvio O. Conte, Letter to Special Industrial Radio Service Association, October 18, 1968

8) Hon. James C. Corman, Congressional Record, September 27, 1968, E8339

Congressional Record, September 30, 1968, E8406-8409

9) Hon. John D. Dingell, Congressional Record, December 6, 1967, H16422-16430

10) Hon. Robert N. Giaimo, Letter to Special Industrial Radio Service Association, October 21, 1968

11) Hon. Warren G. Magnuson, Speech before the Land Mobile Communications Council, Seattle, Washington, September 16, 1968

12) William L. North, Federal Communications Commission, "Bottom of the Barrel," April 4, 1967.

EXHIBIT 2

COMPARISON OF THE 150, 450, and 900 MHz BANDS FOR LAND MOBILE USE

I. INTRODUCTION

It should be pointed out that any meaningful consideration among the various land mobile frequency bands must be predicated on the availability of a full-line of practical, economical equipment, suited to the applications of the many different kinds of users. As the Section has delineated in detail in its filing in Docket No. 18262, and in III of this Exhibit, this situation does not exist in the 900 MHz band.

Further, a comparison between the various land mobile frequency bands must be placed in the context of specific situations in order to be meaningful. Frequency space loss between 150 and 450 MHz and between 450 and 900 MHz indicates a loss of about 5 to 8 db in each case as the frequency is increased. However, ignition noise tends to favor higher frequencies, and urban and foliage loss strongly favor the lower frequencies. A useful approach would involve a comparison cost of a radio system at 150 MHz and 450 MHz under several different conditions.

II. ILLUSTRATIVE EXAMPLES

A suburban user will frequently be able to operate with an antenna of approximately the same height in either 150 or 450 MHz bands. Differences in costs between these systems are then primarily to increase the ERP of the 450 MHz units through use of a gain antenna, larger transmission line and in the inherently higher costs of the equipment itself. Thus, a user is handicapped to the extend of about 15% for what is generally degraded level of service.

A new situation is encountered when a large city is taken as an example. While it is understood that this is an unusual special case, it is of value to consider the opposite extreme to the moderate case in the preceding paragraph. The following example, however, is also practically encountered in some areas outside of the downtown section of a large city.

A 15 mile range in the 150 MHz band can be obtained at typical transmitter powers with only 50 feet of antenna height. Erecting a tower of this height in the city is not difficult, and would ordinarily cost about $300. The antenna would cost just under $200 and a small diameter, low loss, transmission line with foam dielectric can be bought for about $44. The total for the site would then be approximately $544.

At 450 MHz, an antenna height of 270 feet is needed to provide 15 miles range in the city. It is usually rather difficult for a private radio user to erect a tower of this size inside a city boundary, since it requires an area of 320 ft. by 370 ft. for supporting guys. Zoning laws and neighborhood objections often make construction of such a tower impossible. But if a tower can be built, it would ordinarily cost about $3,552, complete with aircraft warning lights. The antenna itself would be about the same price as at 150 MHz or about $200. A larger diameter transmission line with air dielectric would be needed for this band and tower height. Such a line would cost about $473 for this installation, and give a loss of 2.4 db to the system. Many users in this frequency range elect to install their station on a large downtown building in order to obtain the necessary antenna height. The cost of this varies widely, but in Chicago, the rental cost ranges from $75 to $100 per month. The long, lossy and expensive transmission line can be shortened considerably in this case. Other expenses are incurred when a site is rented, such as the remote control telephone line rental cost (typically $5 per mile per month) and the cost of remote control equipment (about $200). In addition, rented sites are generally crowded with other radio users, so cavity filters, duplexers, and circulators may be necessary to prevent mutual interference. The cost of renting a site depends on so many variables that a typical figure cannot be given. For comparison purposes, assuming the user builds a tower, the total cost for a 450 MHz installation would be about $4,225.

For the large city case for the 900 MHz band, a 600 ft. antenna height would be needed to provide reliable coverage over a 15 mile radius. Such a tower would be out of the question in a city. Even if such a tower could be constructed, the price would be prohibitive. The price quoted for a 500 ft. tower is $11,094. If the line loss is considered in this system, it becomes apparent that the range requirement cannot be met using a conventional tower. At about 600 ft., increasing the tower height another 100 ft. gives a theoretical increase in signal of 1.2 db. However, increasing the line another 100 ft. will introduce a loss of 1.37 db. No matter how high a tower is built, the range requirement cannot be met. A larger transmission line must be used (next size up is 1 5/8" diameter at $3.70 per foot), but this still has about 0.62 db loss per 100 ft., which will dissipate half the power in a 600 ft. length. The only practical solution would be to rent space on a building or mountain top so the transmission line can be reduced in length. The same costs mentioned in connection with the 450 MHz band would apply here. The antenna itself would be very close in price in the lower frequency types, or about $200. An alternative to this plan would be to establish multiple station sites with lower antenna heights to give the required coverage. This, of course, would be very expensive to buy and maintain, and also raises some control problems, since the stations normally cannot transmit or receive simultaneously without elaborate and expensive additions.

The AC/LMRS Report has some date of interest on this subject. Their conclusions are in part:

> "For average radio systems under average conditions, the band of frequencies from 100 to 200 MHz is optimum."
>
> "For short range under high noise environment, the band from 400 to 600 MHz gives the best results."
>
> "For very short range and special applications, the band from 600 to 1,000 MHz is suitable."

Their feeling seems to be that the 600 to 1,000 Mhz range has very limited use for normal two-way radio use, but they do call for further investigation of this frequency range.

Their conclusions, and the data used in obtaining them, seem to be valid, but the report appears to be incomplete in some respects. For example, building or city loss, foliage loss, and multipatch effects were all neglected since no data was available to the committee. The factors are mentioned, but not reflected into the results. If these factors were included, the difference between frequency ranges would probably be even more pronounced.

Another example of the the large city situation will further illustrate the differences in the three frequency bands. In this example, the resultant coverage ranges will be compared under conditions of equal transmitter power and antenna height.

The following ranges were calculated assuming a 30 watt transmitter, and a 100 ft. antenna height. Noise and other losses are also assumed, as given in Section II.

150 MHz	450 MHz	900 MHz
16 mi.	10 mi.	7 mi.

This example may not tell the entire story since the range does not increase as rapidly with antenna height on the higher bands as it does on the lower bands. This is due to the more rapidly increasing transmission line losses with greater antenna height, and more rapidly increasing propagation losses at greater ranges.

III. DISCUSSION OF PRACTICAL EQUIPMENT CONSIDERATIONS

As might be expected, the loss to a radio signal increases with frequency. Measurements by the F.C.C. and others indicate that 450 MHz has about 11 db more loss than 150 MHz at a given point, and 900 MHz has about 17 db more loss at this point. A study by Bell Labs indicates a different set of figures, possibly due to the locations where the data was taken. Bell measurements show 450 MHz to have 7 db more loss than 150 MHz at a given point, and 900 MHz to have 10 db more loss than 150 MHz at the same point. Other available measurements on the lower bands are close to the F.C.C. data.

Rough terrain makes a substantial difference in propagation loss, although it may not rise as sharply as might be expected. A statistical shadow loss taken from Bullington's work, predicts a loss of 11 db for 150 MHz, 14 db for 450 MHz, and 18 db for 900 MHz. These losses will be exceeded only 10% of the time in a region with 50 foot hills. Another article dealing with losses in rough terrain states that a loss of 23 db will be observed on 150 MHz, 35 db on 450 MHz, and 44 db on 900 MHz, if a country-wide average of rough terrain is considered.

There are many other losses that must be considered in a UHF system design, besides the theoretical ones. Foliage loss is very significant in the UHF region. Since there is little data available on this factor, it is often ignored in studies of frequency utilization. Because the magnitude of these losses is very high the results of such a study may well be misleading. Experience on 450 MHz indicates that losses of 20 to 25 db relative to open country can be expected in wooded areas. Other sources place the foliage loss closer to 30 db for heavily wooded areas. Little is known about the foliage losses at 900 MHz, but judging from range measurements that have been made, it does not appear to be substantially worse than 450 Mhz, and possibly no more than 6 db worse. Losses due to foliage on 150 MHz have not been accurately measured, but are fairly low, perhaps in the order of 10 db, for moderate tree cover.

Another loss that must be considered is the city loss, or loss over the theoretical value due to absorption and shadowing of the signal by buildings and other structures in a city.

This factor has been measured to be about 10 db in the 150 MHz band, 28 db at 450 Mhz, and 34 db at 900 MHz. This loss is only for residential and industrial areas; very densely built-up areas such as the Chicago Loop and Manhattan will give much higher loss.

One other loss that becomes quite significant in the UHF region is the transmission line loss. These losses are much greater than in the VHF region. For a given line, say 7/8" air line, the loss per 100' at 150 MHz is 0.5 db, at 450 MHz, 0.88 db, and for 1,000 MHz, 1.37 db. At approximately 600 ft. tower height, a point of diminishing returns is reached at 900 MHz, and the additional line losses incurred by increasing the tower height offset an increase of range from the additional antenna height.

There are some compensations to the additional losses found in the higher frequencies. Most important of these if the lower noise levels found in the UHF region. Measurements indicate an average receiver sensitivity degradation of 15 db on 150 MHz, 6 db on 450 MHz, and an estimated 1 to 2 db for 900 MHz. Another compensation is the higher antenna gain that can be obtained on the higher frequencies. Practical gain figures that can be obtained on the various bands are 6 db for 150 MHz, 10 db for 450 MHz, and 13 db for 900 MHz.

EXHIBIT 3

PROJECTED GROWTH OF LAND MOBILE SERVICES

Methodology and Results: 1970-1990

In 1963 the Electronic Industries Association projected that by 1970 the number of licensed transmitters in the private land mobile services would be 3,672,000. The Report of the Advisory Committee for the Land Mobile Radio Services released in 1967 a forecast that the number of licensed transmitters in 1970 would be 3,500,000,and that by 1972 the figure would be approximately 5,200,000. The method used to arrive at the above projections was to take the past growth rate of total licensed transmitters and then to project this rate statistically into the future.

It should be noted that not only are these two figures relatively consistent with each other, but they appear to be quite accurate in view of the fact that the 1967 figure for actual licensed transmitters was 2,680,000.

Tne Land Mobile Section's approach was predicated on a service-by-service projection of licensed transmitters. This enabled us to determine what unique factors, if any, would be applicable to any particular service, and which would thereby modify the slope of the projections.

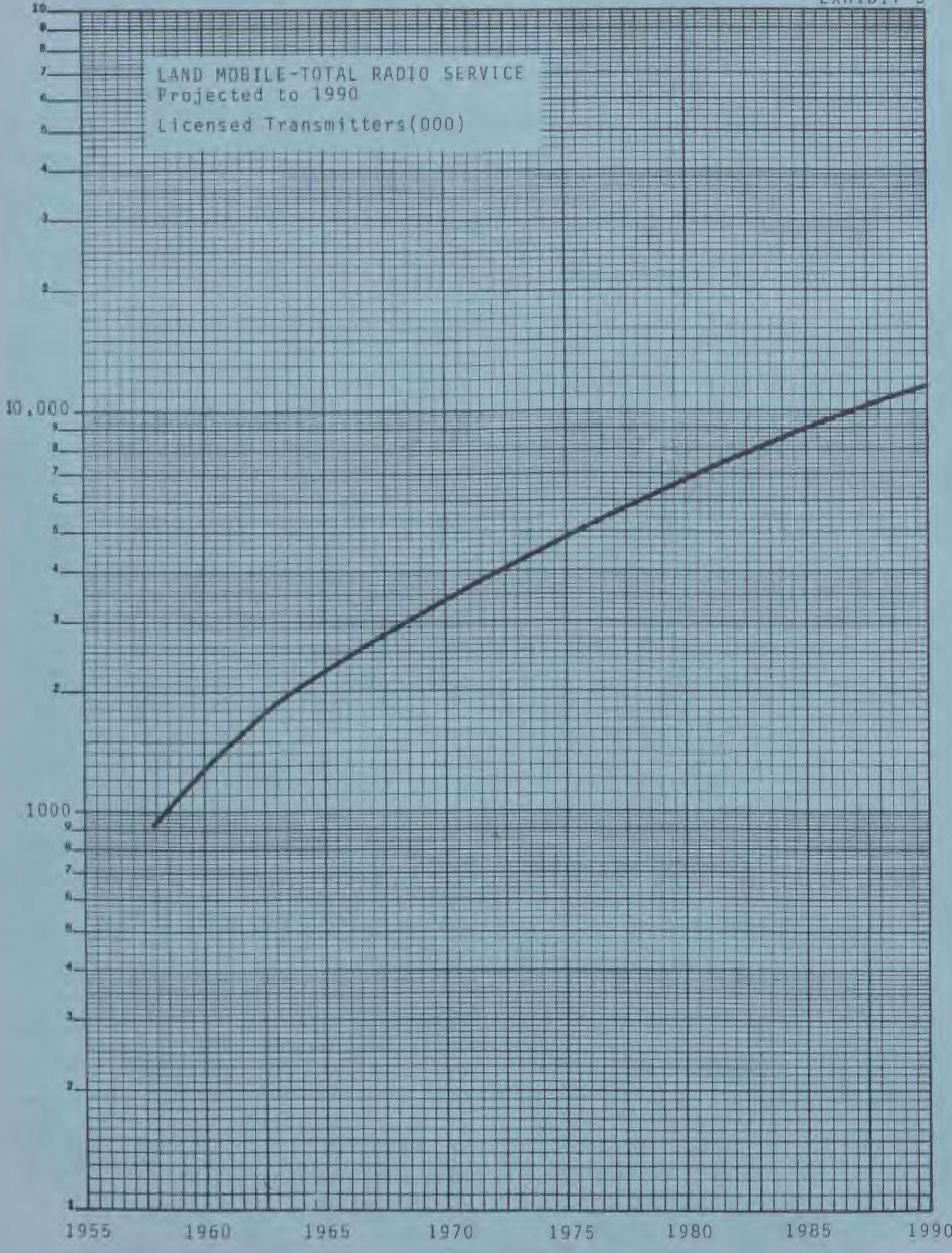
The initial step was based on an examination of the FCC records over the past five years to calculate past growth rate for each land mobile service. While license records were also explored farther back in time as well, the past five-year period was given more credence.

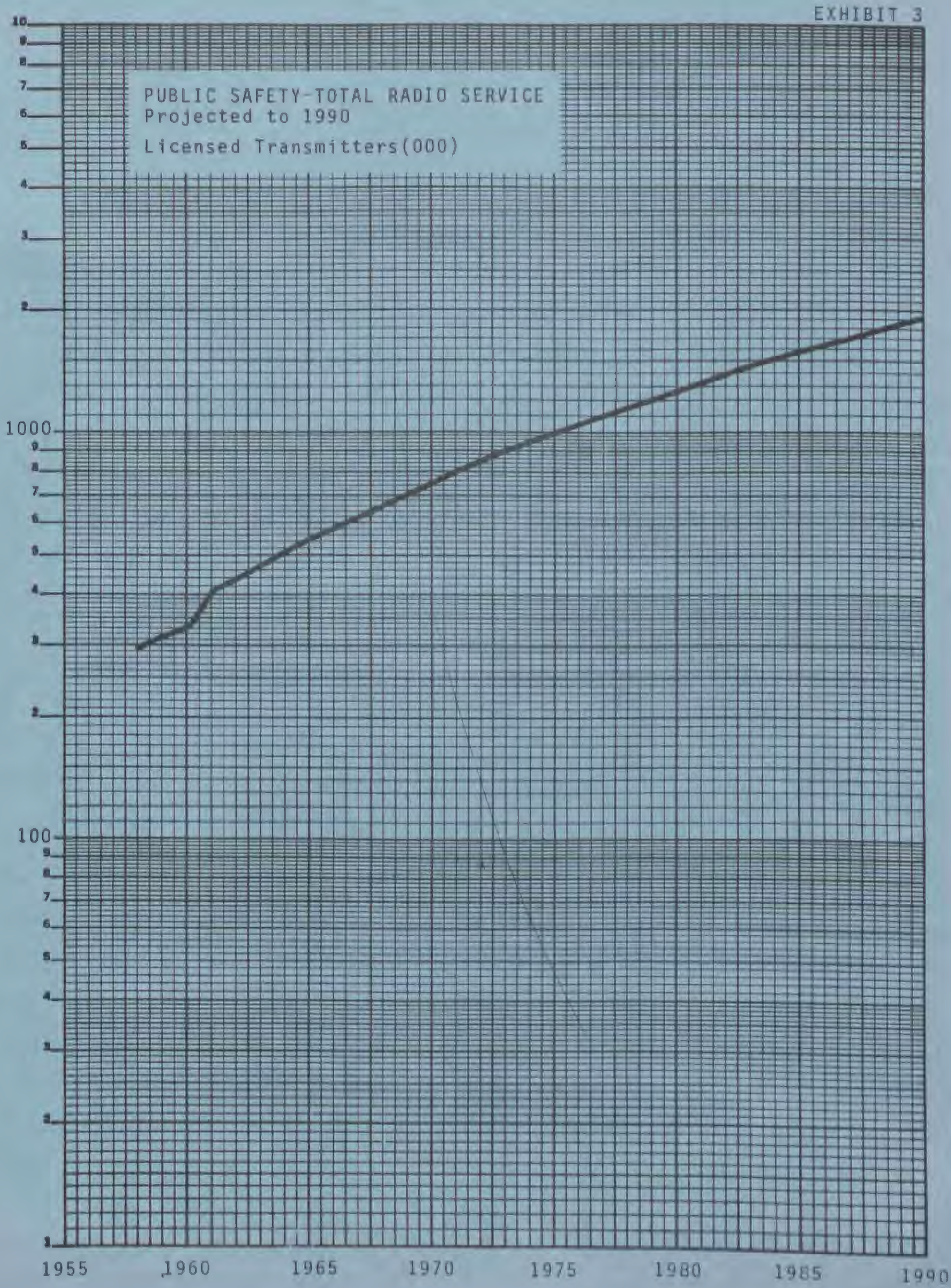
To establish a more definitive base for our projections, the Section examined the growth trends of both the public and private sector of Gross National Product. Population forecasts and employment statistics furnished by the U.S. Department of Labor, and information regarding governmental expenditures for goods and services at a state and local level were among the sources relied on. Finally, of course, the Section employed a judgment factor based on our experience regarding each service to modify the final projections appropriately.

It is interesting to note that the results of this more complex process are in reasonable agreement with those of the 1963 EIA projection and of the Land Mobile Advisory Committee. The Section's totals are somewhat lower but not substantially so. Graphs showing our projections for each private land mobile service are attached.

One important caveat must be borne in mind; the projection does not take into account to any meaningful degree the impact on growth which future new users for radio or the availability of new equipment may cause.

EXHIBIT 3


LAND MOBILE-TOTAL RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
10,000
1000
1955
1960
1965
1970
1975
1980
1985
1990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PUBLIC SAFETY-TOTAL RADIO SERVICE
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Licensed Transmitters(000)
1000
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1955
1960
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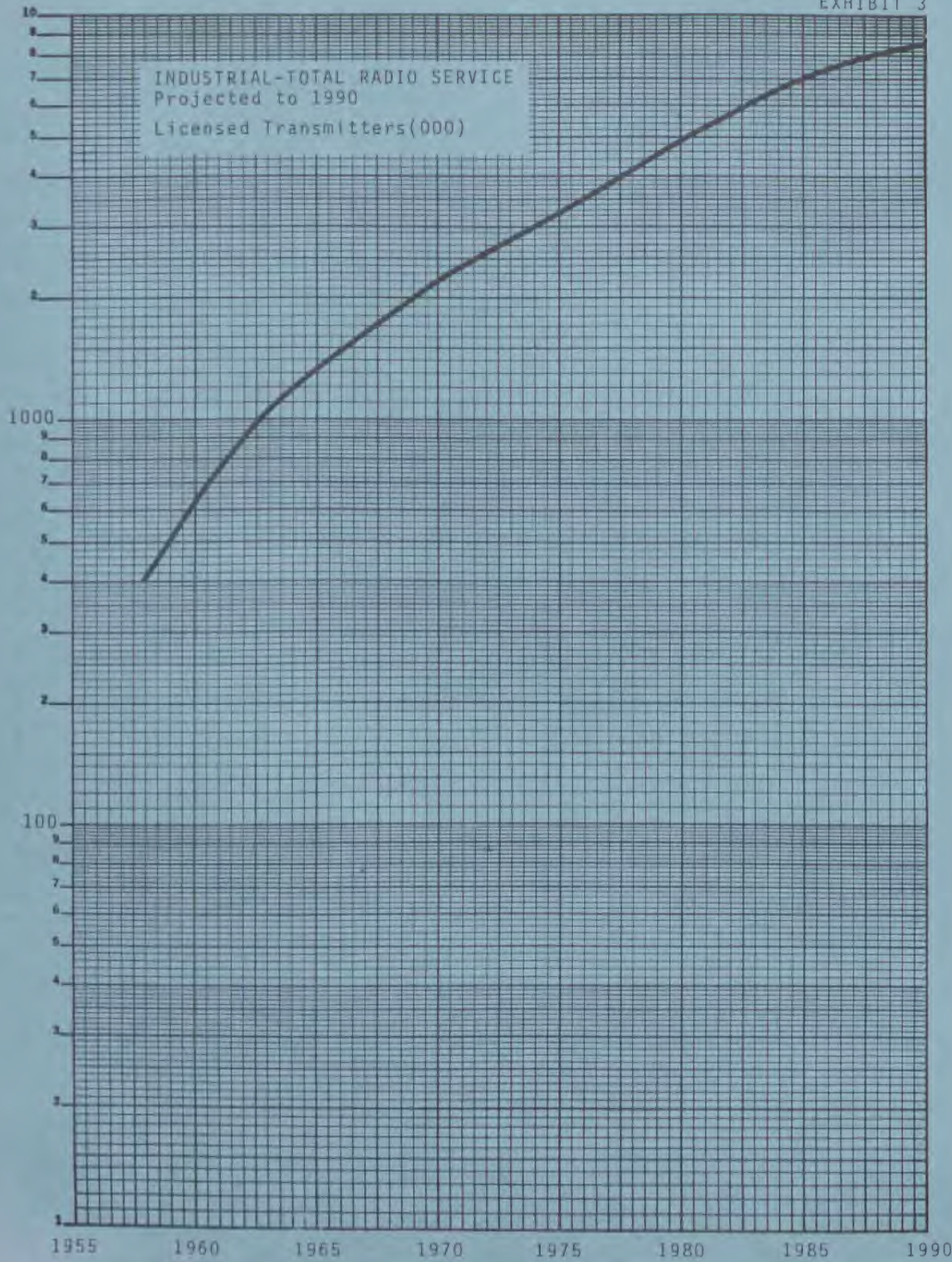
1990

EXHIBIT 3


INDUSTRIAL-TOTAL RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
1000
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1955
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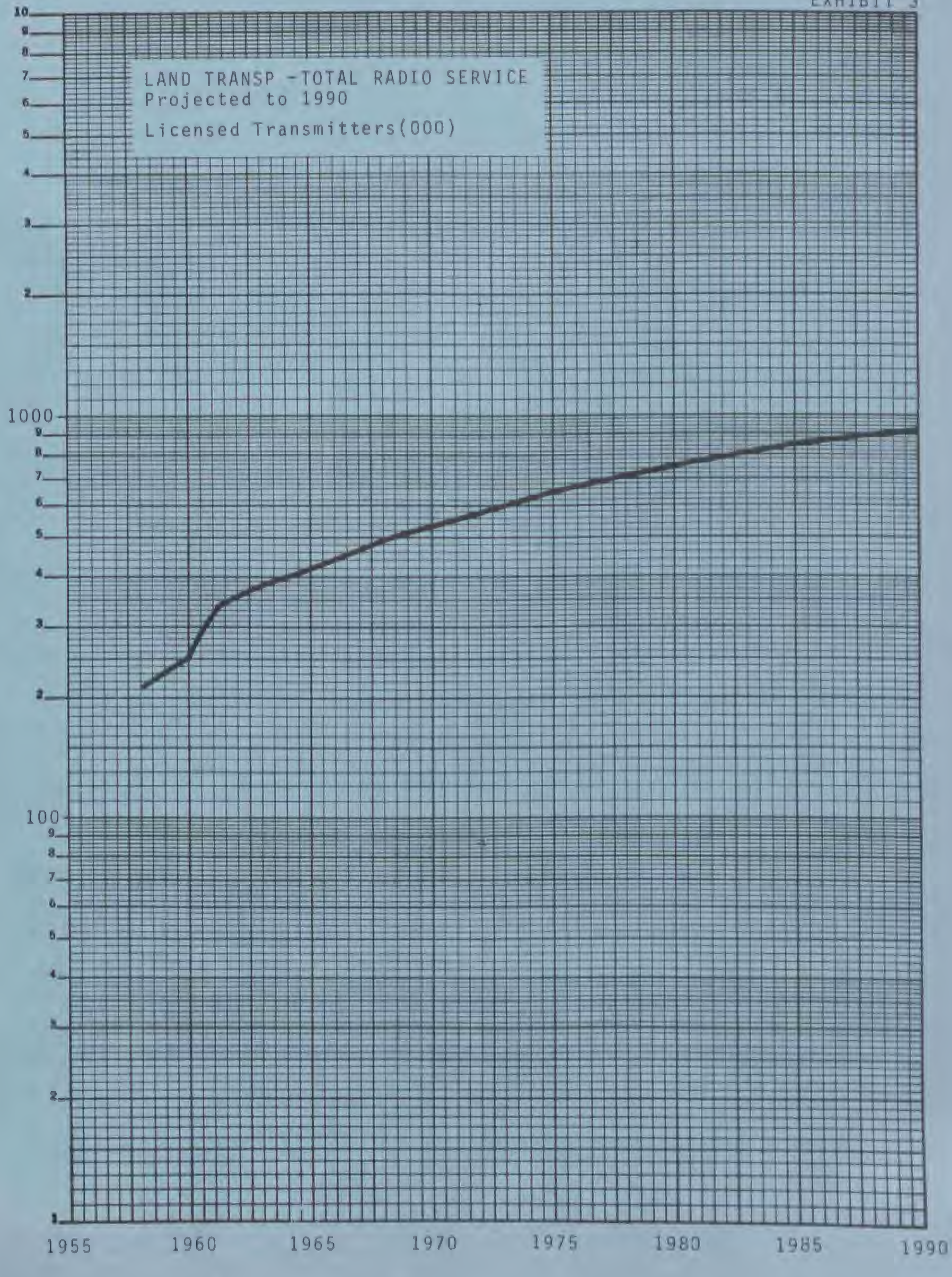
1990

EXHIBIT 3


LAND TRANSP -TOTAL RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
10
9
8
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5
4
3
2
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100
1
1955
1960
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1970
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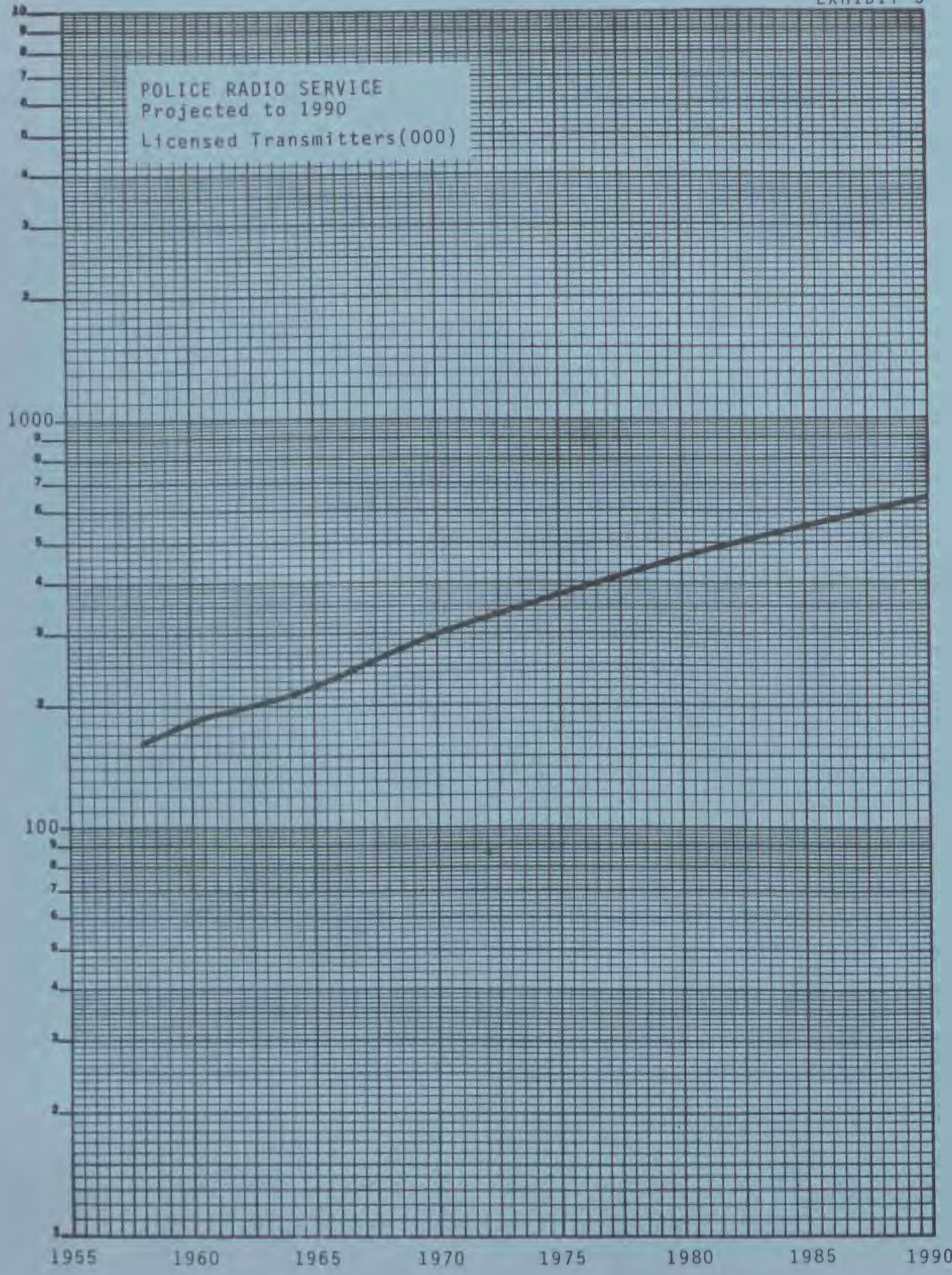
1990

EXHIBIT 3


POLICE RADIO SERVICE
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Licensed Transmitters(000)
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EXHIBIT 3

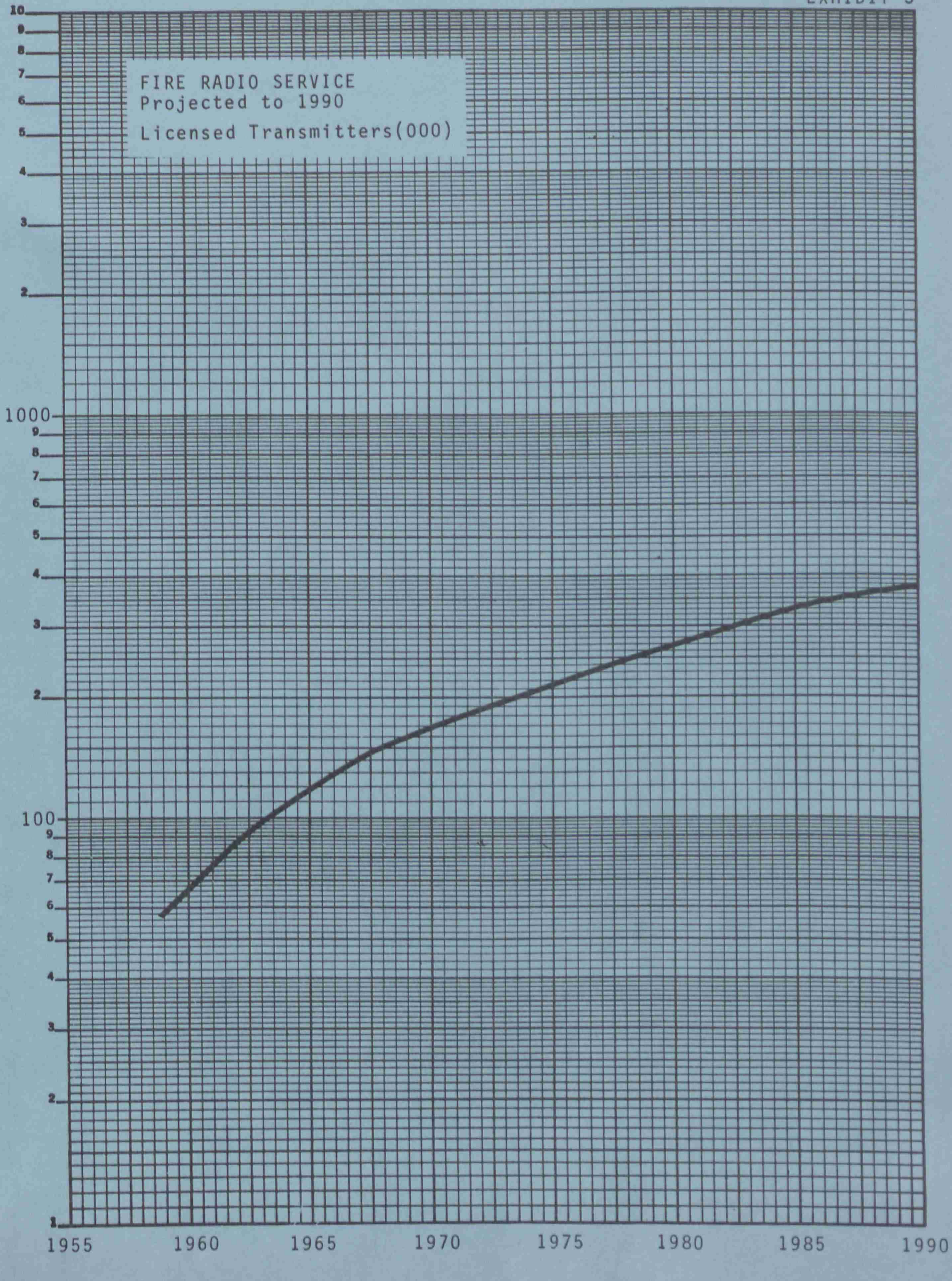
FIRE RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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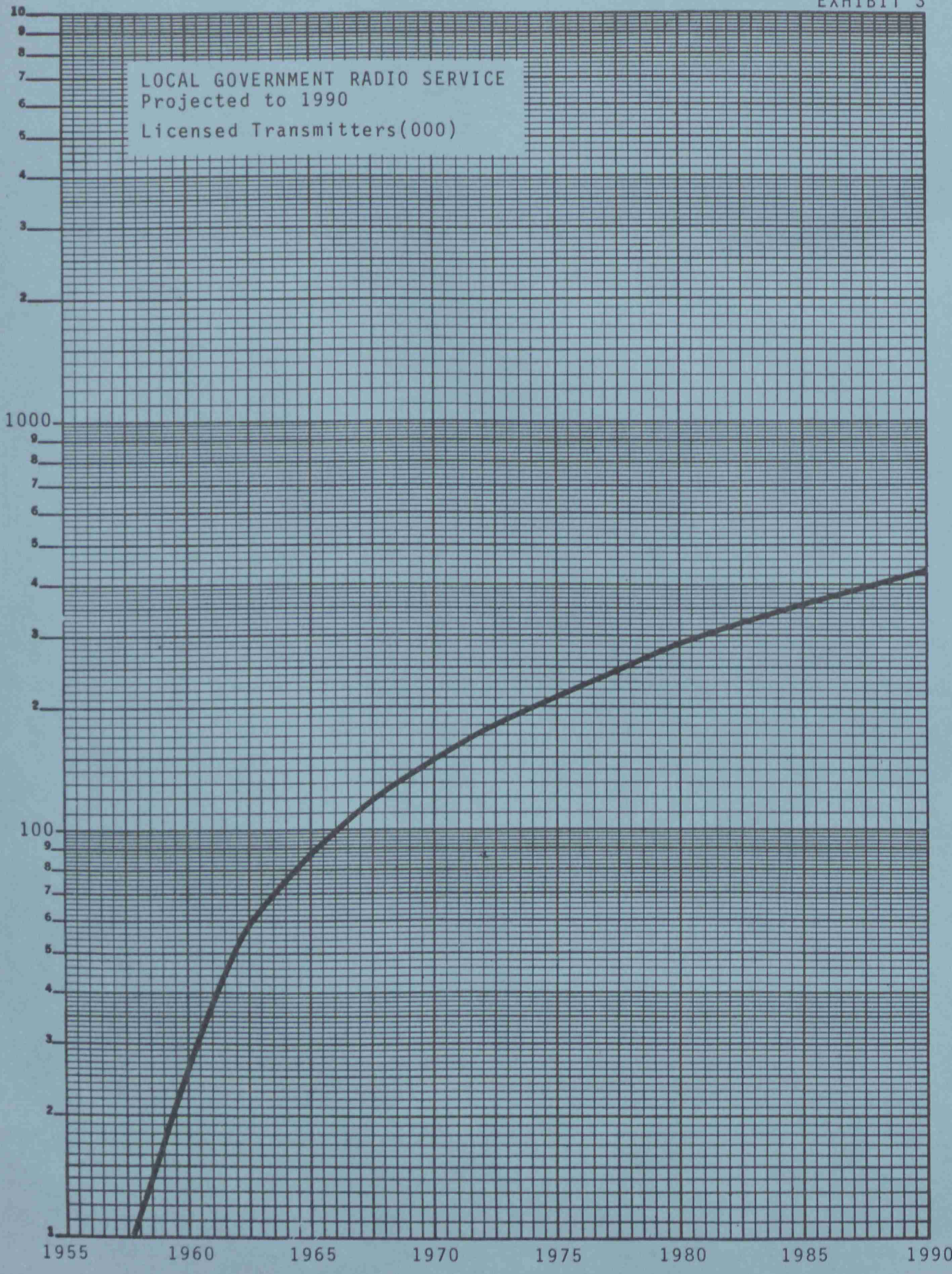
EXHIBIT 3


LOCAL GOVERNMENT RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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1000
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EXHIBIT 3

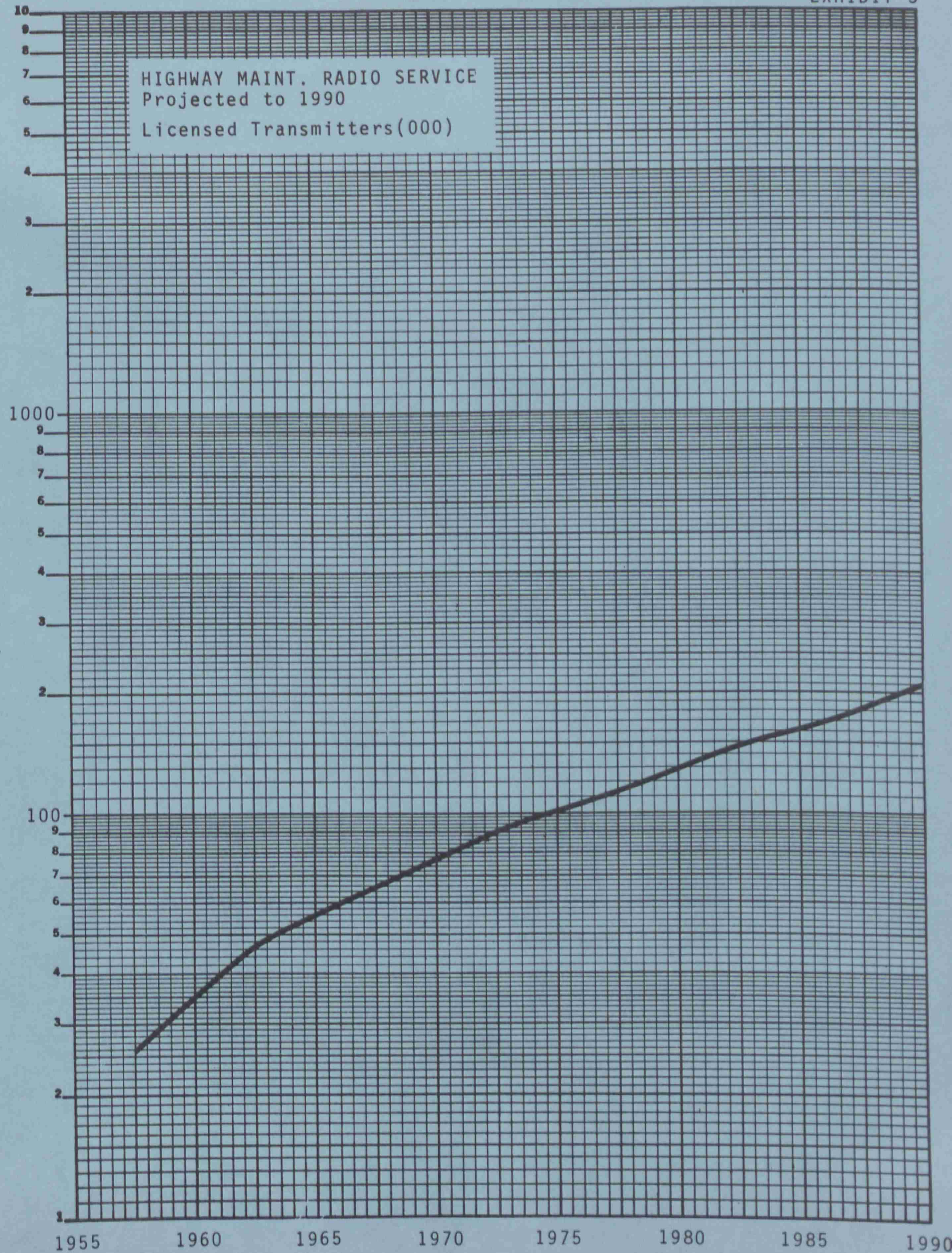
HIGHWAY MAINT. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
1000
100
1955
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EXHIBIT 3

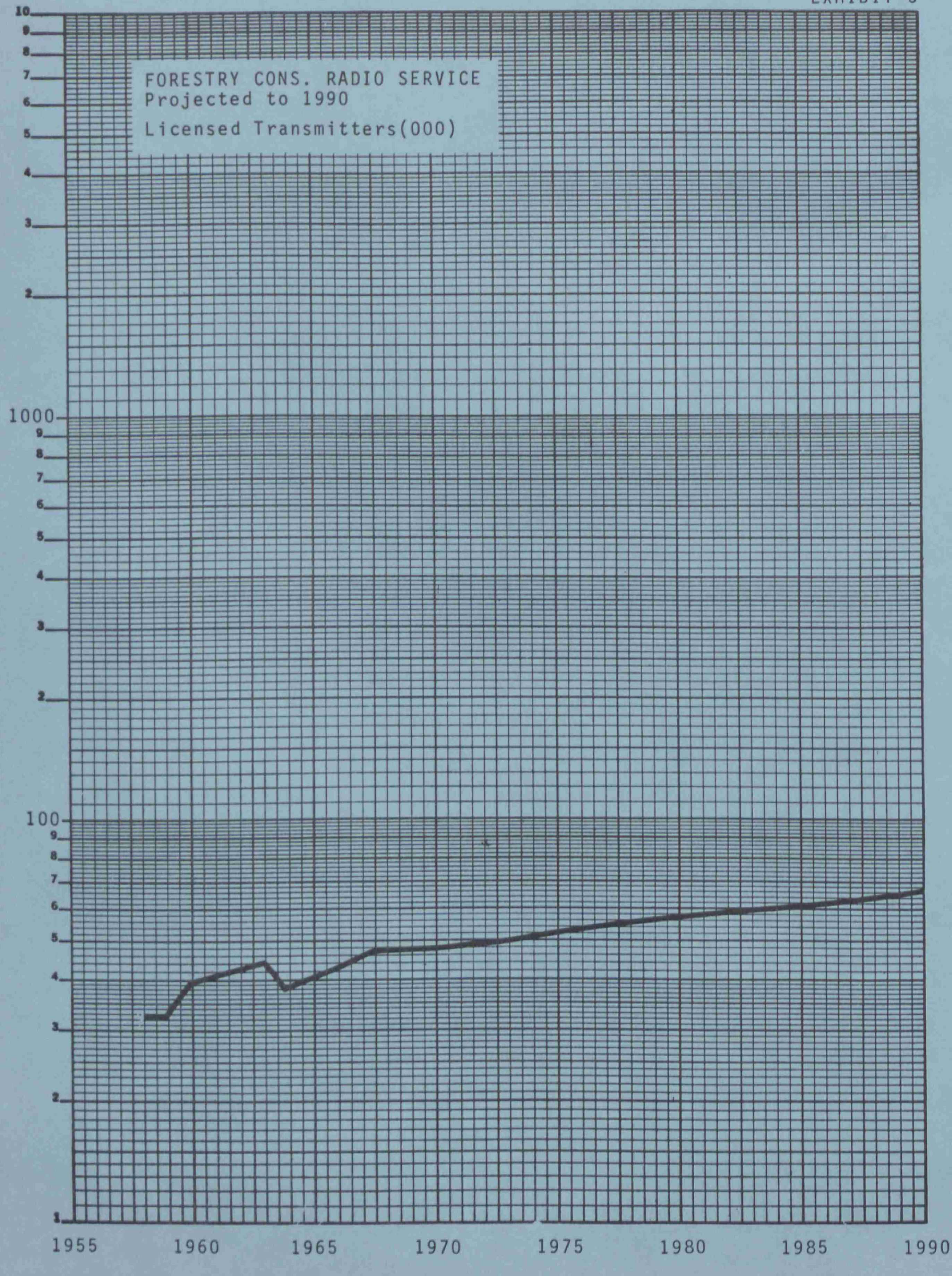
FORESTRY CONS. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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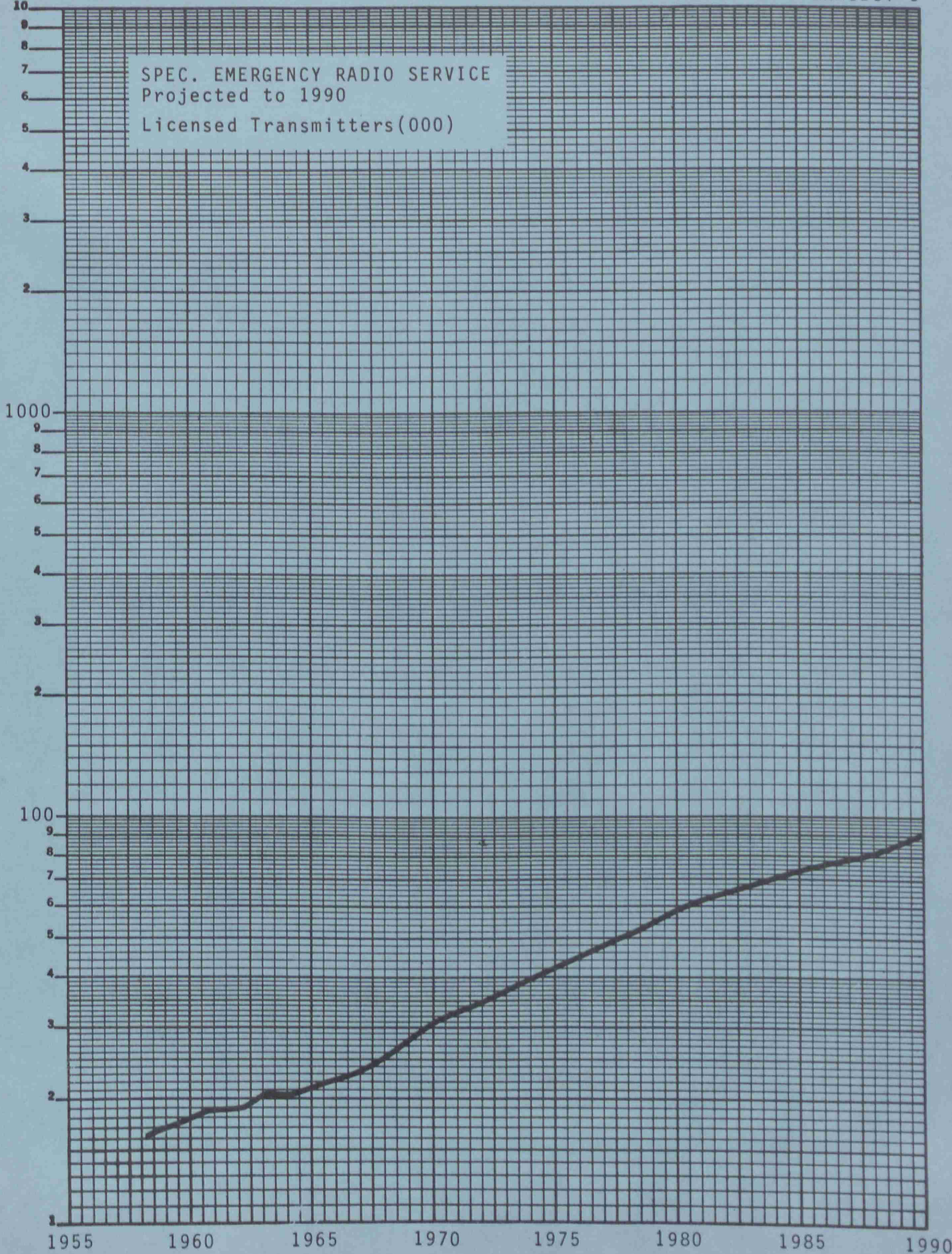
EXHIBIT 3


SPEC. EMERGENCY RADIO SERVICE
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Licensed Transmitters(000)
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EXHIBIT 3

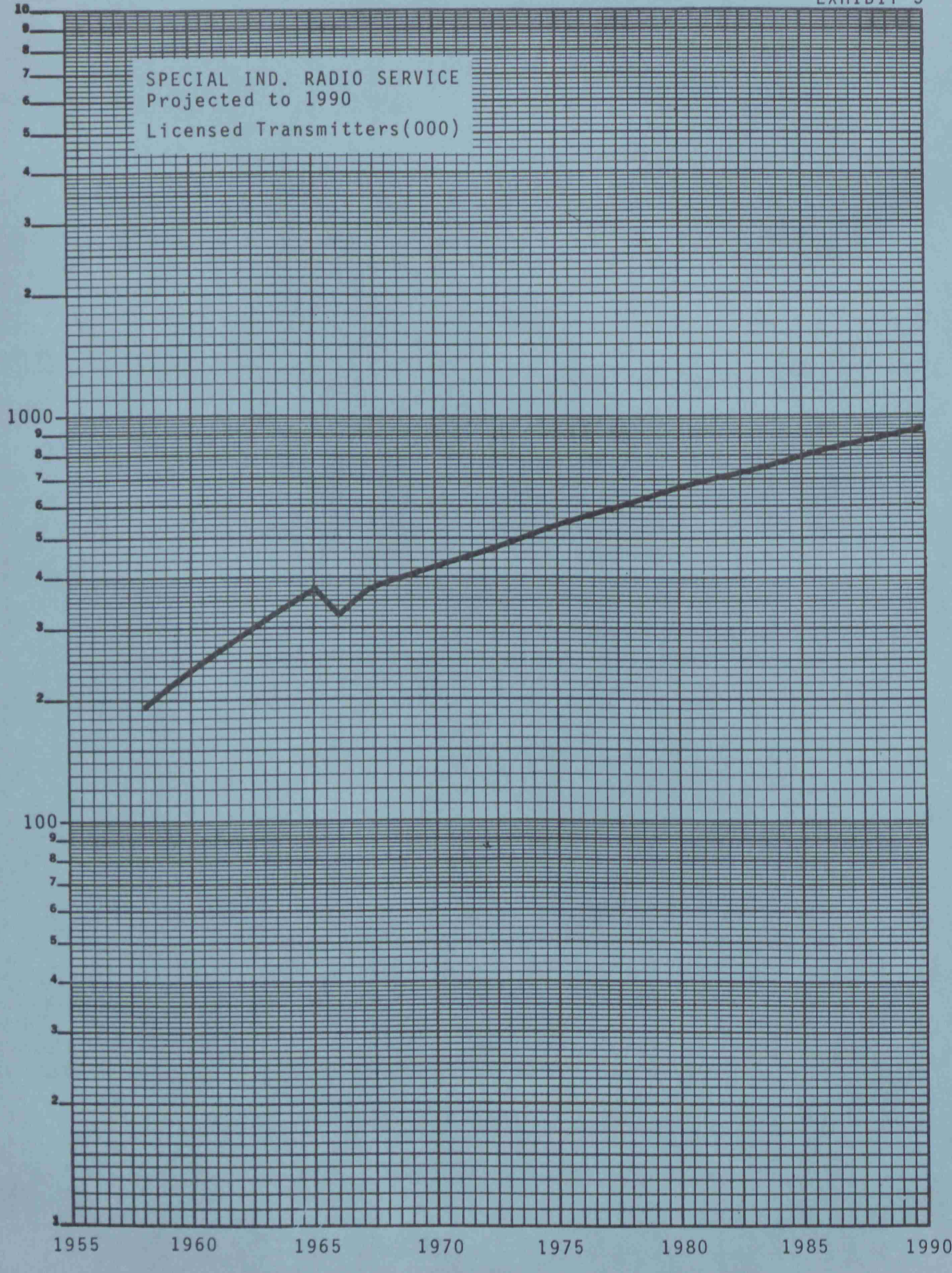
SPECIAL IND. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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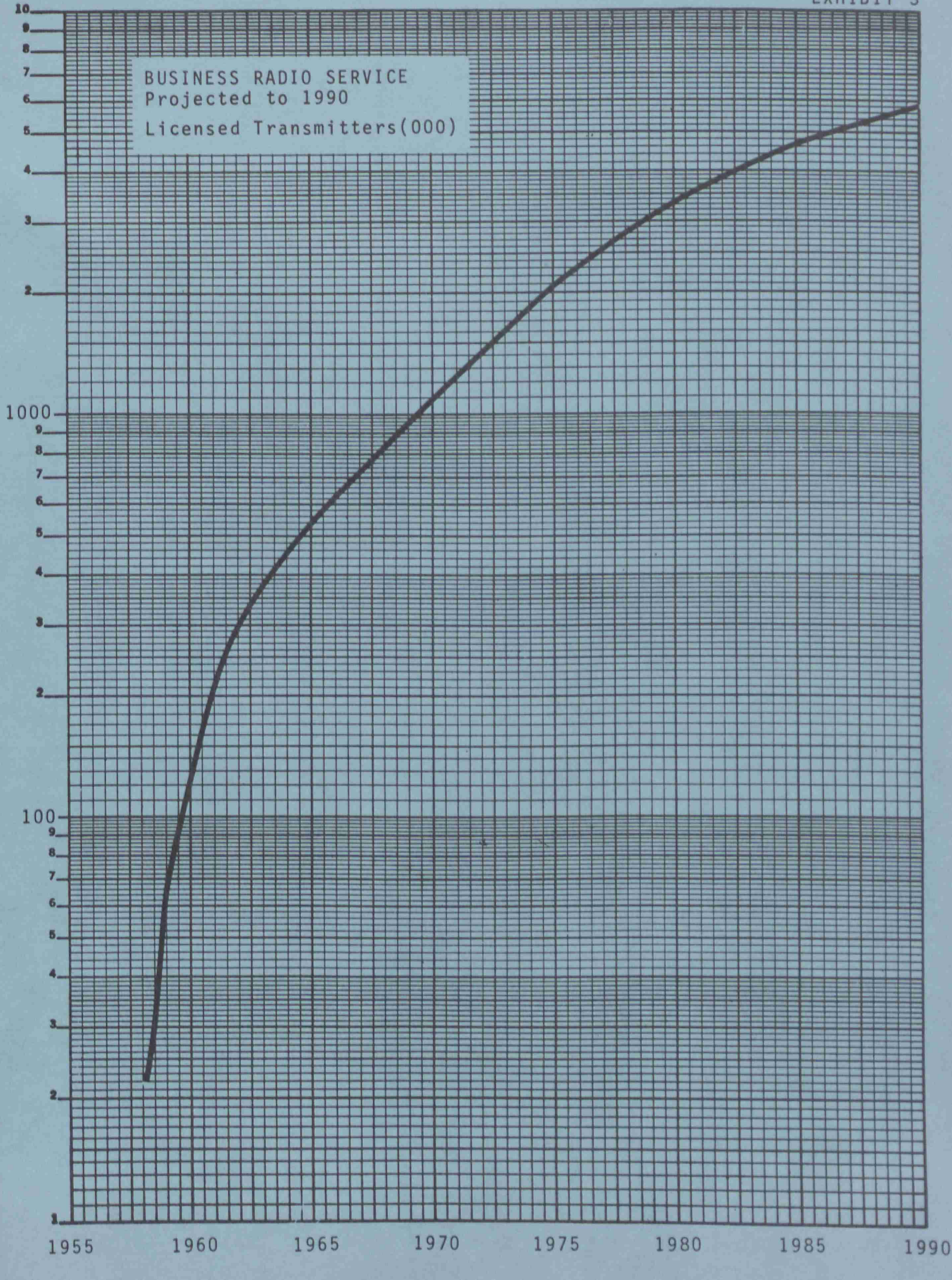
EXHIBIT 3



BUSINESS RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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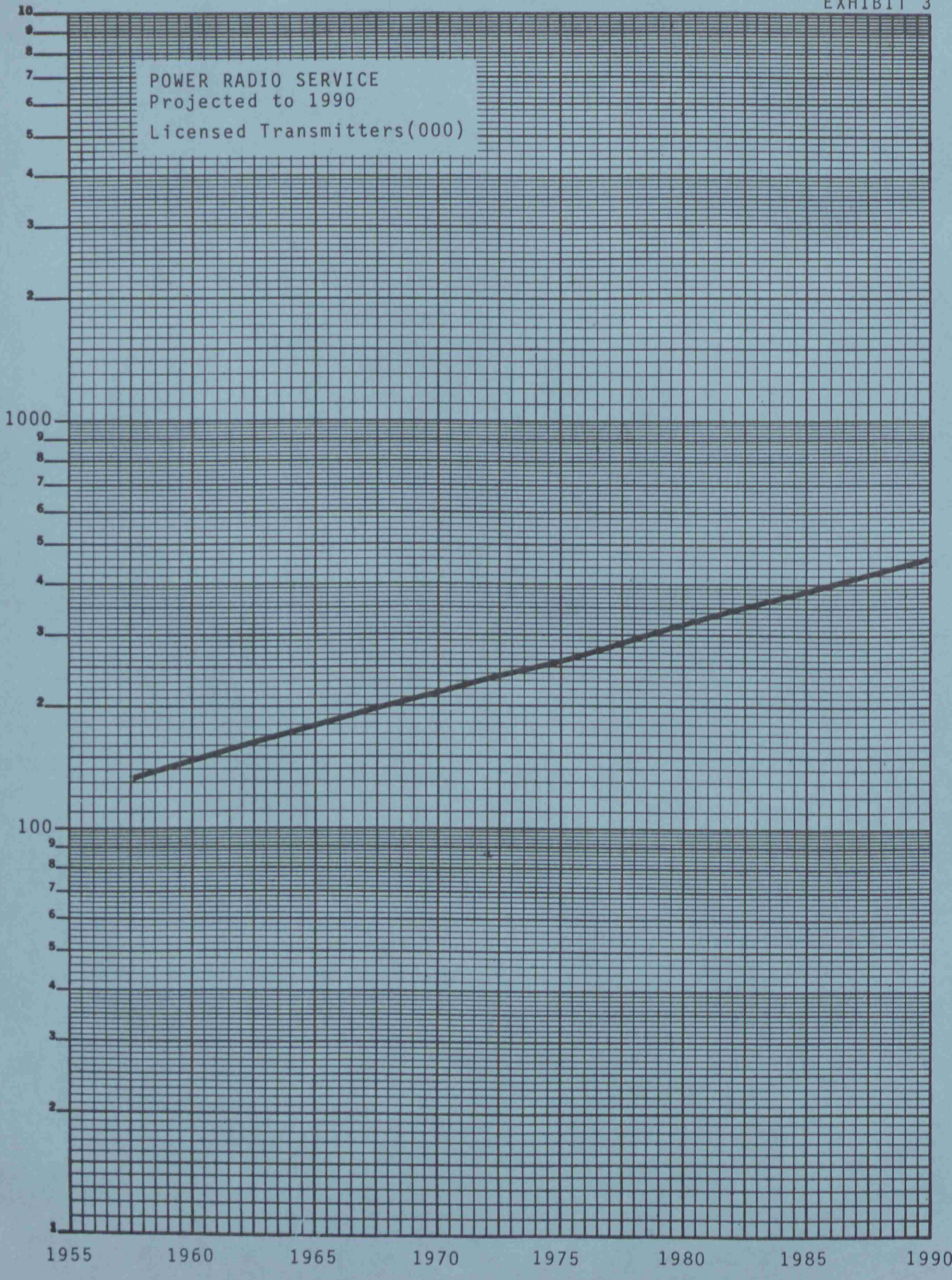
EXHIBIT 3


POWER RADIO SERVICE
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Licensed Transmitters(000)
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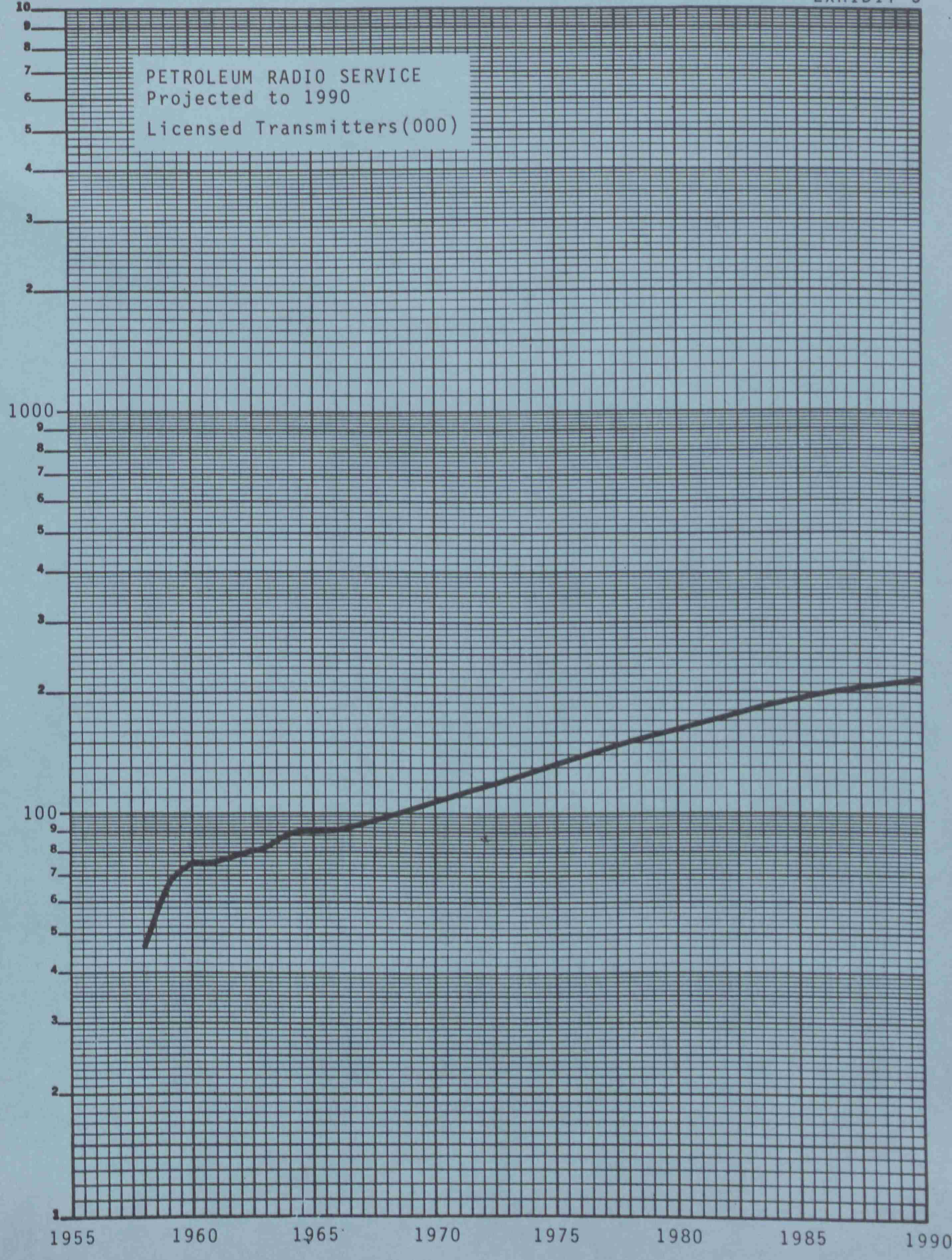
EXHIBIT 3


PETROLEUM RADIO SERVICE
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Licensed Transmitters(000)
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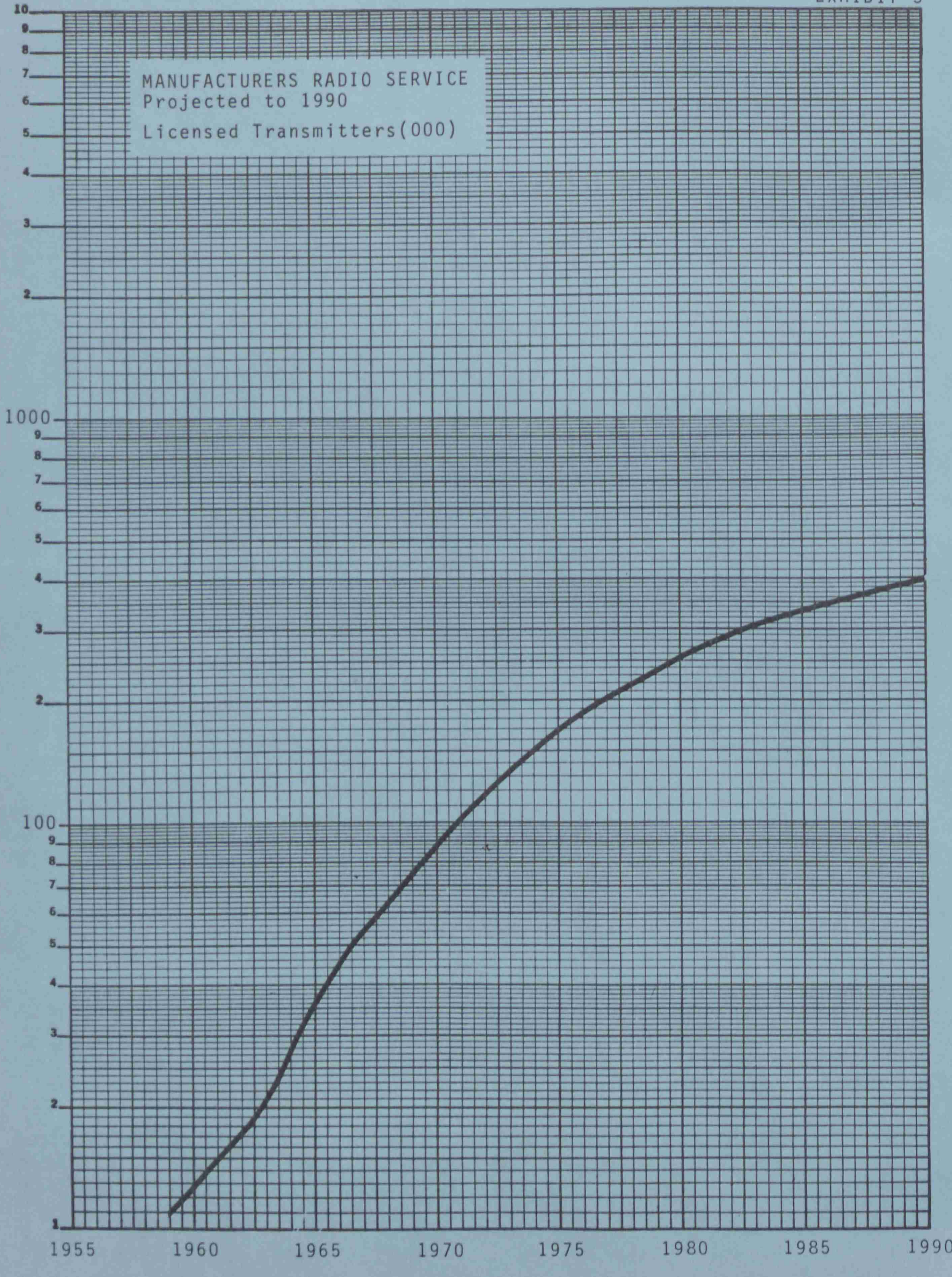
MANUFACTURERS RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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EXHIBIT 3

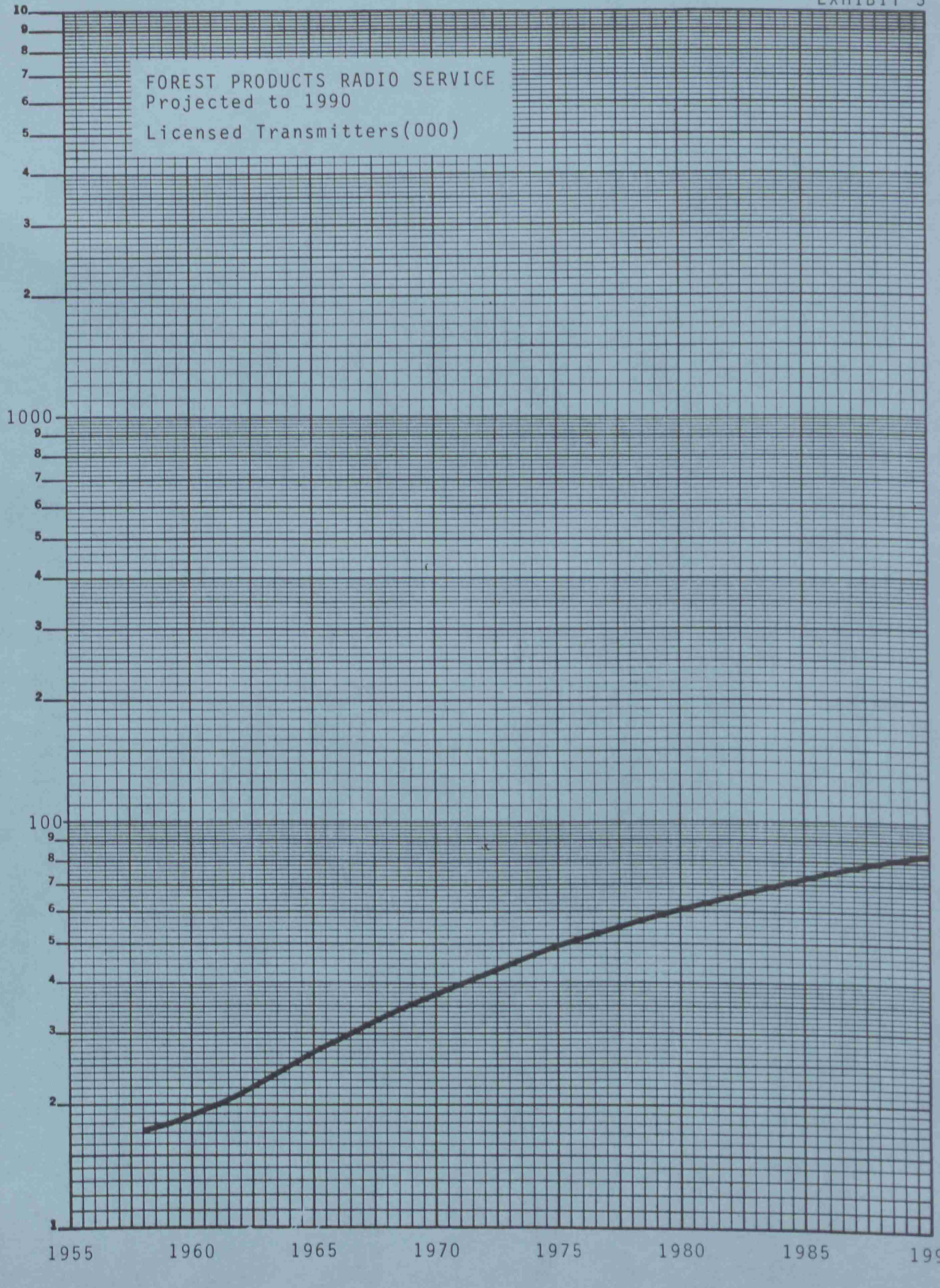
FOREST PRODUCTS RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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EXHIBIT 3

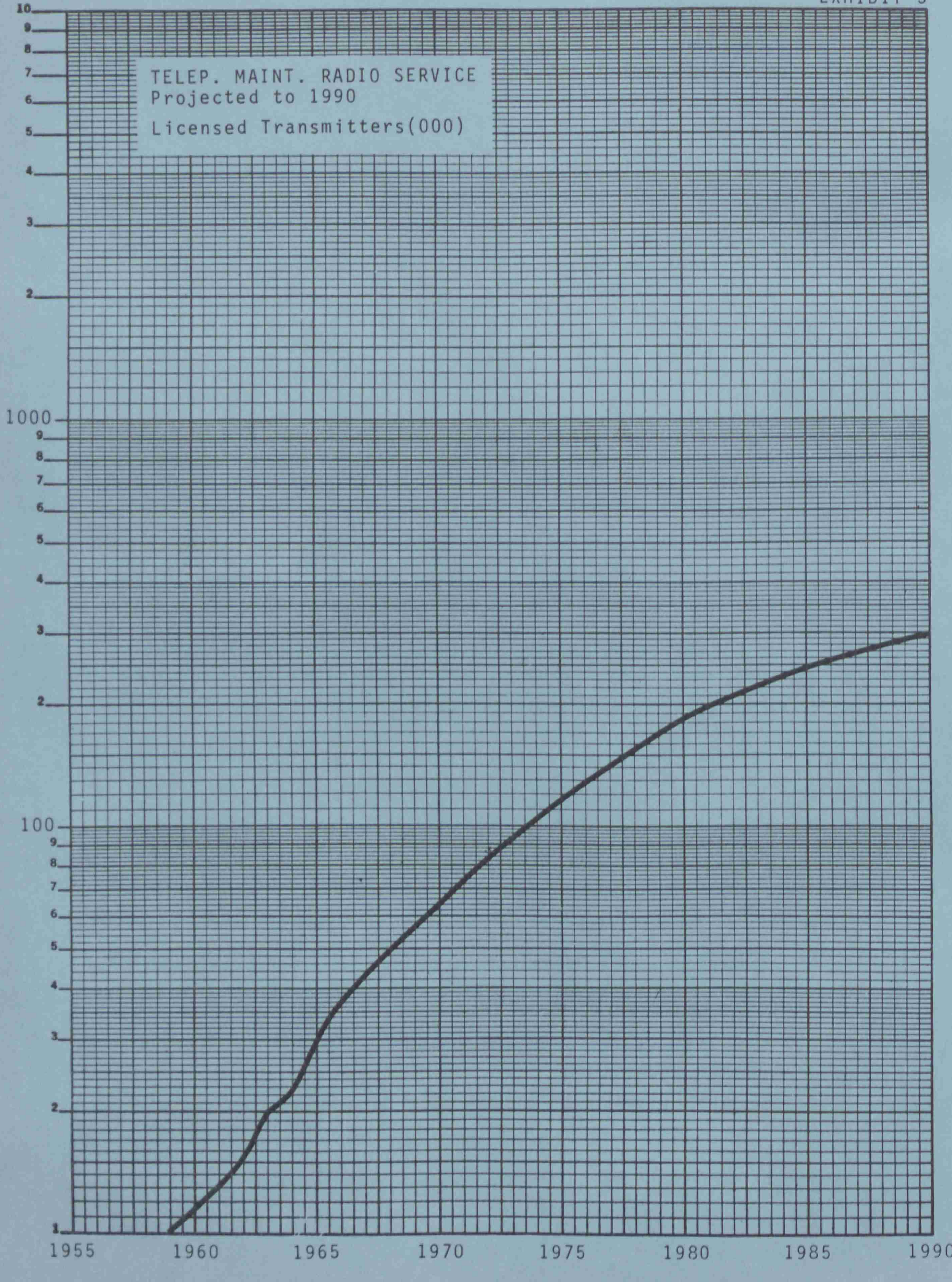
TELEP. MAINT. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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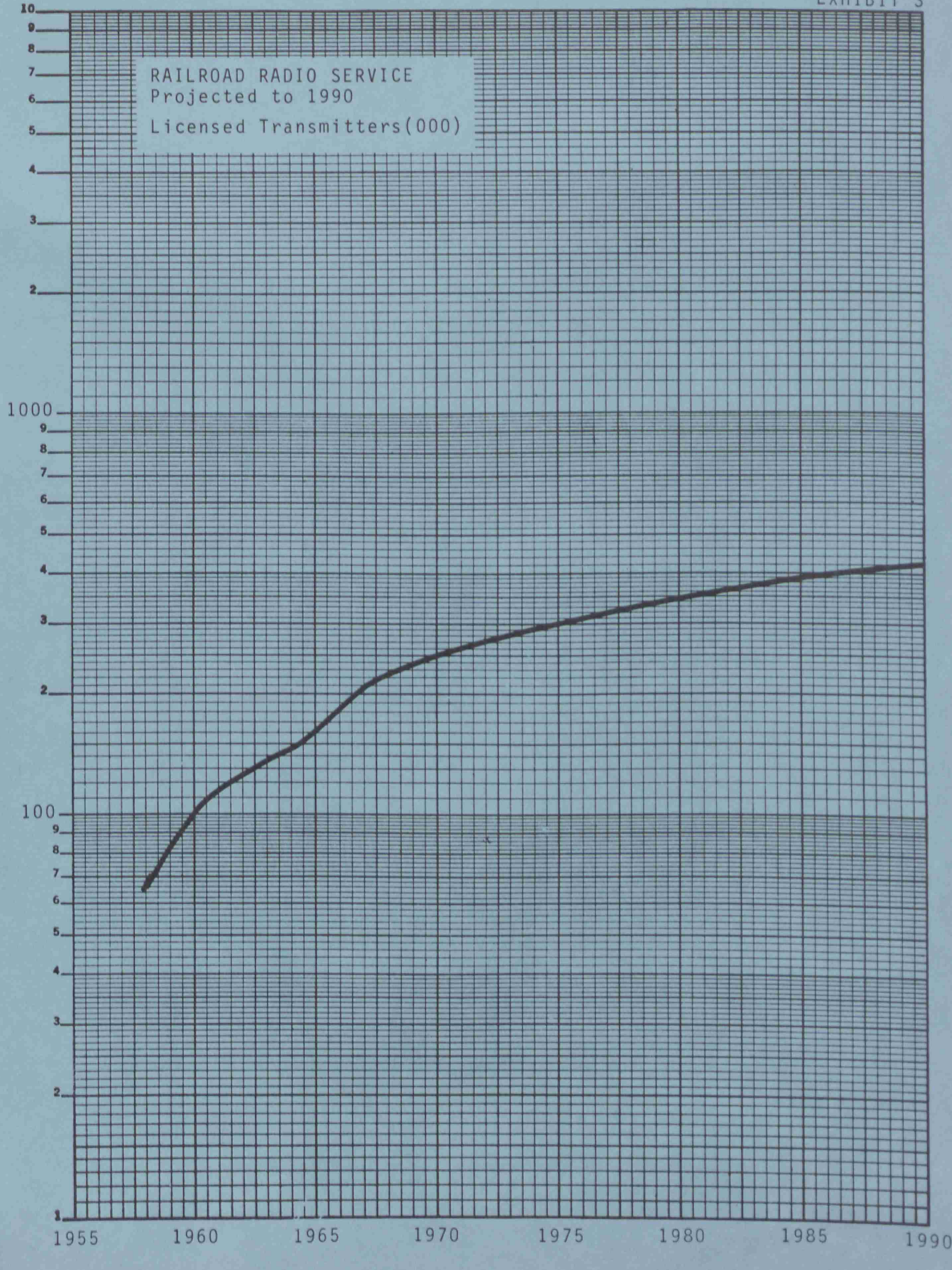
EXHIBIT 3



RAILROAD RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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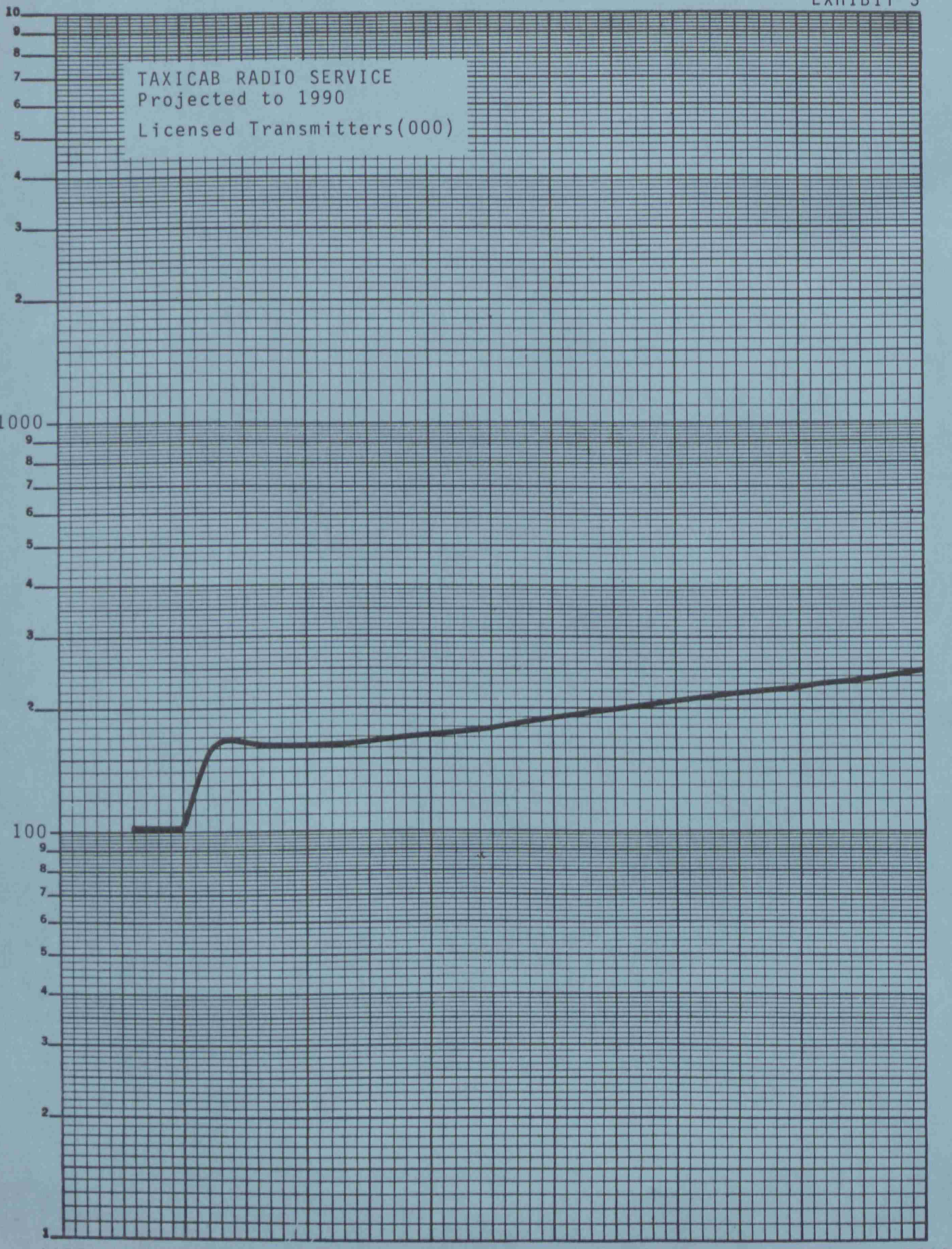
EXHIBIT 3


TAXICAB RADIO SERVICE
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Licensed Transmitters(000)
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EXHIBIT 3

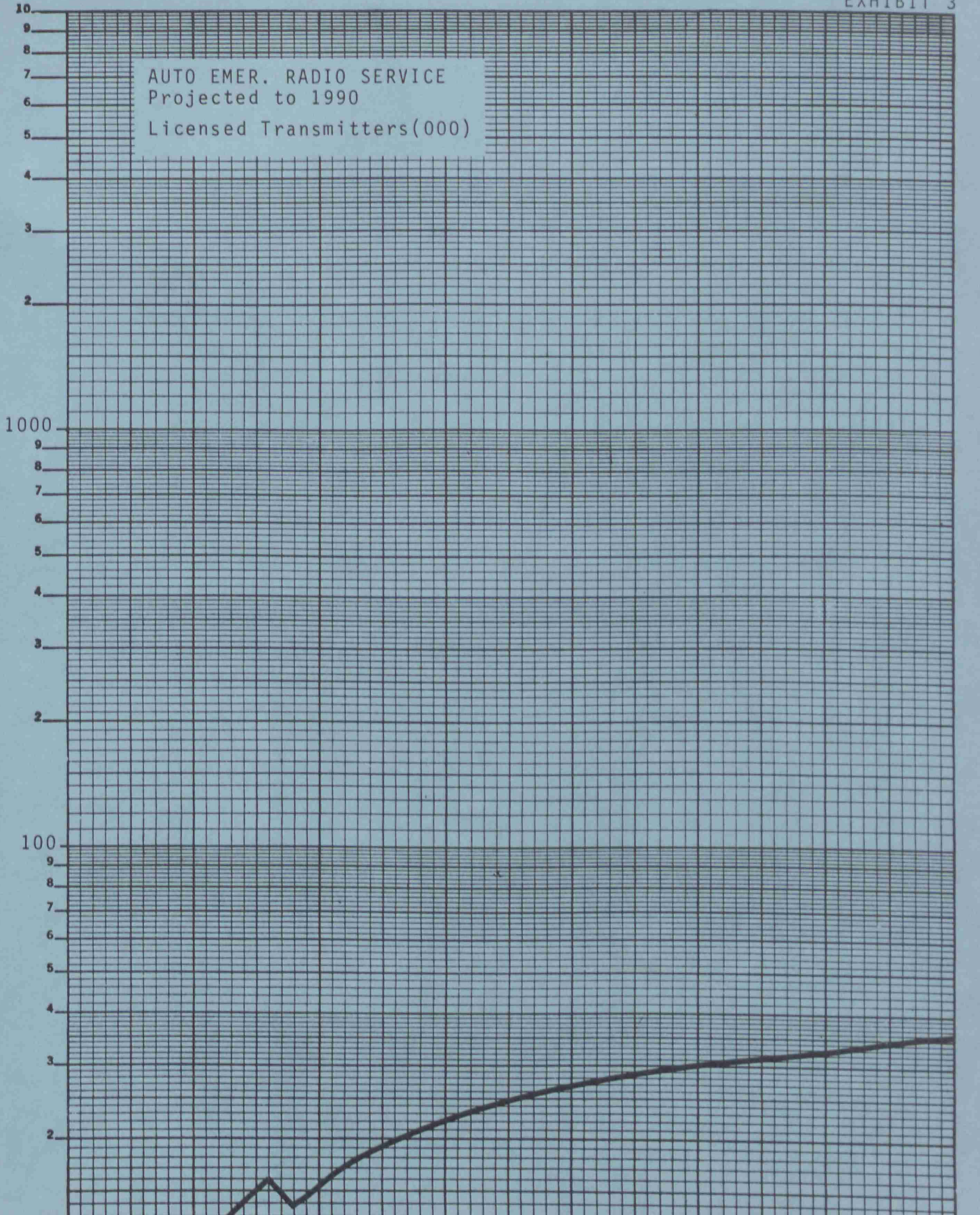
AUTO EMER. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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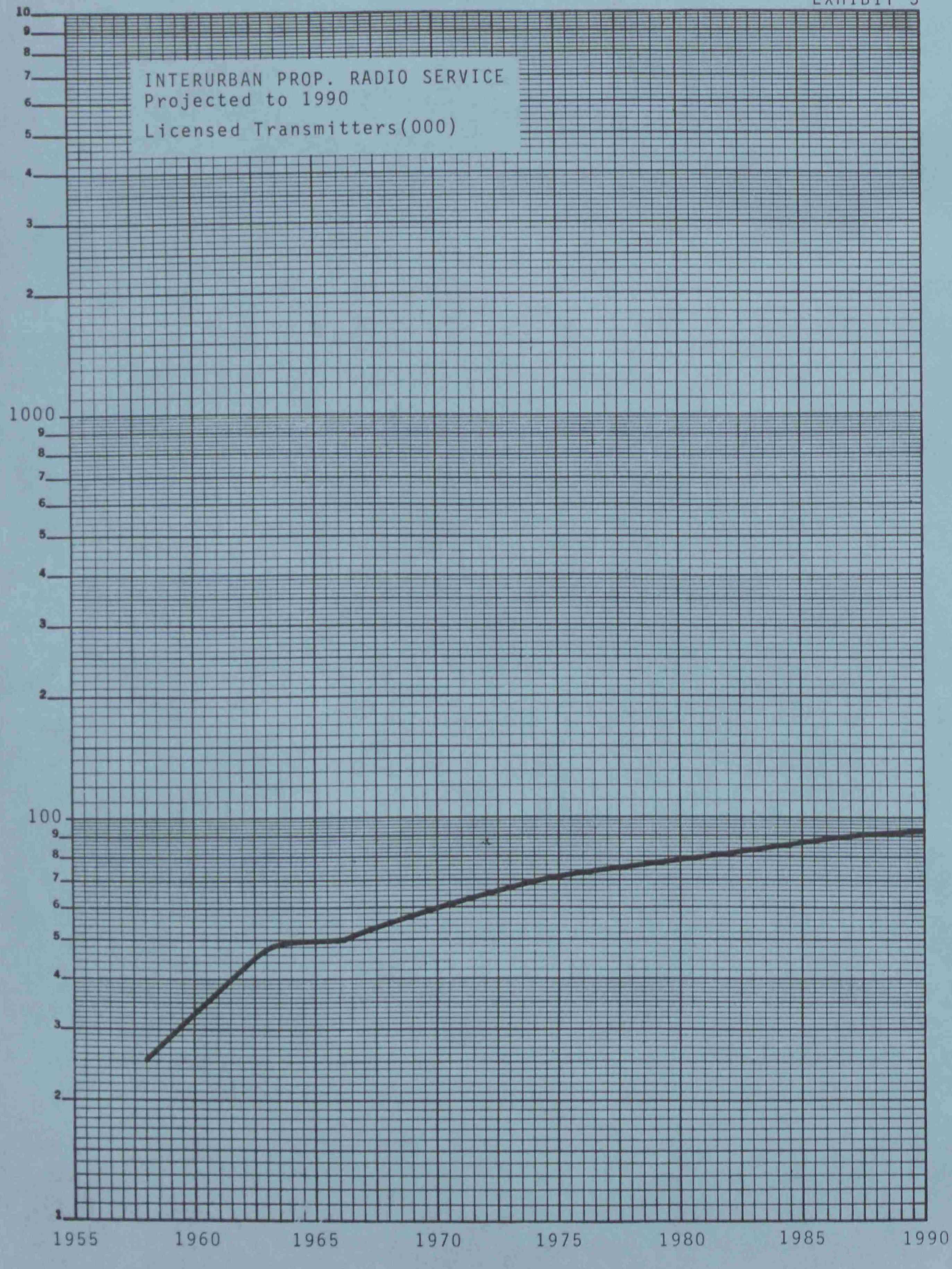
EXHIBIT 3



INTERURBAN PROP. RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
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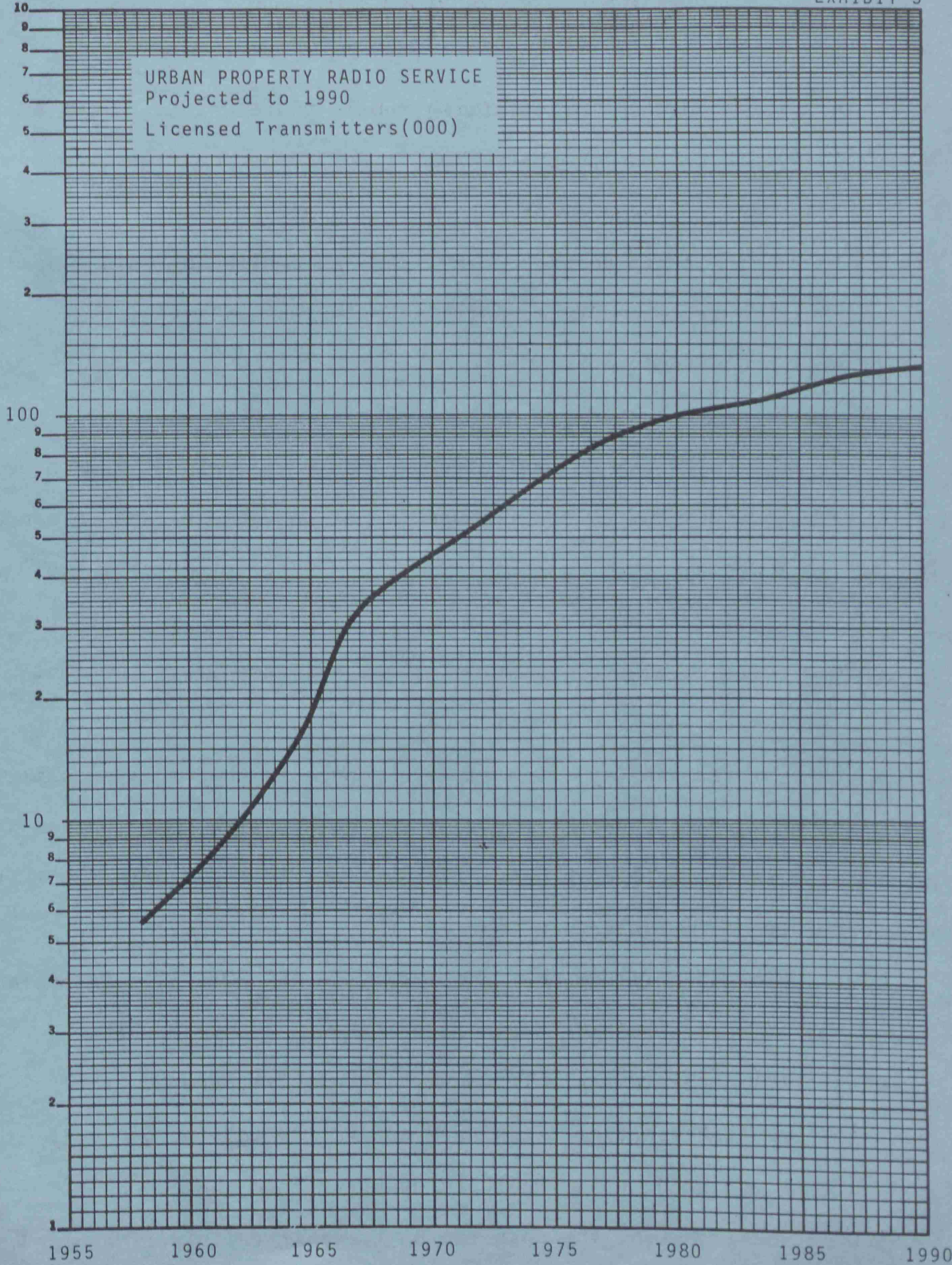
EXHIBIT 3


URBAN PROPERTY RADIO SERVICE
Projected to 1990
Licensed Transmitters(000)
100
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1955
1960
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EXHIBIT 4

EFFECT OF NEW TECHNOLOGY ON LAND MOBILE RADIO SPECTRUM NEEDS

The initial purpose for utilizing mobile radio was to effect communications with the man in the vehicle. Police headquarters wanted to give an order to a squad car; the taxi dispatcher reached a cab via radio to direct him to pick up a fare. Accomplishing this objective is still a key element necessitating the use of mobile radio, and it will undoubtedly continue to be so.

However, as the nature of our society and economy has become more complex, additional communications needs have emerged. Employees of Government and industry are frequently not in vehicles and so cannot respond to a message from headquarters. Hand-carried portable equipment is undergoing constant development and improvement to meet that communication requirement. Sometimes the use is two-way: to provide communications to and from the fireman inside the blazing building. In other cases, it is one-way: the employer contacts the employee while he is on an assignment and directs him to another site to combat an emergency. The principle, however, is essentially the same; it permits person-to-person communication wherever they are.

The socio-economic demands do not stop there. Often, information of a detailed nature must be transmitted in such quantity that the recipient will either not get it completely or will have to waste valuable time (and spectrum) seeking "repeats" so that he can copy it down. Again, Land Mobile radio is stepping into the breach by developing modes whereby the data can be transmitted into a machine and stored until it is ready to be used. A description of stolen cars can be transmitted to mobileprinters located in patrol cars to be read by the driver when time permits. The next day's freight schedules can be similarly fed into a printer the night before, ready to be picked up and acted upon by the morning shift. These examples represent communications from a person to a machine.

It is a short step to visualize communications designed for use from machine to machine. Various remote control devices operate to direct machines into areas where conditions would not permit people to go. Automatic vehicle location systems permit any or all vehicles to be interrogated as to their where-abouts, and the responses can be programmed so that decisions can be made on a future course of action. Radio permits both the interrogation and the response to be made, essentially without the intervention of man.

The following examples of new technology are merely that: indications of a few paths which can already be seen. It is safe to conclude, however, that although thus far the concepts have outstripped the applications the future will see many more of these ideas reach practical fruition.

1. PAGING

The general use of personal pagers is expected to increase toward a general equipping of individuals with pagers similar to the current usage of telephones. The number of people will increase as cost and size of paging equipment is reduced.

Within the past five years there have been tremendous changes in the semiconductor industry. The rapid growth of new devices and the development and growth of integrated circuit technology has made miniature radios a realizable item within the present state of the art.

A simple version of a wrist receiver (less battery and loudspeaker) may become feasible within five to ten years. A complete two-way unit, including a low-power transmitter, would take several years more.

II. INFORMATION TRANSMISSION

A. Teleprinters - The use of dedicated or shared teleprinter channels for printed messages for public safety and business use.

Radio teleprinter operation can provide unique benefits in fulfilling mobile communication requirements not fully satisfied by the two-way voice communication systems, thus complimenting voice communications. The benefits of teleprinters include the improved message accuracy gained by recording the message, unattended reception of messages, operation in acoustically noisy environments, direct interface with data sources and message privacy.

Some of the potential users of teleprinter include law enforcement and public safety agencies, utilities, manufacturing operations, transportation operations, airline terminal operations and automobile emergency services.

B. Facsimile and Slow-Scan TV - For visual communications and transmission of graphic information.

As further improvement in graphic transmission technology occurs, it is becoming more feasible for use in vehicles. This would permit transmission of pictorial information, maps and documents in original format. If scenes must be transmitted and do not contain rapidly moving objects, slow-scan television to a vehicle can be employed. Slow-scan signals can be transmitted over much narrower channels than the 6 MHz used for standard television broadcast.

For map viewing, slow-scan TV may be quite practical, since changes are not likely to occur more rapidly than the system can accommodate. Police application of this system would allow a patrolman to view "show-ups" as they were being conducted at the police headquarters. Similarly, daily bulletins of the police or other organizations could be viewed remotely to avoid the accumulation of excess hard copy in the vehicle.

C. Data Input to Computers - Inquiry systems from mobiles to computers for information.

It is now technically feasible to use the radio channel between a vehicle and its control center to provide direct access to data stored in the memory files of a computer. An inquiry on a keyboard in the vehicle is translated by an encoder into signals suitable for transmission over the radio link. At the control center the received signals are automatically routed to the computer, which processes the incoming message and searches the memory for the desired information. The information or other suitably composed reply is automatically encoded and fed to the base station for transmission to the vehicle when the channel is free. At the vehicle the receiver feeds the signal into a decoder, where it is translated into a form suitable for driving a mobile teleprinter or other display device such as a cathode-ray tube.

D. Location Systems

Vehicle location systems have been recommended by the President's Commission on Law Enforcement and Administration of Criminal Justice, and in the related Task Force Report - Science and Technology. Extensive experimental and developmental projects are currently being undertaken by manufacturers.

The FCC has initiated an inquiry into the requirements for car locator systems with a view toward modifying the land mobile rules to provide for licensing of these systems.

A location system has three distinct communication needs although they may share common channels. These are:

1) Location Measurement

This function uses a radio channel to make measurements of time, phase, etc., from which a position is derived. Even an onboard dead-reckoning system might use the channel for up-dating or resetting.

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2) Interrogation

This function requires a channel which is used to select and prepare the vehicular equipment for the measurement function.

3) Reporting

This function requires a channel to report a measurement parameter to a computing or displaying center.

E. Vechicle Identification Information - Automatic identification of the specific vehicle transmitting a message.

A number of systems have been designed to provide identification for each of the vehicles in a radio system. Vehicle identification is also an inherent part of a location system. A variety of users have indicated that vehicle identification will provide unique benefits to their everyday operation. Some of these types of users are police, utilities, and bus companies.

F. Transfer of Information from Ambulances to Hospitals - Electrocardiograph (EKG), blood pressure, encephalograph and similar medical instrument outputs.

These systems provide communication channels for emergency assistance to and from hospitals. They tie several area hospitals to a central or regional hospital, portable-radio-equipped workers at a disaster scene to the hospitals, and amublances, rescue squad trucks, and other emergency vehicles to each other, to hospitals, and to workers on foot.

Recently new techniques have been developed using these systems. A Los Angeles ambulance service has tested a system which transmits the heartbeats of a cardiac patient over the ambulance radio to the dispatch office. The information is in turn relayed by a special telephone line to an EKG recorder at the hospital. Thus a doctor can examine the electro-cardiogram and make preparations for the reception and care of the patient while the patient is enroute to the hospital via ambulance.

The availability of a number of channels should eventually make it possible to send information on other physiological functions, such as blood pressure, pulse wave velocity, respiratory volume, skin temperature, etc.

G. Telemetry

Extensive use of remote telemetry will be used in watershed reporting systems, river level reporting systems, etc., where sensors spread over a wide area report information to a central control point.

III. PORTABLE REPEATER SYSTEMS

As the use of portable radio systems increases, additional spectrum is needed for associated repeater channels.

Since the principal purpose of a repeater is to extend the ranges of personal portable radios, particularly within buildings, the propagation characteristics of the various frequency bands with respect to portable radio performance must also be considered. In this connection it has generally been found that RF penetration of structures is enhanced by the use of frequencies above 150 MHz, and especially within the 450 MHz range. This choice is further strengthened by the relative inefficiency of portable radio antennas at the lower frequencies.

Within the next five years, medium or large scale integration combined with hybrid micro-electronics, should allow miniature radios to be built with power outputs equal to today's hand-held portable units. A break-through in battery technology will also enable smaller and smaller units to be built.

IV. WARNING

A. Selective Warning Systems - This includes tornado and Civil Defense warning systems for schools and other public buildings.

There is a trend toward using a wide area, county or even state-wide radio channel for emergency warning systems. For example, the 10-10 system operated by the Illinois State Police permits any school or similar institution to gain access to the system by purchase of appropriate radio equipment. In event of need for a warning, a tone signal is sent out, opening the audio circuits of the radio receiver so that the voice warning message is received.

B. Alarms from Remote Locations - Intrusions, burglar, fire, and similar alarms from remote areas or places.

Unguarded remote sites are generally vulnerable to vandalism. Equipment at such sites may be protected by a building within a fenced in compound. Such sites can also be protected from illegal entry by alarm systems which report to 24 hour communication or dispatch centers. Fire and burglary alarms, equipment disablement detectors, etc., can be similarly protected. A more recent development is the Ice and Frost Alarm. Highway departments find it desirable to immediately know about snow conditions on roads and frost or icing conditions on bridges or exposed sections of highways. Frost and ice can form on the road surfaces, creating a severe hazard to driving not expected by the motorist. Highway engineers prefer to eliminate this problem by sanding or salting as soon as possible rather than relying on warning signs or driver judgment.

The Maintenance Department of the Iowa State Highway Commission has recently been experimenting with frost and ice detectors. Sensors were embedded in the bridge floors about midway into one traffic lane and connected to a control unit mounted on a nearby utility pole. The alarm output controlled a radio transmitter mounted on the pole which would broadcast the alarm to a monitor receiver located at the local maintenance foreman's residence.

C. Distress Signals from Motorists

1) Vehicle to Emergency Center

2) Roadside Call Box to Emergency Center

The various public safety agencies have expressed an interest in systems to enable a citizen in distress to call for assistance. The fire department, police or sheriff may be needed. The assistance required may take a variety of forms. For medical aid, a doctor, ambulance, or oxygen equipment may be needed. A mechanic or tow truck to assist with a disabled vehicle is a frequent requirement. A rescue squad may need to be summoned in the event of a cave-in, explosion, train or airplane crash, etc.

V. CONTROL

A. Remote Control of Vehicular Equipment - For example, cranes, road-building equipment and trains.

Radios and other electronic devices have made possible the control of hazardous operations at a safe distance, the remote control of operations in a location inaccessible to a human operator, and the completely automatic control of many operations.

Examples of remotely controlled operations are:

1) Remote control of overhead traveling cranes. This is a common, well-known application for a portable, radio-type, remote control system. This system enables one man to control the lifting and movement of goods quickly, accurately, and efficiently from a position close to the work itself.

2) Remote control of switch engines or other track-type movers. This is a recently-adopted application of the same type of equipment as described in 1) above.

3) Remote control of a bull-dozer to clear fire-breaks in a forest-fire-fighting operation.

4) Remote control of a vehicle to carry and aim a firehose close to a forest fire, where the heat may be too great for men to stand.

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5) Remote control and aiming of a water nozzle mounted at the upper end of the movable tower or extension arm of a fire truck. This application, in conjunction with a low-cost, expendable television camera mounted next to the nozzle and feeding a CCTV monitor located at the control position, would enable a source of water to be brought closer to the heart of a fire in a building.

6) Computer-directed road building equipment. Automatically controlled road-building equipment can be designed to be directed by computers. Either special or general-purpose computers would direct the machines to move in specified directions, prepare a road bed to a specified grade, bank a curve to a specified angle, lay a base of specified thickness, etc.

B. Turn-on - Turn-off functions - Remotely operated at fixed locations where the use of wire line is not feasible because of conditions such as mountainous terrain, etc.

Such systems are used for the remote control of traffic signs along roads, control of equipment on remote mountain tops and control of a large number of switches such as the electric water heater switching systems as implemented by the Detroit (Michigan) Edison Company. This system has radio-actuated switches controlling the customer water heaters permitting the power company to regulate the loading on the power system.

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VI. PRIVACY AND SECURITY

There is an increasing need for the ability to transmit messages which can be understood only by the intended person or groups of persons. The application is obvious in law enforcement agencies. Industrial and business users also want privacy from their competitors.

It is expected that as more stringent requirements for privacy and security develop, channels that are wider than those presently available will be needed.

VII. ADDITIONAL BANDWIDTH REQUIRED FOR NEW TECHNOLOGY IN ALL SERVICES

Additional spectrum will be required for new technical developments although not in proportion to the channel occupancy of these developments. It is necessary to determine whether sharing of an existing channel is possible or if separate channels are required. New systems can fall into any of these categories:

A. Can be used on existing voice channels. This assumes that there are sufficient channels with available air time.

B. Cannot be used on existing channels, and additional spectrum is needed, due to one of the following reasons:

1) Cannot be used on a given user channel due to interference from currently existing heavy radio traffic; the system is compatible with a voice dispatched systems, however.

2) Technically not feasible. For example, an effective voice privacy system requires a wider channel than is presently allocated by the FCC. Also, portable systems used with vehicular repeaters require more frequencies than mobile-

to-base radio systems.

3) There is an operational incompatibility. For example, a dial interconnect paging system is usually not compatible with conventional dispatcher operation of a mobile system.

In exploring the various bands in the radio spectrum, certain technological limitations become apparent.[1] Power output and coverage tends to decrease in the higher frequency bands. Also foliage effects tend to reduce propagation at higher frequencies.

In conclusion, new technology provides many new and useful functions which will require additional spectrum over that required for present day conventional voice communication.

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[1]Suitability of various frequency bands for land mobile radio use. Report of the Advisory Committee for the Land Mobile Radio Services, Federal Communication Commission. 1967

Exhibit 5

Source Describing Los Angeles Congestion

The Joint Technical Advisory Committee, Spectrum Engineering - the Key to Progress, Supplement 5, "Urban Area Radio Spectrum Usage," March, 1968

EXHIBIT 6

An Analysis of Projected Growth in Metropolitan Chicago In Relation to the 1960 Urbanized Area

Examination of patterns of new housing, new school construction, and new industries reveals where the economic and demographic growth is going to occur in the Chicago Metropolitan area. In fact, there is evidence that this growth has already begun.

1. Housing

Population density is increasing and more land is under development. "Vertical" growth, the population of the City of Chicago, has stabilized; "horizontal growth" outward from Chicago can be identified as the major element of growth.

Table A shows the growth of housing in the Chicago area. Since 1945, the major element of that growth has been outside the City of Chicago.

As densities of population rose in the suburbs immediately adjacent to Chicago, new communities rose from the cornfields. Thus, as early as 1960 the principle growth in the Chicago area was within, but at the outer edge of, the urbanized area defined by the U. S. Population Census of 1960. As densities increased in the peripheral communities, new land has come under development outside the 1960 urbanized area. As an example, from 1964 through 1968, Arlington Heights, Illinois led all areas of Chicago in homebuilding. However, in 1969 leadership in homebuilding will move to newer communities such as Schaumburg, Streamwood and Buffalo Grove which are all outside this 1960 area. Arlington Heights has simply run out of land for development.

2. School Construction

These new communities have become the focal points for natural population growth. This, from 1962-1967 the City of Chicago recorded only 35% of new-born babies while the surrounding areas accounted for the remaining 65%.

Two high school districts serving northwestern Chicago suburbs have tabulated their growth from 1960, and projected this growth forward to 1975. District 211 serves areas largely outside the 1960 urbanized area. District 214 serves townships

TABLE A

PERMITS ISSUED FOR NEW DWELLING UNITS
CHICAGO METROPOLITAN AREA

	Chicago			Suburbs & Unincorporated Areas		
	Homes	Apt. Units	Total	Homes	Apt. Units	Total
1967	1,714	9,966	11,680	20,135	16,359	36,494
1966	2,438	9,083	11,146	16,332	11,076	27,408
1965	2,620	7,071	9,691	18,552	12,334	30,886
1964	2,438	(2)7,588	10,026	16,428	11,032	27,460
1963	2,663	6,308	8,971	17,074	13,469	30,543
1962	3,110	9,394	12,504	18,917	19,885	38,802
1961	3,430	10,829	14,259	20,985	19,680	40,665
1960	4,016	10,344	14,360	22,101	7,416	29,517
1959	5,237	4,616	9,853	30,195	7,561	37,756
1958	4,117	4,675	8,792	27,018	4,777	31,795
1957	4,937	5,632	10,569	(x)25,947	3,062	29,009
1956	6,971	6,654	13,625	32,948	2,059	35,007
1955	9,278	6,797	16,075	35,251	1,544	36,795
1954	8,201	4,819	13,020	33,229	930	34,159
1953	8,682	3,165	11,847	27,804	931	28,735
1952	6,552	4,181	10,733	22,380	934	23,314
1951	6,640	4,698	11,338	20,738	862	21,600
1950	8,498	9,109	17,607	24,158	1,588	25,748
1949	4,944	4,869	9,813	16,588	1,375	17,963
1948	4,425	1,654	6,079	15,504	1,073	16,577
1947	3,986	1,982	5,968	14,445	4,331	18,776
1946	4,283	1,532	5,815	11,785	448	12,233
1945	#3,672	(1)1,687	5,359	5,268	503	5,771
1944	2,610	2,480	5,090	3,377	77	3,554
1943	1,276	*3,158	4,434	3,066	--	3,066
1942	1,870	2,649	4,519	5,940	--	5,940
1941	4,431	514	4,945	11,442	--	11,442
1940	3,123	225	3,378	7,561	--	7,561

(x) Includes 18 Homes of Public Housing
" 500 " " " "
(1) " 672 Units " " "
* " 1,500 " " " "
(2) " 1,764 " " " "

Source: Bill Saving and Load Association
Prepared by: Research and Statictics Division
Chicago Association of Commerce and Industry
January, 1968

which are substantially within the 1960 urbanized area. Table B summarizes the growth in student population and the number school buildings required to support these students.

By 1975, District 214 will have reached it's peak in school enrollment. District 211 will continue to grow as development of the area intensifies.

A study by Arthur D. Little, Inc. of the factors which would affect William Rainey Harper Junior College in northwestern Cook County, Illinois states:

> "The population of the College District quadrupled between 1950 and 1960; growing from 32,000 to 129,000; by 1970, we estimate the population will more than double, growing to about 325,000 and by 1980 will exceed 500,000."

Thus, the report indicates the most dynamic population growth will occur in the areas outside the 1960 urbanized area.

3. Industrial Growth

A recent article[1] identifies three key factors in Chicago's future economic growth. The first is development of a third major airport; second, completion of the expressway system paralleling Route 53 in DuPage County; and third, the selection of Weston as the site of the National Accelerator Laboratory. All of these developments will be outside the Chicago urbanized area as defined in the 1960 U. S. Population Census. An observation, applying most particularly to the Weston nuclear facility, is that these develpments constitute an unparalled opportunity to forge a link between the known economy of today with the still to be defined economy of the future.

Industrial development shows a similar pattern. Table C shows the industrial acreage available in metropolitan Chicago. This data indicates that most industrial growth will occur outside the City of Chicago, and for the most part beyond the 1960 urbanized area. Expressways, interstate highways and the Illinois Toll Road system encourage decentralization of industry.

Table D shows the growth of industrial development in new construction and expansion projects. As the construction of O'Hare International Airport brought a proliferation of industry to the northern end of Cook County, the projected new major airport in southern Cook County or Will County will encourage similar industrial development.

1 The Development of Industrial Parks in Metropolitan Chicago; Edwin H. Draine, Commerce Magazine, July 1968.

TABLE B

EDUCATIONAL GROWTH - (1960 - 1975)
- HIGH SCHOOLS -

YEAR	# STUDENTS		# SCHOOLS	
	District 211	District 214	211	214
1960	1,592	4,416	1	2
1961	1,978	5,369	1	2
1962	2,368	6,323	2	3
1963	2,846	7,353	2	3
1964	3,218	8,276	3	4
1965	3,631	9,383	3	4
1966	4,193	10,784	3	5
1967	4,832	12,007	3	5
1968	5,508	13,520	3	6
1969*	6,348	14,560	3	6
1970*	7,060	15,779	4*	6
1971*	8,178	17,125	4*	7*
1972*	8,965	18,336	5*	7*
1973*	9,777	19,516	5*	7*
1974*	10,491	20,442	5*	7*
1975*	10,999	20,984	6*	7*

*PROJECTION

Source: District 211 Headquarters Report dated 9/26/68. (Palatine/Schaumburg Township)
District 214 Headquarters: Office of Mr. Jack Martin. (Wheeling/Elk Grove Township)

TABLE C

INDUSTRIAL DISTRICT SURVEY - 1967-68

	Number of Industrial Districts		Total # of Acres of Land in Districts		# of Acres Sold & Leased		Number of Acres Available for Industry	
	1968	1967	1968	1967	1968	1967	1968	1967
City of Chicago	29	25	3,211	2,742	2,299	1,889	912	853
Suburban Cook County, Ill.	119	108	13,536	12,612	5,837	4,847	7,699	7,765
North Cook	66	59	7,387	6,697	3,492	2,718	3,895	3,979
West Cook	25	23	1,511	1,502	1,287	1,118	224	384
South Cook	28	26	4,638	4,413	1,058	1,011	3,580	3,402
DuPage County, Ill.	26	25	6,588	7,419	1,497	1,856	5,091	5,563
Kane County, Ill.	25	21	3,143	3,616	932	710	2,211	2,906
Lake County, Ill.	23	15	2,647	2,104	605	312	2,042	1,792
McHenry County, Ill.	1	1	325	300	0	0	325	300
Will County, Ill.	10	11	3,466	4,062	534	560	2,932	3,502
Lake County, Ind.	12	10	1,194	1,077	222	201	972	876
Porter County, Ind.	2	0	630	0	25	0	605	0
Chicago Metropolitan Area	247	216	34,740	33,932	11,951	10,375	22,789	23,557

TABLE D

INDUSTRIAL DEVELOPMENT - BY GEOGRAPHICAL AREA

New Construction and Expansion Projects Only
($000)

	1967	1966	1965	1964	1963	1962	1961	1960	1959	1953
CHICAGO:										
Total	$103,130	$73,587	$79,643	$43,024	$61,988	$50,986	$55,769	$65,082	$36,597	$48,336
Central	4,155	3,637	5,059	10,036	6,279	3,004	3,731	3,040	3,120	3,941
North	6,327	8,882	3,900	2,860	3,416	8,369	7,580	2,559	5,405	4,215
West	5,895	3,852	12,760	6,400	2,527	8,227	4,840	6,843	2,680	4,415
South	86,753	57,216	57,924	23,728	49,766	31,386	39,618	52,640	25,392	36,265
COOK:										
Total	200,766	202,192	221,998	141,713	127,642	119,531	108,827	147,594	108,217	98,965
Total-Excl. Chicago	97,636	128,605	142,355	98,689	65,654	-	-	-	-	-
North	51,426	70,328	53,248	50,425	42,365	36,155	30,553	29,901	25,282	22,400
West	14,610	35,424	46,498	25,665	15,704	14,134	20,025	30,581	26,088	14,339
South	31,600	22,853	42,609	22,599	7,585	18,256	2,480	22,030	20,250	13,890
DuPage	19,628	30,418	38,838	24,338	4,597	4,694	6,995	11,811	3,170	12,225
KANE	8,603	40,035	10,988	8,072	4,826	6,720	8,295	3,521	6,625	2,980
LAKE, ILL.	5,513	11,956	32,879	36,767	3,862	12,965	9,068	9,860	3,175	3,305
MCHENRY	2,638	4,609	3,469	1,335	4,385	1,361	2,225	3,825	2,950	-
WILL	163,280	15,190	20,548	5,513	5,250	7,960	10,360	1,195	7,450	10,640
LAKE, IND.	338,658	105,294	297,665	342,393	232,058	231,769	52,077	36,365	81,020	54,514
PORTER	-	127,020	77,620	75,810	275,120	144	640	63	100,075	-
Total Consolidated Area:	$739,086	$536,714	$704,005	$635,941	$657,740	$385,114	$198,517	$214,244	$312,682	$182,539

Source: Monthly Reports on Industrial Developments in Metropolitan Chicago
Research and Statistics Division, Industrial Development Division
Chicago Association of Commerce and Industry

For example, the Weston neuclear laboratory is expected to spawn a whole new generation of supporting industries and services, westward to the Fox River Valley and throughout DuPage County.

Conclusions

The evidence indicates that metropolitan Chicago is rapidly expanding with principle thrust northwest and west of the 1960 urbanized area. New factors will influence growth to the south and southwest.

Beyond 1975, the projection is for continued outward development, with the balance of population majority shifting from the City of Chicago to the suburban areas.

These indicators demonstrate the need for more flexibility in meeting the socio-economic needs of Chicagoland, than is expressed by the 1960 urbanized area definition.

Similar analyses for other metropolitan areas would give like evidence. The needs of 1968 are not those of 1960. The needs of the 1980s will be dramatically changed from those of 1968.

EXHIBIT 7

Analysis of the Findings of FCC Land Mobile Frequency Relief Committee, Working Group 2

In 1949, in the Third Report and Order, the maximum proposed power permitted a UHF station was 200 kw (23 dbK). The antenna height considered with this power was 500 feet above average terrain. The grade B service signal strength was determined as 64 dbu for UHF, presumably from receiver sensitivity. Using these factors, and allowing a 28 db desired-to-undesired ratio at the 64 dbu grade B contour, the TV station spacings were determined. A summary of the numbers is this:

Range (F50,50) to 64 dbu contour (23 dbK, 500 ft.)	Tolerable interfering signal = 64 dbu - 28 db =	Distance from interfering 23 dbK, 500 ft. station to produce 36 dbu F(50,10) signal
36 mi.	36 dbu	129 mi.

Total separation between stations resulting is 36 + 129 or 165 mi.

This technical basis was then altered by the Commission in the Sixth Report and Order in order to offer more television service to the country. The spacing on UHF was reduced to 155 miles in Zone 1. The justification given was that due to the concentration of cities, residents of the area would not be deprived of service, since there would be an overlapping of service contours on different channels located in the interference areas. The Commission also stated that the 155 mile spacing corresponded with the minimum facilities spacing (50 kw and 500 feet antenna height). It perhaps felt at the time that the maximum facility stations would be few in number.

Power and antenna height increases were permitted over the original figures. The power limit on UHF was raised to 1 megawatt in the Sixth Report and Order in an attempt to equalize UHF and VHF coverage. If all stations increase to the same maximum, no change in interference contours results, since both desired and undesired signals increase by the same amount. The location where the desired and undesired are 28 db apart then remains in the same place. The case where stations are running unequal powers or antenna heights, is dismissed with the comment that the coverage area gained by the higher-powered station is greater than that lost by the lower-powered station. It seems that the Commission's objective here was to provide TV service for everyone, from one station or another.

The exceptions should be pointed out. The Commission reduced the original calculated 165 miles UHF station spacing in Zone 1 to 155 miles, since it was assumed that many stations would be present, and few would be deprived of service due to interference. However, the Commission went the other way in Zones 2 and 3. Reasoning that Zone 2 would be mostly rural, the permissible station spacing was increased to 175 miles. It was stated that persons in the interference areas between closely spaced co-channel stations would not have a choice of other channels to provide them service in such a sparsely populated area. So the spacing was increased with the result that coverage is limited by noise, rather than interference between stations. The same reasoning applied to Zone 3, the Gulf Coast states. Here, exceptional propagation known to exist dictated a further increase in station spacing to 205 miles.

It appears that the station spacings that were determined in the Sixth Report and Order were predicated more on policy than on adherence to strict technical standards. This conclusion is based upon close analysis of the Sixth Report and Order in which the present TV standards were set, but the technical rationale validating them was absent.

It is against this background that we shall examine the three plans proposed by Working Group 2 of the FCC Frequency Relief Committee. It should be noted that each plan established minimum separation distances between land mobile stations and co-channel or adjacent channel television stations.

In the working group calculations, the land mobile signal is not permitted to be less than 50 db below the desired TV signal. As a matter of practice, measurements have been made on VHF TV sets, and the 50 db figure appears to be realistic. A lower figure may result in noticeable interference, and consequently the Section considers 50 db the necessary level of protection to television facilities.

Plan 1

Plan 1 is described as giving equivalent interference protection to TV reception as now exists between TV stations. In essence, it appears to apply the standards of the Sixth Report and Order by allowing land mobile stations to create the same amount of interference as now results between TV stations. An interfering UHF TV signal must be a minimum of 28 db below the desired TV signal to provide a satisfactory level of service, according to the Sixth Report and Order.

Plan 1 utilizes the propagation information that is presently in the Rules and Regulations governing the broadcast service (Part 73). These curves were derived from lower VHF signal strength data, not UHF as is considered here.

The distances calculated for this plan seem to have been determined in the following manner:

1. The minimum spacing between TV stations is taken from the current rules and regulations.

2. 28 db is taken as the desired-to-undesired (D/UD) ratio. (TV)
3. Using the existing F.C.C. VHF propagation curves the F(50,50) curves for desired and F(50,10) curves for the undesired signals are applied to establish the point at which the 28 db ratio occurs. (40 miles from the desired station for co-channel zone 1).
4. The desired F(50,50) signal is known at this point and the 50 db land mobile to TV ratio is subtracted to determine the allowable land mobile signal level.
5. The F (50,10) curve is now used to determine the minimum distance the land mobile station must be spaced away from the 28 db ratio point.
6. The sum of the land mobile distance to the ratio point and the TV distance to the ratio point give the total TV to land mobile minimum separation distance.

The minimum separation found by this method assumes that the 28 db D/UD ratio point is at various distances within the desired TV field and depends upon the TV station spacing. The ratio, however, is defined in the Sixth Report and Order, only at the UHF service grade contours. It is 28 db at Grade B (64 dbu) and 36 db at Grade A (74 dbu) for offset TV stations. (higher for non-offset).

Since the (zone 1) 28 db ratio point desired signal level is 76 dbu it is within the Grade A contour where a 36 db ratio would appear to be required, a probability of interference would seem likely. Hence, we would conclude that Plan 1 is not a feasible approach.

In summary, Plan 1 consists of:

a. Allowing land mobile signals to be no less than 50 db below the 76 dbu signal near the Grade A contour of a TV station when sharing the same channel.

b. Allowing the land mobile signal to be equal to the 76 dbu TV signal strength near the Grade A contour of a TV station where adjacent channels are used.

c. Use of the VHF prediction information published in the present Part 73 rules and regulations.

Plan 2

Since many TV viewers located at the Grade B service limit of a TV station use directional antennas to obtain a better picture, this fact was utilized to obtain additional protection from interference in any channel sharing scheme. A directional TV antenna is estimated to provide 15 db of protection against a co-channel land mobile signal. It is still desired to have a ratio of 50 db between the desired TV, and the undesired land mobile signal at the terminals of the TV receiver, but the antenna with its 15 db of rejection of the land mobile signal would now allow a higher undesired signal strength at the Grade B limit of the TV station: only 35 db below the desired TV signal in this plan.

A similar plan is used for the adjacent channel case. In Plan 1, the land mobile signal could be equal to the desired TV signal if it was in the adjacent TV channel. Here, however, if the factor of antenna rejection is considered, the land mobile signal can now be 15 db above the TV signal at the Grade B contour.

With the higher land mobile signals permitted at the TV station Grade B contour, the land mobile stations may be located closer to the TV station under this plan. However, the assumption of virtually total antenna directivity does not necessarily coincide with actual conditions, and hence does not appear to establish a sound basis for sharing. On the plus side, this plan uses the more recent propagation prediction information published in Report R-6602.

In summary, Plan 2 consists of:

a. Allowing land mobile signals to be no less than 35 db below the 64 dbu signal at the Grade B contour of a TV station when sharing the same channel.

b. Allowing the land mobile signal to be 15 db greater than the 64 dbu TV signal at the Grade B contour of a TV station where adjacent channels are used.

c. Use of UHF propagation prediction information published in F.C.C. Report 6602.

Plan 3

This plan is similar to Plan 2, except that no antenna rejection of the land mobile signals is assumed. The permissible co-channel and adjacent channel ratios are the same as in Plan 1 and 2.

In summary, Plan 3 consists of:

a. Allowing land mobile signals to be no less than 50 db below the 64 dbu signal at the Grade B contour of a TV station when sharing the same channel.

b. Allowing the land mobile signal to be equal to the 64 dbu signal at the Grade B contour of a TV station where adjacent channels are used.

c. Use of UHF propagation prediction information published in F.C.C. Report 6602.

SUMMARY COMPARISON OF THE PLANS

Plan 2 and Plan 3 are based on determining the ratio of desired TV Grade B service level to the land mobile F (50,10) service level. In all three plans 50 db is assumed to be the desired ratio for co-channel TV and land mobile channels and 0 db is assumed to be the desired ratio for adjacent channel TV and land mobile channels.

Plan 1 has a lesser separation requirement than Plan 3. It is based on less accurate propagation curves and no assumed TV receiver antenna directivity. The method of selecting the signal reference point is not well-defined or technically supported.

Plan 2 has the least separation requirements since it is based in the latest propagation curves, but arbitrarily assumes TV receiver antenna directivity. The signal reference level is determined at the TV Grade B contour.

Plan 3, the selected plan, is essentially the same as Plan 2, and since antenna directivity is not assumed, the separation is greater. Current, more accurate propagation curves are used. The signal reference level is determined at the TV Grade B contour.

Plan 3 is consistent with the Federal Communication Commission's previous decision. It provides the the maximum separation range (mutual interference protection) and does not use directional antennas to reduce the minimum mileage separation requirements. These criteria make Plan 3 a reasonable choice.

CONCLUSIONS OF THE SECTION

The complex issue of spectrum sharing between Land Mobile and Broadcast Services must include consideration of mutual interference, administration and spectrum utility.

Our findings regarding Plan 3 should not be construed as an endorsement of this as a solution; rather it recognizes that adequate, or even more than adequate, protection to TV is mandatory. Instances in which interference has been an issue between television and land mobile have been resolved at the expense of the latter. Therefore, prudence distates that the technical criteria for sharing must be, if anything, over-protective. While Plan 3 meets this test, it does not provide for any meaningful spectrum utility for the Land Mobile Radio Services.

Assuming arguendo that sharing under Plan 3 did satisfy land mobile needs, there is no guarantee that there would be unanimity on the question of whether the protection to television is sufficient. As a practical matter, mutually acceptable criteria would have to be developed. The experience which the FCC, land mobile, and broadcast has undergone during the pendency of the Notice of Inquiry in Docket No. 15398, adopted March 23, 1964, in seeking agreed technical criteria for sharing VHF channels does not present a sanguine prospect. No solution is in sight for the VHF environment after almost five years. The likelihood of solving the lower UHF sharing problems in any shorter time peroid is certainly not promising. Even if such an agreement were conceived, it would be an awkward arrangement administratively, requiring extensive engineering filings by each potential land mobile user. Each in turn would have to be reviewed and acted upon by the Commission's staff.

The net result, at best, would be costly, minimum relief for a few. Thus, whether Plan 3 does provide reasonable, or adequate, or excessive protection for television becomes a distinction without a difference. If it is inadequate, land mobile would be precluded from operating almost totally; but even if television would be left unsullied, a crucial defect still remains: it does not provide adequate relief for the Land Mobile Services.

EXHIBIT 8

EXAMPLES OF LAND AREA GROWTH PROJECTIONS IN METROPOLITAN AREAS

The attached maps depict the maximum Urbanized Area Boundary limits which are expected to exist in 1980. These limits were determined and drawn from a review of the following sources.

1. The Census Bureau's "check" boundary outlines for the 1970 Urbanized Area Census review contain those areas where a check will be made of the population density; this in turn will be used to determine if the area should be contained within the Urbanized Area Geographical limits. These "check" boundary outlines were used in projecting the direction and amount of land area growth.
2. The book, "Dimensions of Metropolitanism" by Jerome P. Pickard (1967) of the Urban Land Institute contains projections of Urbanized Area population and total land area in square miles out through the year 2000. The projected land area increases for the urbanized areas were compared for the years 1960 and 1980 to obtain a percentage increase in square miles area (See Figure 3).
3. Using the data from 1 & 2 above, maximum Urbanized Area Boundaries were drawn for the year 1980. The term maximum is used because in some cases the boundary line was determined by the nearest legal (county line) or natural (river, lake, etc.) boundary. In such cases, the chosen legal or natural boundary line always included the maximum square mile increase in urbanized area.

EXHIBIT 8 - LOS ANGELES-LONG BEACH URBANIZED AREA

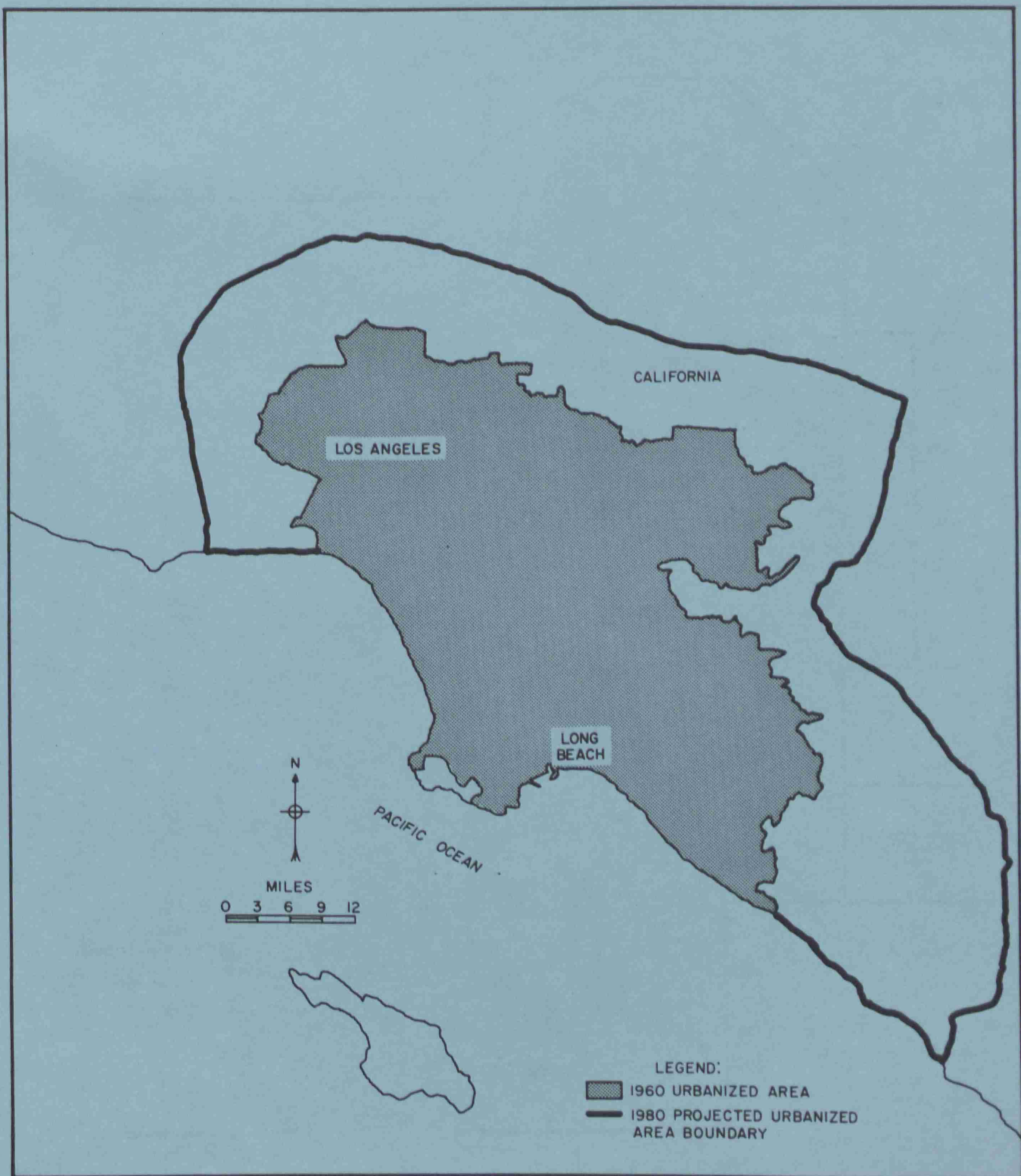

EXHIBIT 8 - DETROIT URBANIZED AREA

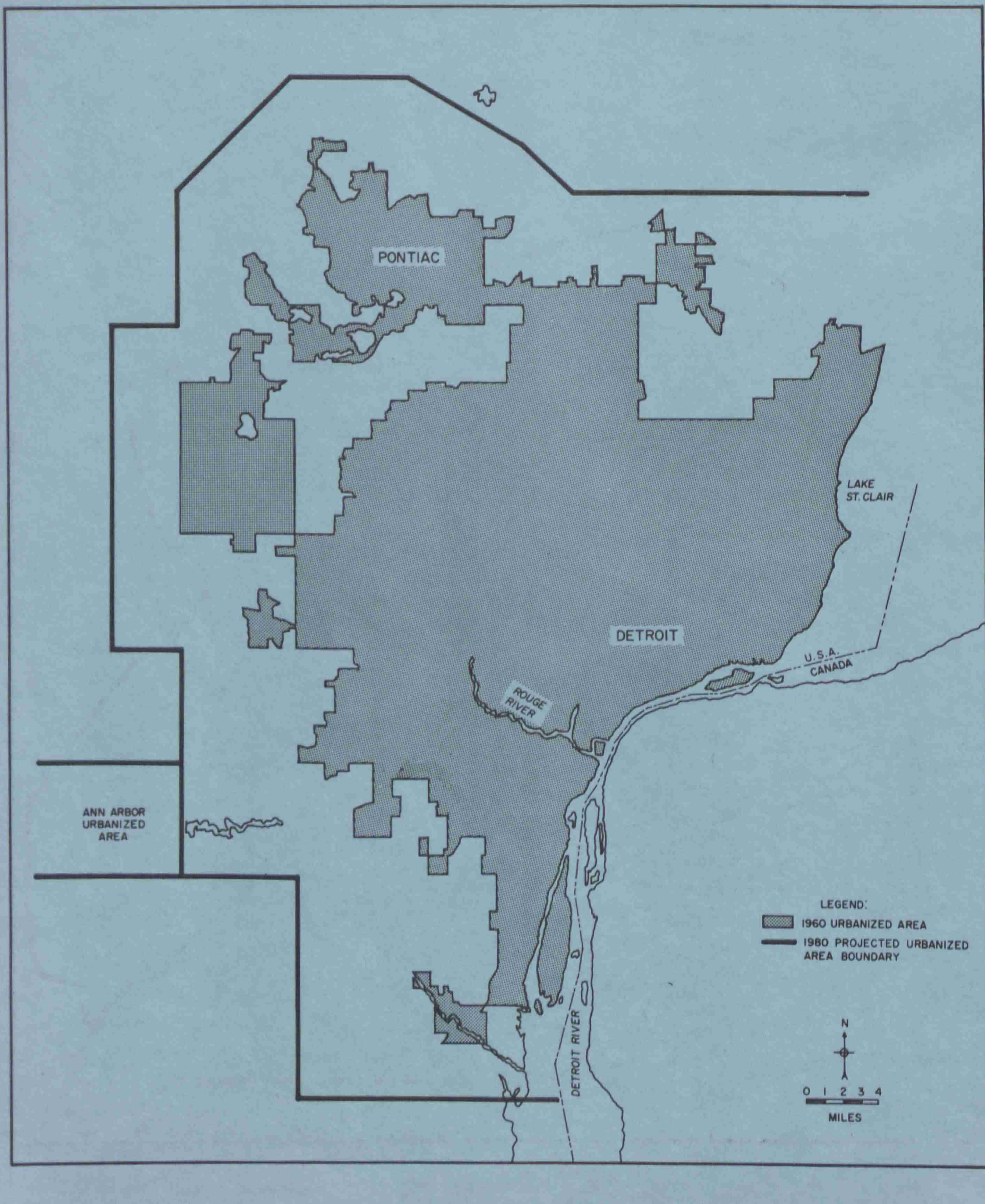

EXHIBIT 8 - CHICAGO-NORTHWESTERN INDIANA URBANIZED AREA

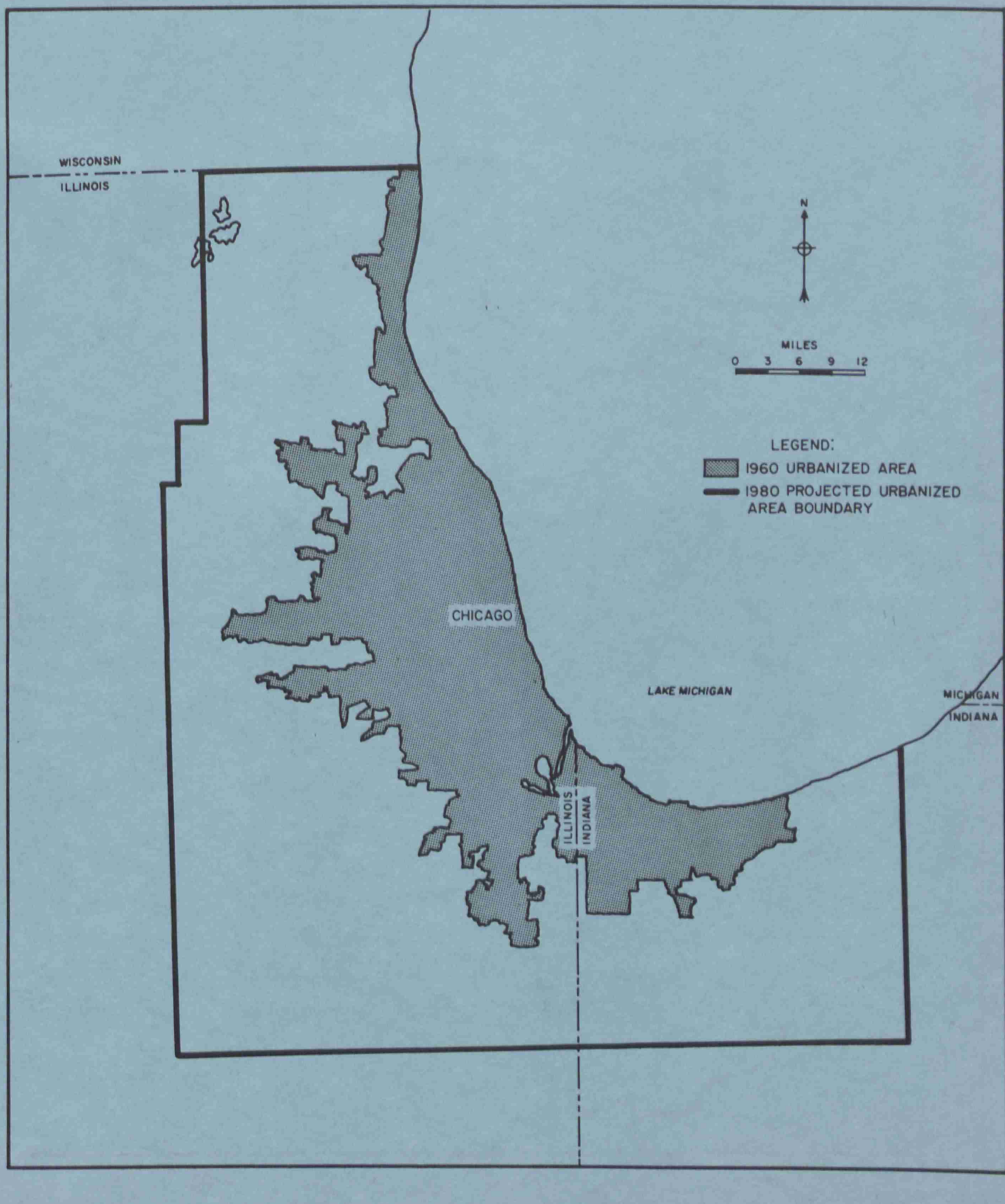

EXHIBIT 8 - NEW YORK-NORTHEASTERN NEW JERSEY URBANIZED AREA

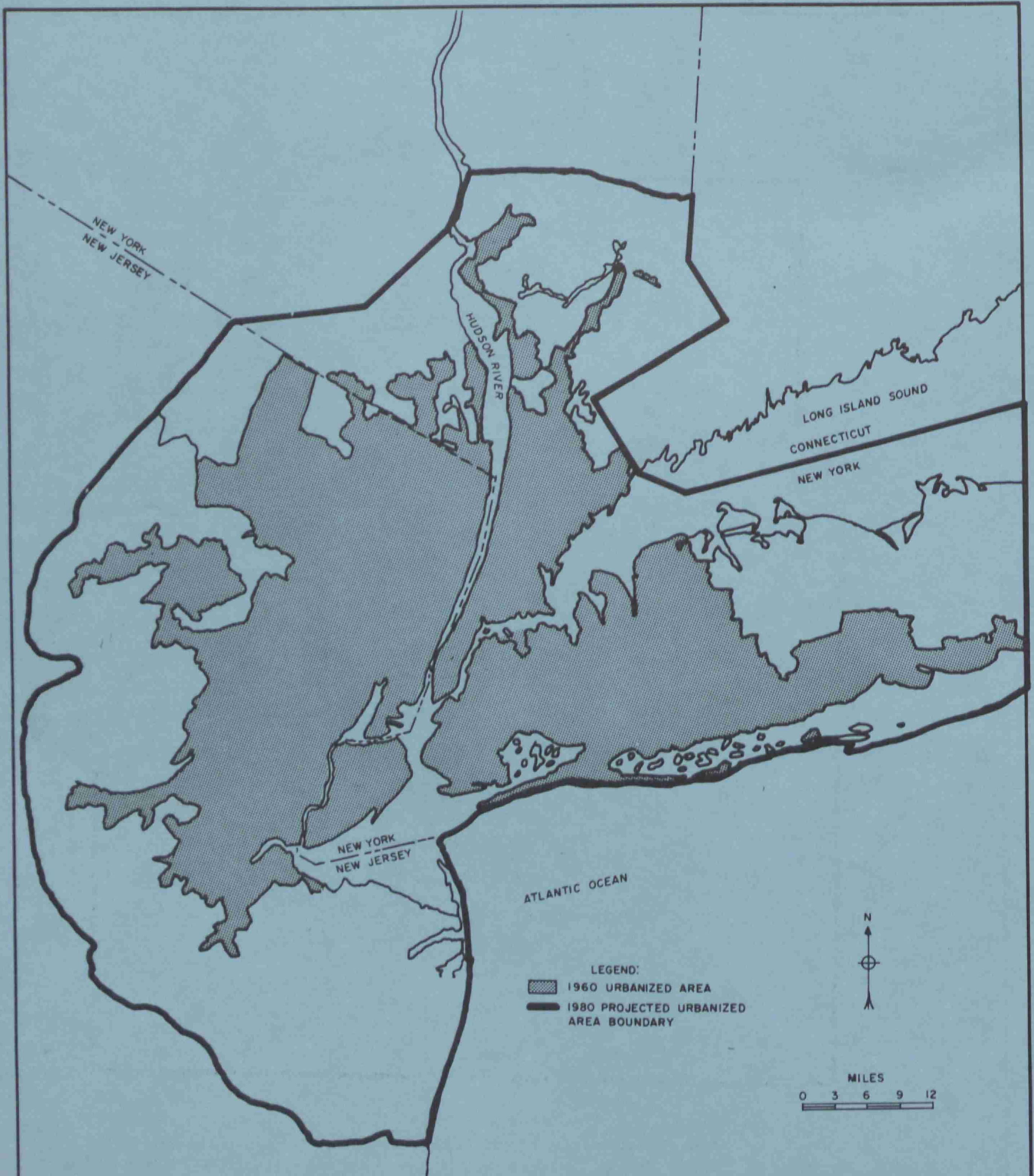

EXHIBIT 8 - SAN FRANCISCO-OAKLAND URBANIZED AREA

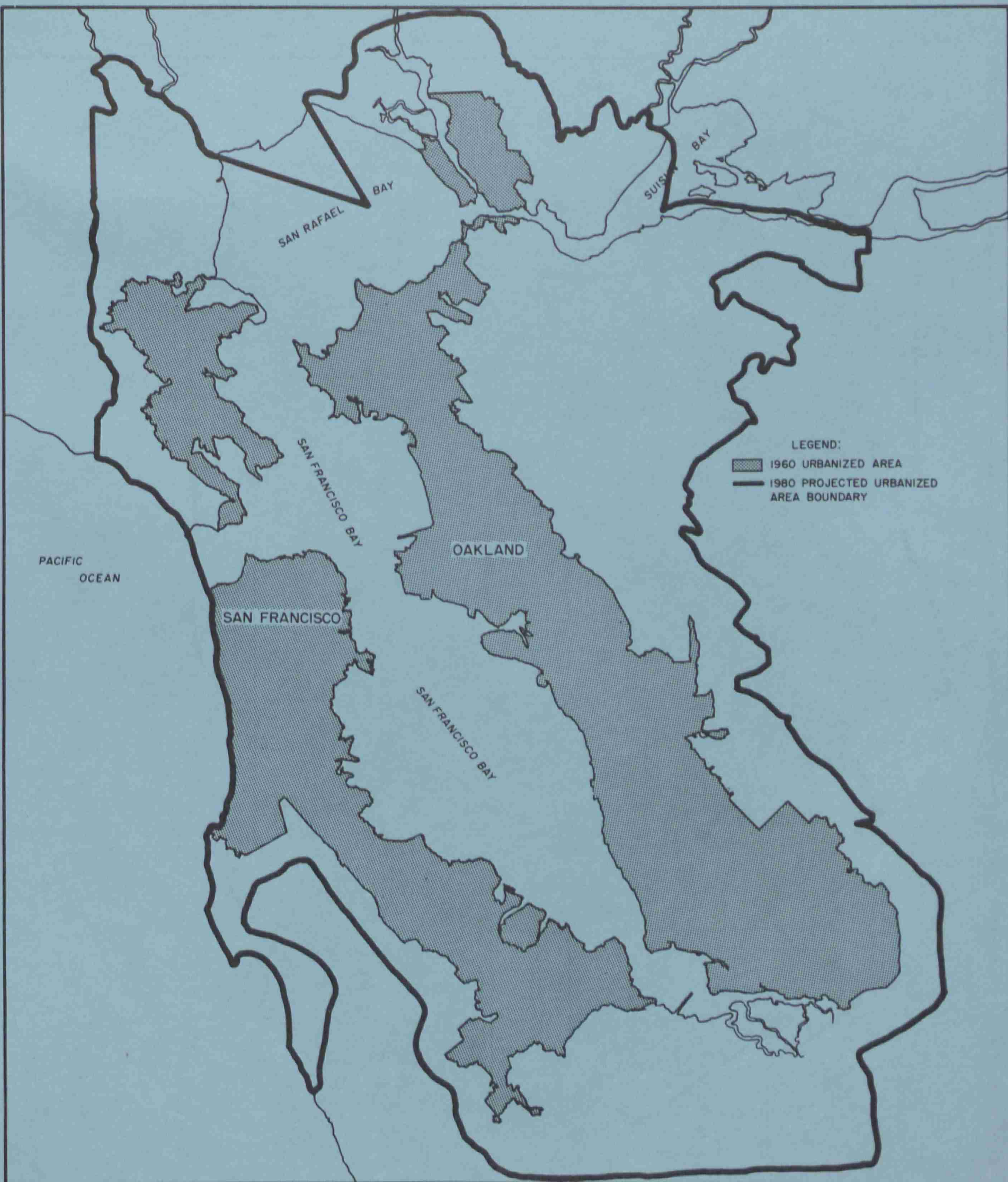

EXHIBIT 8 - PHILADELPHIA URBANIZED AREA

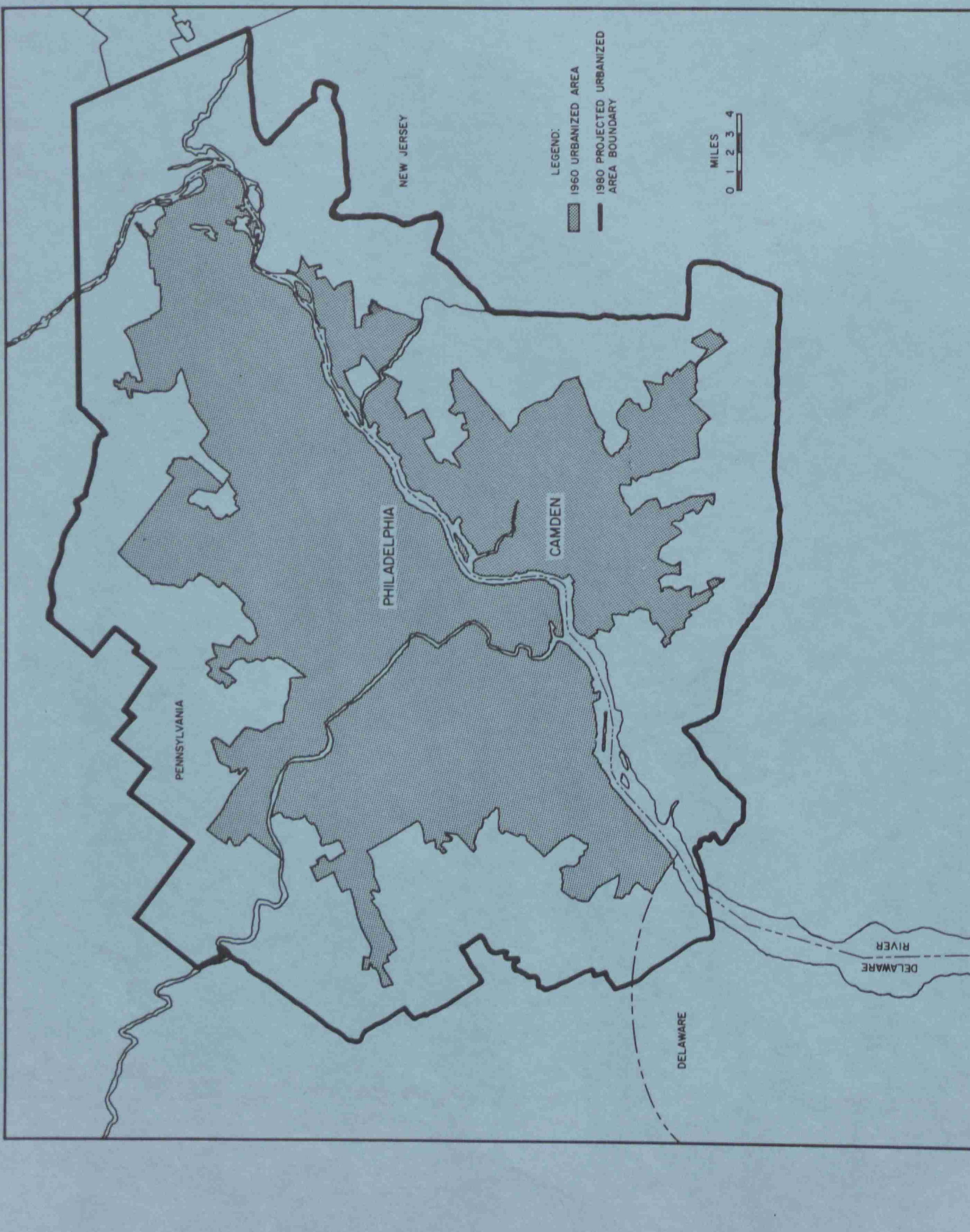

EXHIBIT 9

EFFECTS OF THE POWER AND ANTENNA HEIGHT RESTRICTIONS ON LAND MOBILE RANGE

Information has appeared in several publications on the loss encountered by radio signals in urban areas. Most of the information available relates this loss to theoretical or smooth earth values of signal. The figures given then, are not directly applicable to the published Federal Communications Commission (FCC) information given in reports R6602 or R6406. This is because the F.C.C. information already contains some modification factor of the theoretical values of predicted signal.

Briefly summarizing the various factors:

1. K. Bullington of Bell Telephone Laboratories states that in New York City the median field intensity at street level for random locations is about 25 db below the signal predicted by plane earth calculations. Ninety percent of the locations are less than 35 db below the plane earth field strength. This loss is stated to be essentially independent of the frequency band.
2. W.R. Young, in plotting signals in the New York City area, shows several graphs of signal versus distance. At 450 Mc., the median appears to fall approximately 32 db below the theoretical value of the signal, when distances 5 miles or

less from the base station are considered. At distances greater than this, other effects obscure the results.

3. The Allocations Committee of the Land Mobile Advisory Committee (Working Group 6) found that in the downtown areas of large cities the shadow losses at street level may be in the order of 30 db or more for frequencies in the range of 40 to 150 Mc. It was also stated that the received signal may vary as much as 20 db within a distance of a few feet because of wave interference caused by reception of multiple reflected signals.

4. Since trees lining city streets contribute significantly to radio signal losses in the 450 Mc. region, they must be considered in any realistic prediction of urban radio coverage. A report made by A.D. Ring and Associates for the Land Mobile Advisory Committee states that studies at frequencies near 500 Mc. led to the conclusion that these losses, as referred to smooth earth field, were on the order of 30 P_f decibels, where P_f is the average percentage of tree cover in a given area. It further states that the actual losses at any individual location may depart substantially from the average losses for the area.

There appears to be a spread of values describing the loss that could be encountered in a city. A figure of 30 db has been chosen for calculation purposes, since it is in the center of the spread.

This 30 db value will be added to the theoretical smooth earth calculations to describe the actual field strength available in city streets at 450 Mc.

Figure 1 shows a plot of field strength versus distance calculated from the Bullington plane earth method. The dashed line at the bottom of the plot shows the same Bullington calculation considering the 30 db factor. The predicted information using F.C.C. reports R6602 and R6406 are also plotted for comparison. Distances less than 5 miles were not plotted, since there is wide divergence between methods in this range. A transmitting antenna height of 100 feet and a 6 foot mobile antenna height is assumed. Radiated power of 1 kilowatt e.r.p. is plotted in order to be consistent with the F.C.C. curves. Figure 2 shows the field strength versus distance with a 500 foot antenna height assumed at the base station.

Note that on both Figures 1 and 2, the predicted field strength curve for any distance between 5 or 20 miles is about 16 db below the F.C.C. information contained in report R6602. The corrected value of signal strength in an urban area can thus be obtained from these figures. This information with all correction factors applied is plotted in Figure 3.

To determine useful mobile range, it must first be decided what signal strength constitutes adequate service. F.C.C. report R6406 sets some limits for this in the Domestic Public Land Mobile Service. For the 450 Mc. band, 25 dbu is considered the median signal strength for commercially acceptable service. It is important to note that this is the median. While this grade of service would be acceptable for some industrial radio users, most would need 39 dbu which the referenced report gives as the required signal for 90% reliability. Police, Fire, and other Public Safety users of land mobile systems where safety of life and property are concerned would require nearer to 99% reliability.

The above figures are based on equipment performance of the early 1950's. The F.C.C. report states that the receiver sensitivity assumed was -138 dbW, or about 0.9 microvolt. Since that time, equipment has improved somewhat so that receiver sensitivities are now in the order of -143 dbW, or 0.5 microvolt.

Construction of Figures 1 and 2

From Report R6406 - Technical Factors Affecting the Assignment of Facilities in the Domestic Public Land Mobile Service, by Roger B. Carey.

$$E = \left(\frac{Pr\ f^2}{3.12 \times 10^{-11}}\right)^{\frac{1}{2}}$$

where E = field strength in microvolts per meter

f = frequency in megacycles

Pr = receiver input power - watts

If F is field strength expressed in db above 1 microvolt per meter,

$$F = 20 \log_{10} E = 105 + 10 \log_{10} f$$

For a 1 microvolt signal across 50 ohms impedance:

$$F = 105 + (-137) + 54 \qquad Pr = \frac{e^2}{z} = \frac{(1 \times 10^{-6})}{50}$$

$$F = 22 \text{ dbu} \qquad Pr = 2 \times 10^{-14} \text{ watts}$$

Since 1 microvolt = -137 dbW = +22 dbu,

then -137 - 22 = 22 dbu - 22

or -159 dbW = 0 dbu

To be consistent with F.C.C. information, prediction information will be referenced to 1 kw radiated power (30 dbW).

Path loss necessary to give a 0 dbu or -159 dbW signal, is the difference between 1 kw (30 dbW), and -159 dbW

$$+30 \text{ dbW} - (-159 \text{ dbW}) = 189 \text{ db}$$

If the actual path loss is less than this value, the amount by which it is less is the signal in dbu

$$189 - \text{Path Loss} = \text{Signal (dbu)}$$

The information in Figure 1 was found in the following manner: The Bullington Method of predicting path loss is described in his paper appearing in the October 1947 Proceedings of the I.R.E. entitled "Radio Propagation at Frequencies Above 30 Megacycles".

Distance from Station - Miles	Bullington Plane Earth Loss - 100 ft. to 6 ft. Antenna Hts. Dipole Antennas	Bullington Earths Curvature Diffraction Loss at 500 Mc.	Total Path Loss (Median)	Resulting Signal in dbu with 1 kw xmtr 189-P.L.= dbu
5 mi.	117 db	1 db	118 db	71 dbu
10	128	3	131	58
15	135	6	141	48
20	141	8	149	40
25	144	12	156	33
30	148	15	163	26

The Bullington information on Figure 2 was generated the same way, except the antenna height was 500 feet.

The limiting antenna height specified for this method at 500 Mc. is about 70 feet. However, Bullington states that if either antenna is as much as twice as high as this limiting height, the method indicates a loss that is too great by about 2 db. This small error has been neglected in these calculations. Ground conductivity effects are negligible at these frequencies, and have also been neglected.

It must be emphasized that the preceding calculations are for Domestic Public Radio Service users whose reliability requirements are substantially less than those of Private Land Mobile users.

Bibliography

1. Jasik, Henry, The Antenna Handbook, McGraw Hill, Chapter 33.

2. Young, Jr., W. Rae, Comparison of Mobile Radio Transmission at 150, 450, 900, and 3700 Mc., Bell System Technical Journal, November 1952.

3. AC/LMRS, Final Report Project Coordinating Group 6, Suitability of Various Frequency Bands for Land Mobile Use, E. H. Wilder, Chairman.

4. Head, Howard T., Development of Land Mobile Transmission Loss Curves, A.D. Ring and Assoc., January 11, 1966, for Group B-1 of Land Mobile Advisory Committee (LMAC).

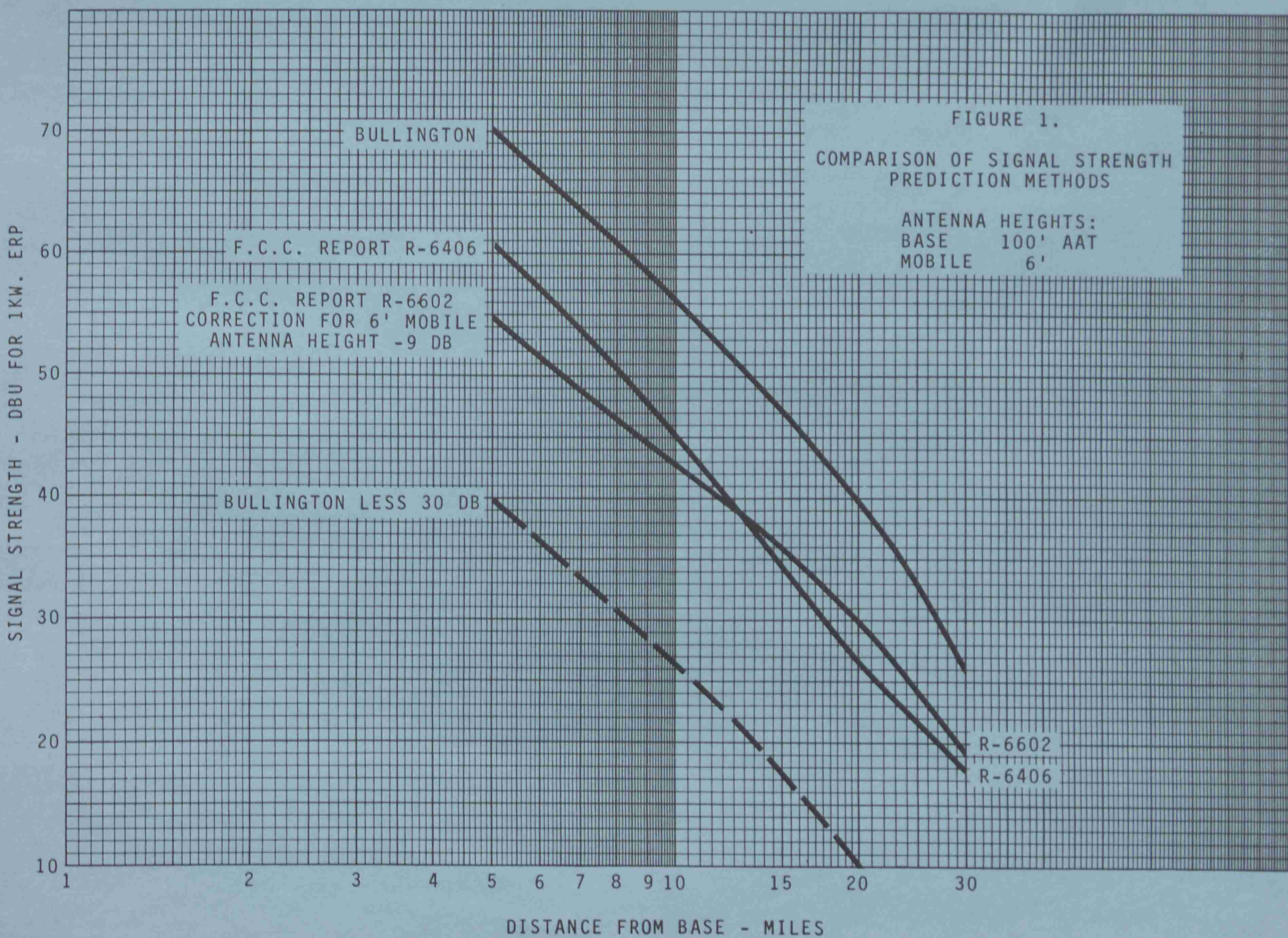

FIGURE 1.

COMPARISON OF SIGNAL STRENGTH
PREDICTION METHODS

ANTENNA HEIGHTS:
BASE 100' AAT
MOBILE 6'

EXHIBIT 9

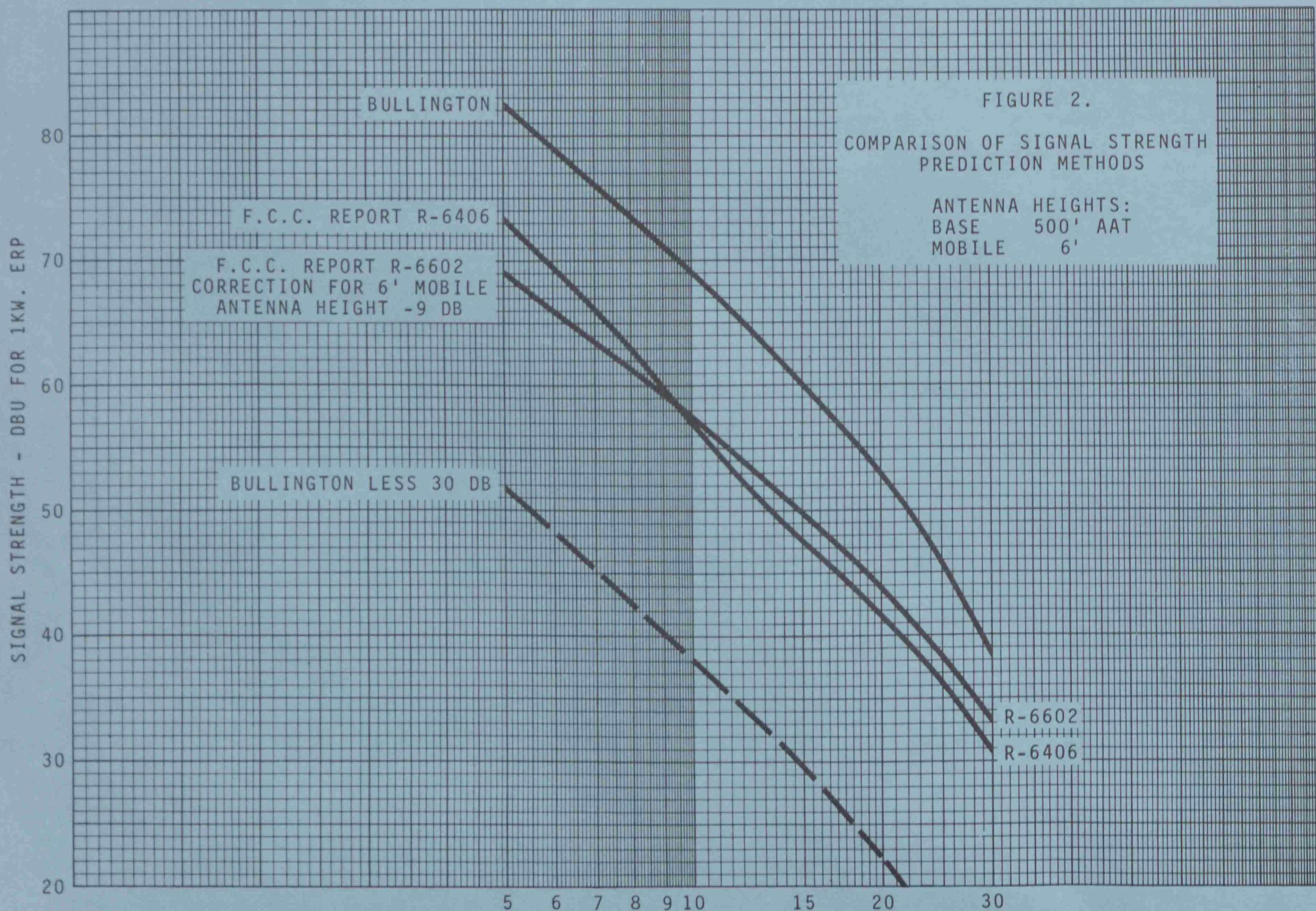
FIGURE 2.
COMPARISON OF SIGNAL STRENGTH PREDICTION METHODS
ANTENNA HEIGHTS:
BASE 500' AAT
MOBILE 6'
BULLINGTON
F.C.C. REPORT R-6406
F.C.C. REPORT R-6602
CORRECTION FOR 6' MOBILE
ANTENNA HEIGHT -9 DB
BULLINGTON LESS 30 DB
R-6602
R-6406
SIGNAL STRENGTH - DBU FOR 1KW. ERP
80
70
60
50
40
30
20
5
6
7
8
9
10
15
20
30

EXHIBIT 9

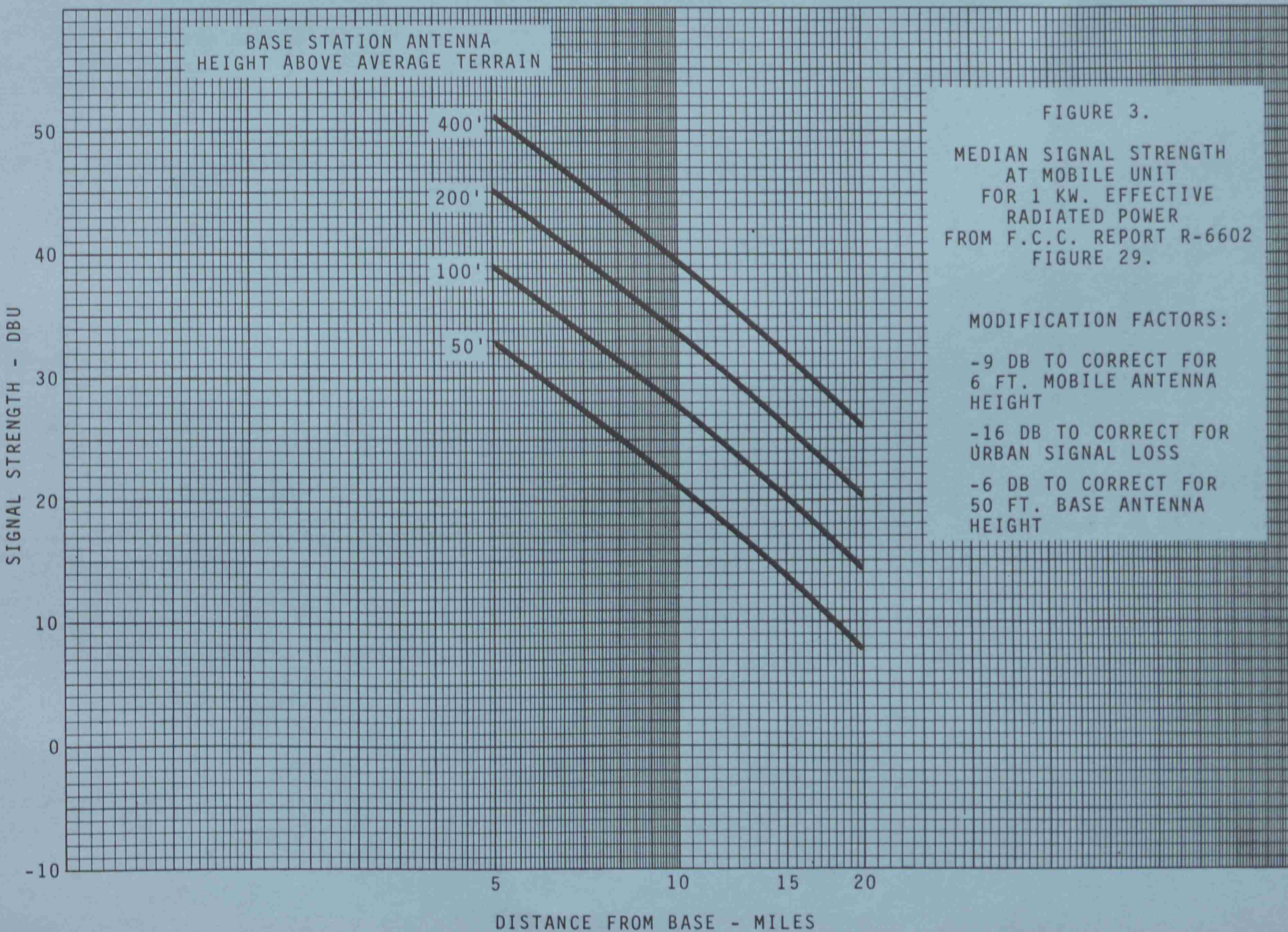
BASE STATION ANTENNA
HEIGHT ABOVE AVERAGE TERRAIN
400'
200'
100'
50'
FIGURE 3.
MEDIAN SIGNAL STRENGTH
AT MOBILE UNIT
FOR 1 KW. EFFECTIVE
RADIATED POWER
FROM F.C.C. REPORT R-6602
FIGURE 29.
MODIFICATION FACTORS:
-9 DB TO CORRECT FOR
6 FT. MOBILE ANTENNA
HEIGHT
-16 DB TO CORRECT FOR
URBAN SIGNAL LOSS
-6 DB TO CORRECT FOR
50 FT. BASE ANTENNA
HEIGHT
SIGNAL STRENGTH - DBU
50
40
30
20
10
0
-10
5
10
15
20
DISTANCE FROM BASE - MILES

EXHIBIT 9

EXHIBIT 10

FACTORS INFLUENCING THE RELIABILITY OF 450 MHz MOBILE COVERAGE IN METROPOLITAN AREAS

There are a number of important practical engineering factors which must be applied to theoretical propagation predictions in order to provide the signal coverage reliability required for land mobile operation in metropolitan areas.

Some of these factors are due to obstructions such as terrain roughness and trees, multipath effects, urban area losses, and building losses.

1. OBSTRUCTIONS

An article by John Egli[1] contains some of the most complete data available comparing the use of various frequencies in irregular terrain. The same data can also be applied to determine the unique losses found in cities. Equation 4 on page 1385 gives the theoretical value of signal modified by empirical results observed in areas of rough terrain. Figure 1 of this article gives a correction factor that must be applied to theoretical propagation predictions when used for areas of rough terrain. Note the increase at the higher frequencies. Egli also indicates another correction factor to apply for

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[1] Egli, John J., Radio Propagation Above 40 MHz Over Irregular Terrain, Proceedings of the I.R.E., October 1957.

more reliable radio coverage, that is to achieve a given signal strength at 90% of the locations rather than at only 50% of the locations. This correction factor is shown in Figure 4 on page 1386, and also increases with frequency. The combined effect of these factors is shown in Figure 6 on the same page.

To observe the effect of these factors on range in a mobile radio system, let us apply the F.C.C. range curves shown in Figures 1 and 3 of Commission Report R6406. On page 3, the Commission states that 25 dbu is the median field strength required for commercially acceptable service in the 450 MHz band. When operating in this band, the range for a 100 ft. antenna height and a 1 kw radiated power is predicted to be 22 miles over smooth earth. A correction factor of 35 db is necessary to achieve coverage in 90% of the locations at 450 MHz; this means that the system must be designed for a field strength of 60 dbu. The predicted distance then is approximately 5 miles.

An additional loss not mentioned in the above referenced article is tree loss. This becomes highly significant at 450 MHz. Examples in Bullington[2] point this out. Also, tests in the UHF television band[3] indicate that tree loss is almost

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[2] Bullington, K., Radio Propagation Fundamentals in The Antenna Handbook, by Jasik, McGraw-Hill, 1956.

[3] Head, H.T., The Influence of Trees on Television Field Strengths at Ultra High Frequencies, Proceedings of the I.R.E., June, 1960, pg. 1020, Fig. 8.

negligible at 40 MHz, but is 20 to 30 db at 470 MHz. These losses can occur even in flat terrain and will drastically cut range in the UHF region. This can easily be seen if they are applied to the prediction curves as in the previous example.

11. MULTIPATH EFFECTS

The factors previously discussed describe the variation in signal loss in an area which may typically be a few hundred feet in diameter. If careful measurements are made, it will be found that the signal strength will vary considerably if the receive antenna is moved only one or two feet. This effect is due to alternate reinforcement and cancellation of multiple signals reflecting from surrounding objects. A discussion can be found in Egli's work under the heading Terrain - Small Sector Field Strength Variation. A graph of distance vs. signal strength is shown in his Figure 10. While the signal dip is sharp, it is quite deep, and can easily cause a signal to be below receiver threshold, if the antenna happens to be in the null. Also, at 450 MHz, there can be a deep null every foot in certain directions of travel.

When a vehicle is in motion, the multipath propagation tends to average out, and it manifests itself as an annoying flutter that reduces voice intelligibility. However, for slowly moving vehicles or portable unit communication, moving through the signal dip may take appreciable time, and part of the message can be lost if the antenna is in the signal dip or null. The radio system designer must design for higher signal strengths to reduce this possibility when stationary vehicle margins must be applied.

Egli's Figure 8 shows the statistical distribution of the multipath signal variation. For 99% of the locations within a small area, a maximum dip of 18 db in signal strength would be expected. In 1% of the locations, a dip greater than 18 db would occur.

This multipath margin must be considered <u>in addition</u> to the margins for terrain or building variations when still vehicle conditions must be accommodated.

III. URBAN AREA SIGNAL LOSSES

Experience has shown that in large cities, buildings and trees cause significant degradation to radio signals, particularly in the UHF region. Bullington reports that the median field intensity at street level for random locations in Manhattan (New York City) is about 25 db below the theoretical plane earth value. Ten percent of these locations may have a loss in excess of 35 db. This data is for frequencies between 40 and 450 MHz. Losses as high as these will reduce the dependable range of a Land Mobile radio system to far less than the theoretical values.

IV. SIGNAL LOSSES IN BUILDING INTERIORS

With the increasing use of portable radio equipment more Land Mobile radio users are requiring coverage inside of buildings. Bell Laboratories has made measurements of the signal losses in skyscraper type buildings.[4] Median building loss (which was measured relative to the street immediately outside the building) was found to be 24 db at 35 MHz, and 22 db at 150 MHz. A radio system designer would not use these median values, since the system reliability would be only about 50%. Range calculations would more likely be made using the values exceeded only 10% of the time. These were measured to be 43 db at 35 MHz, and 38 db at 150 MHz. Little information exists on building losses at 450 MHz, since portable equipment in this range has not been available for a very long period. Preliminary work indicates that losses in this band will be a few db less than those for 150 MHz.

The building loss must be added to the urban area loss mentioned previously. The radio signal initially encounters a high loss (the urban loss) as it propagates from the transmitting antenna to the streets in the vicinity of the building to be covered; then a further loss (the building loss) is encountered as the signal penetrates into the building walls.

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[4] Rice, L.P., Radio Transmission Into Buildings at 35 and 150 Mc., Bell System Technical Journal - 1959.

These two losses combine to restrict dependable radio coverage inside buildings to only a few miles from the transmitter, even with the use of high power and high antenna sites.

V. SUMMARY

In summary, there are several factors which must be considered when a realistic calculation of signal strength or coverage range is to be made in urban areas. Classical radio propagation theory, if used alone, will give highly misleading results since it assumes idealized conditions. Empirical factors must be added to the theory to account for the actual environment in which the radio system is to operate. These factors include terrain corrections, tree loss correction, multipath losses, urban area losses, and where applicable, building losses. All of these factors must be accounted for in either higher land mobile transmitter power or greater antenna height above average terrain.

EXHIBIT 10

Radio Propagation Above 40 MC Over Irregular Terrain*

JOHN J. EGLI†

Summary—**Radio transmissions in the vhf and uhf frequency region over land areas always contend with the irregularities of the terrain and the presence thereon of dispersed quantities of trees, buildings, and other man-made structures, or wave propagation incumbrances. The determination of path attenuation is not easily satisfied by simple, curved, or plane earth calculations. However, quantitative wave propagation data are available in varying degrees which take into account conditions experienced by fixed-to-fixed and fixed-to-moving transmissions over irregular terrain. This available statistical wave propagation information on terrain effects vs frequency, antenna height, polarization, and distance is analyzed, expressed by empirical formulas, and presented in the form of nomographs and correction curves amenable for use by the systems engineer.**

Introduction

RADIO transmissions above 40 mc more often than not take place over irregular terrain so that the ordinary method of calculating propagation attenuation over plane earth, curved earth, and simple diffraction edges becomes unsatisfactory. As one moves about in irregular terrain in a vehicle, the received signal is characterized by a slow variation dependent on the major features of the terrain and on distance, and by a fast variation about the median in a small sector which is independent of the transmission distance but is dependent on the speed of the vehicle and on the frequency of the transmission.

In the practical sense, the systems engineer is interested in knowing how well his equipment will be able to service an area, or how well his equipment will cover many areas in a very large area. Some of these areas may typify curved earth while other areas may be highly mountainous; all others will be in between these areas in terms of surface irregularity.

This irregular terrain has dotted on it, trees, buildings, and other man-made wave propagation encumbrances. If one could run the entire gamut of terrain conditions in a statistical manner and arrive at the transmission loss which would have to be designed into a system at a given frequency to provide the desired coverage, it would appear that such information would be invaluable to the systems engineer.

Fortunately, such data have been collected and studied by the Federal Communications Commission for use in connection with their studies of the vhf and uhf television allocation problems, and by others in connection with mobile service.

* Original manuscript received by the IRE, February 5, 1957; revised manuscript received, June 7, 1957.
† U.S. Army Signal Eng. Labs., Fort Monmouth, N. J.

The majority of the terrain data,[1] on which the following material will be derived, are based on survey data taken by commercial organizations in various parts of the country including New York, N. Y.; Washington, D. C.; Cleveland, and Toledo, Ohio; Harrisburg, Easton, Reading, Pittsburgh, and Scranton, Pa.; Kansas City, Mo.; Cedar Rapids, Iowa; San Francisco, Calif.; Bridgeport, Conn.; Nashville, Tenn.; Fort Wayne, Ind.; Richmond and Norfolk, Va.; and Newark, N. J. In each of these locations, a number of radials were investigated. In all, over the uhf range, 288 to 910 mc, 804 miles on 63 radials are represented in the data. The method of measurement, while not the same at all locations, falls into three categories: continuous mobile recording sampling every 0.2 mile, spot measurements properly weighted so as to be considered unbiased, and clusters of measurements. In the vhf region, 50 to 250 mc, approximately 1400 measurements, consisting of continuous data analyzed over 1-mile and 2-mile sectors, are included in the data.

In discussing service area, we will be concerned with expressing the percentage of locations one could expect to cover statistically at a predescribed distance. Thus, if one arbitrarily divides a 10-mile circle into 100 equal parts with each division represented by a point (location) and superimposes this configuration on the statistically derived landscape represented by the data, then 10 per cent coverage would mean that 10 of the points (locations) would receive satisfactory or better transmissions, while at the balance of the points reception would not be possible. Likewise, when considering 90 per cent coverage, 90 of the 100 points would receive transmissions while the balance would have no reception.

Actually, in dividing the circle into 100 locations, it was assumed that these locations represented the median value of signals in the immediate vicinity of the location, since one finds that in the ımmediate vicinity of a given location, say a few hundred feet, there will be fine variations in received field strength.

TERRAIN-FREQUENCY, DISTANCE DEPENDENCE

The theoretical plane earth field strength expression is given by

$$E = \frac{h_t h_r f}{95 d^2} \sqrt{P_t}$$

where

E = field intensity in microvolts per meter
h_t = transmitting antenna height in feet
h_r = receiving antenna height in feet
f = transmission frequency in megacycles
d = distance from transmitter in miles
P_t = effective radiated power in watts.

Eq. (1) is limited to those geographical areas which are similar to plane earth, such as relatively short overwater and very flat barren land paths. Even in these areas man has erected bridges, Texas towers, billboards, and so forth, which alter considerably the propagation characteristics as expressed by the theoretical plane earth formula.

While the theoretical received field strength increases with frequency, all other constraints being the same, it is important to note that the voltage across the input to a receiver will be the same at all frequencies when the receiving antenna is a half-wave dipole. However, if the antenna at the higher frequency is constructed so that it presents an effective area equal to that of the half-wave dipole at the lower frequency, then this increased field strength at the higher frequency will be realized as increased voltage at the input to the receiver.

The measured field strength data[1] over irregular terrain were compared with what one could expect over plane earth rather than curved earth, since the best median field strength data fit for distances up to 30 to 40 miles shows that the inverse distance squared trend for plane earth is better than the curved earth field, at least for low antenna heights. Beyond 30 miles to 40 miles the data are sufficiently meager as to be unworthy of analysis as a representive quantity of data. Therefore, the median field at a given frequency can be described by the theoretical plane earth field intensity, less the median deviation therefrom. This median deviation data from the theoretical plane earth field, called terrain factor, is shown in Fig. 1. The straight line on this figure very nearly passes through all the FCC data, and it will be noted that the deviation from the plane earth field strength varies inversely with the frequency and is independent of distance. The intersection of this line with the theoretical plane earth field strength is at 40 mc, so that the variation with frequency is with respect to this frequency.

With this statistical information, (1) becomes empirically for the median field at the 50 percentile locations, E_{50}, independent of frequency

$$E_{50} = \frac{40 h_t h_r}{95 d^2} \sqrt{P_t}. \tag{2}$$

This E_{50} field strength may be obtained quickly from the nomograph, Fig. 2.

The theoretical plane earth received power between half-wave dipoles (3) is independent of frequency.

$$P_r = 0.345 \left(\frac{h_t h_r}{d^2}\right)^2 P_t \times 10^{-14}. \tag{3}$$

Making use of the power law variation with frequency for the median deviation from the theoretical plane

[1] H. Fine, "UHF Propagation Within Line of Sight," FCC, TRR Rep. No. 2.4.12; June 1, 1951. Contains material taken from K. A. Norton, M. Schulkin, and R. S. Kirby, "Ground Wave Propagation Over Irregular Terrain at Frequencies Above 50 MC," Ref. C, Rep. of the Ad Hoc Committee of the FCC for the Evaluation of the Radio Propagation Factors Concerning the Television and Frequency Modulation Broadcasting Services in the Frequency Range Between 50 and 250 MC; June 6, 1949.

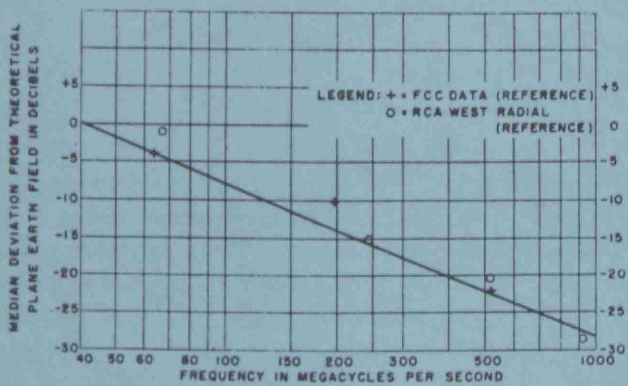


Fig. 1—Median terrain factor for fixed-to-vehicular or mobile service.

earth field, Fig. 1, (3) becomes empirically,

$$P_{50} = 0.345\left(\frac{h_t h_r}{d^2}\right)^2\left(\frac{40}{f}\right)^2 P_t \times 10^{-14}. \qquad (4)$$

Eqs. (2) and (4) show that nature, by interposing terrain features, has essentially placed in juxtaposition the frequency dependence of the field strength and received power above 40 mc over plane earth. Thus, while the theoretical received field strength over plane earth increases with frequency, the median received field intensity above 40 mc over irregular terrain is independent of frequency, and while the theoretical received power between half-wave dipole antennas is independent of frequency, over irregular terrain the median received power above 40 mc varies inversely as the frequency squared.

For the purpose of the systems engineer, in making irregular terrain calculations it is preferable to use the plane earth received power (3) shown in nomographic form in Fig. 2, in its theoretical form because field strength, median value statistically derived, and received power theoretically derived are, at this point of exploration of irregular terrain propagation, independent of frequency.

It is interesting to note that if one determines from diffraction theory the depth of hills[2] which will result in the median loss of Fig. 1, the statistical irregular terrain can be conceived as hills with a depth of about 500 feet. It is also interesting to note that the New York west radial terrain over which data are available[3] has an irregular depression of about 500 feet, 12 miles in extent and distance from the transmitter. Most of the data were accumulated in this portion of the radial, and the median values below plane earth theory are shown in Fig. 1 as the composite for the entire radial.

At this point in the paper it will be well to assume a rather simple problem and use it as a means of exemplifying the development of the material to be presented.

[2] K. Bullington, "Radio propagation variations at vhf and uhf," Proc. IRE, vol. 38, pp. 27–32; January, 1950.

[3] G. G. Brown, J. Epstein, and D. W. Peterson, "Comparative propagation measurements; television transmitters at 67.25, 288, 510 and 910 megacycles," *RCA Rev.*, vol. 9, pp. 171–201; June, 1948.

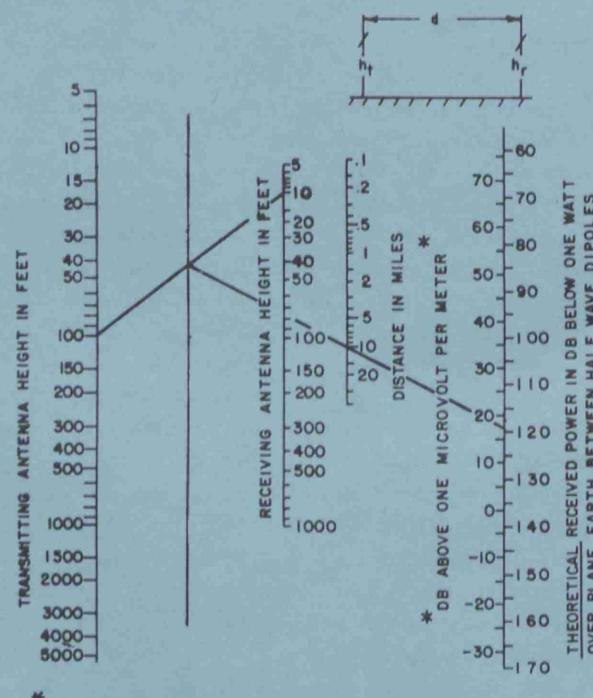


Fig. 2—Received power over plane earth and 50 per cent location median field strength—one watt radiated.

Assume:

- Transmission frequency, 150 mc
- Dipole antennas, half-wave
- Transmitting antenna height, 100 feet
- Receiving antenna height, 10 feet
- Service range, 10 miles
- Service to 90 per cent of locations at 10 miles
- 50 kc IF bandwidth
- Suburban noise
- No transmission line losses.

Required: Transmitter power output.

The theoretical received power in db below one watt will be from Fig. 2, 119 dbw. The field strength at 50 per cent of the locations, Fig. 2, will be 17.5 db above one microvolt per meter, one watt radiated.

Terrain-Frequency Dependence

If one explores the data[1] in terms of the distribution of received field strength over irregular terrain, one finds that the over-all terrain distribution when plotted in decibels above the theoretical plane earth attenuation, is log-normally distributed. Thus, on probability paper, the terrain distribution will appear linear and may be described by its median value and standard deviation, Fig. 3. The terrain distribution of field intensity in the vhf band, taken at a center frequency of 127.5 mc appears to have an over-all standard deviation of 8.3 db, while the terrain distribution of field intensity in the uhf region centered around 510 mc, appears to have an over-all standard deviation of 11.6 db. Of course, the median deviation from theoretical plane earth field is

EXHIBIT 10

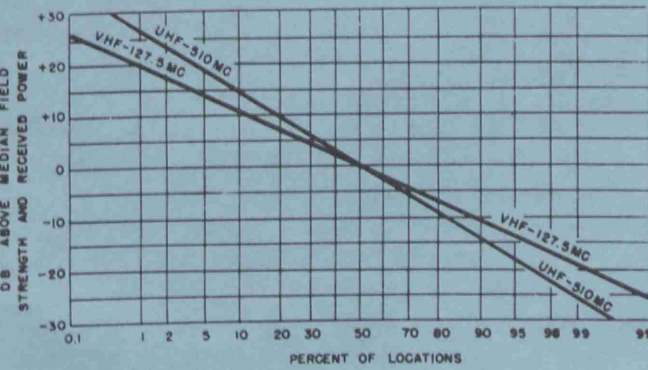


Fig. 3—VHF and uhf terrain distribution.

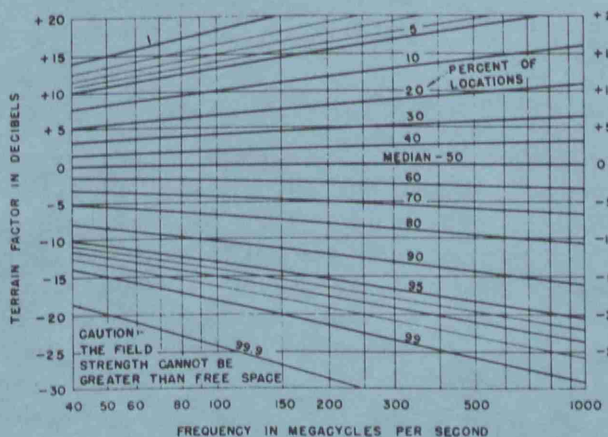


Fig. 4—Fixed-to-vehicular or mobile service field strength terrain factor.

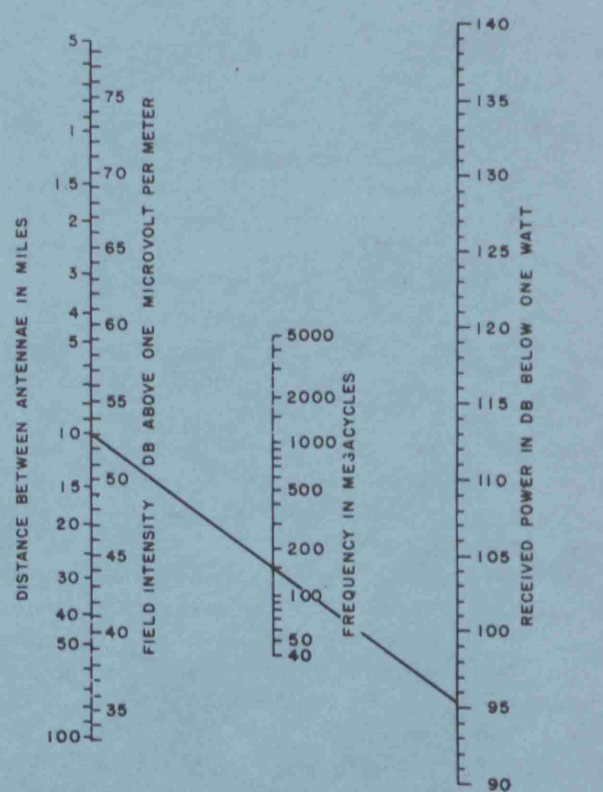


Fig. 5—Free space—one watt radiated between half-wave dipoles

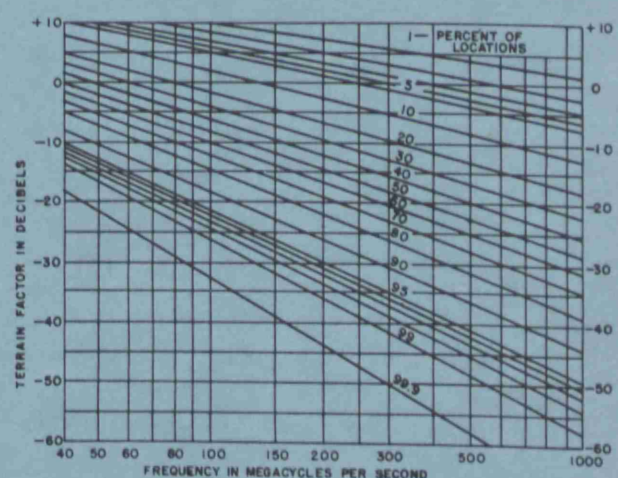


Fig. 6—Received power terrain factor for fixed-to-vehicular or mobile service.

displaced 12 db by the terrain factor for the two frequencies, Fig. 1. From this standard deviation data, Fig. 4 has been prepared which permits the determination of the correction factor to the E_{50} field strength when the received field strength to other than the 50 percentile location is desired. For example, as previously determined, E_{50} was 17.5 db above one microvolt per meter. Applying the terrain correction factor of -11.5 db for the 90 percentile location results in a median received field strength at the 90 percentile location of 6 db above one microvolt per meter, one watt radiated. This value of field strength does not exceed the free space value for 10 miles of 53 db above one microvolt per meter obtained from Fig. 5. Under conditions of greatly increased antenna heights and/or service to a small percentile of locations, the calculated field strength could exceed the free space field. If such is the case, the free space field should be used. It is interesting to note that while the median field strength (2) and terrain factor for 50 per cent of the locations (Fig. 4), are independent of frequency, for percentages of locations less than 50, the field strength increases with frequency, and for $E_{2.3}$ the field strength varies as $f^{1/2}$. Likewise for percentages of locations greater than 50, the field strength decreases with frequency and for $E_{97.7}$ varies inversely as $f^{1/2}$.

Likewise, Fig. 6 has been prepared to reflect the correction factor to the theoretical plane earth received power imposed by irregular terrain. The P_{50} value follows an inverse frequency squared relation as per (4), at $P_{97.7}$ an inverse frequency cubed relation, and at $P_{2.3}$ an inverse frequency relation. As previously determined, the theoretical received power is -119 dbw. The terrain correction factor for the 90 percentile location at 150 mc is -23 db, and the received power at this location will be -142 dbw, or the half-wave dipole-to-half-wave-dipole path attenuation for this degree of service is 142 db. The free space received power is -95.4 dbw from Fig. 3 which exceeds that for the 90 percentile location.

Terrain-Transmitting Antenna Height Dependence

The transmitting antenna height, used in conjunction with the data[1] is defined as the height above the median, 2–10 mile terrain level. This rule has not proven as reliable as one might expect, since it does not take into account the terrain within 2 miles or beyond 10 miles. For purposes of this report the effective height of the antenna will be the height of the antenna above plane earth. In actual practice the transmitting antenna heights could be taken as the effective height above local terrain. For all practical purposes, the data confirmed that the received field strength increased linearly with transmitting antenna height. Transmitter height-gain tests made around the New York area[4] seem to indicate that in poor service locations the effect of transmitting antenna height increase is somewhat less than one would theoretically predict. In median or 50 percentile locations the height gain would approximate the theoretical expected height gain, and for good service locations the height gain would be somewhat more than the theoretical. For purposes of this paper, the formulas and nomographs reflect a linear high gain for transmitting antenna height.

Terrain-Receiving Antenna Height Dependence

Receiving antenna height is the effective height above local terrain. The data do not appear to support any clear-cut variation of field strength with change in receiving antenna height. For receiving antennas which clear surrounding terrain features, the height gain appears to be linear. For receiving antennas which do not clear the surrounding terrain features, no orderly pattern is discernible. However, test results analyzed statistically,[1] show that in the 6 to 30 feet category, the field strength appears to support a square-root height gain variation. Above 30 feet, the height gain is linear. This variation is reflected in the nomograph of Fig. 2.

In practice, when using low antenna heights, as pointed out in the New York tests,[4] the dependence of field strength upon receiving antenna height is quite variable. When locating in a given area, within the confines of available antenna height, the maximum field strength should be found.

Terrain Fading

Both the vhf and uhf studies indicate that the time fading is much smaller for the distances involved than the terrain variation, and may be neglected as a power balance factor in equipment design. In the fear of being misunderstood, suppose equipment is designed for vehicular operation to cover 90 per cent of the locations, at 10 miles from the transmitter. Based on statistical terrain data, the variation in median signal throughout the terrain is far in excess of what the long-time fading would be between two fixed locations. However, fading becomes important for fixed service work. A subscriber land-based for an extended period of time in a poor location, marginal signal, might well compensate for the long-time fading which will ensue by moving to the optimum spot in the small area in which he is to be located, and also by having means for elevating his antenna, which can now be changed to a directional antenna, to the optimum height within the height-raising capability of his antenna system. These two expedients should compensate for time fading and be reflected in a highly reliable transmission circuit.

Terrain-Antenna Polarization

Theoretically, over plane earth at antenna heights greater than a wavelength and for small angles between the direct and reflected rays, as is the case for irregular terrain transmissions, polarization has negligible effect on the behavior of radio waves above 40 mc. Experimental evidence[5,6] over irregular terrain of the received characteristics of polarized waves appears in general to verify the above. While it appears that vertical polarization is somewhat better directly behind hills or deep in the shadow area, horizontally polarized waves afford better reception in back of, but away from, the deep shadows of hills. In wooded areas, the attenuation is less for horizontally polarized transmissions than for vertically polarized transmissions below 300 to 500 mc. In total, little difference can be detected in the average propagation characteristics.

There is one exception to the latter statement and it concerns propagation using antenna heights less than one wavelength. In this case the ground wave is dominant and theoretically vertical polarization provides an apparent height gain over horizontal polarization.[7] This effect is shown in Fig. 7 and pertains only to vertical polarization since for horizontal polarization the effective height is essentially the actual height at frequencies above 40 mc. As shown in Fig. 7, the effective height also depends on the conductivity of the soil over which the transmission will be effective. Unfortunately, as far as the author knows, terrain-statistical data are lacking on the propagation effects resulting from the use of very low vertically polarized antenna heights in the lower vhf region. Until such time as this theoretical information can be placed in dispute statistically by tests, it is

[4] J. Epstein and D. W. Peterson, "An experimental study of wave propagation at 850 mc," Proc. IRE, vol. 41, pp. 595–611; May, 1953.

[5] J. S. McPetrie and J. A. Saxton, "An experimental investigation of the propagation of radiation having wavelengths of 2 and 3 meters," *J. IEE*, vol. 87, pp. 146–153; August, 1940.

[6] J. A. Saxton and B. N. Harden, "Ground-wave field-strength surveys at 100 and 600 mc/s," *Proc. IEE*, vol. 101, part 3, pp. 215–221; July, 1954.

[7] K. Bullington, "Radio propagation at frequencies above 30 megacycles," Proc. IRE, vol. 35, pp. 1122–1136; October, 1947.

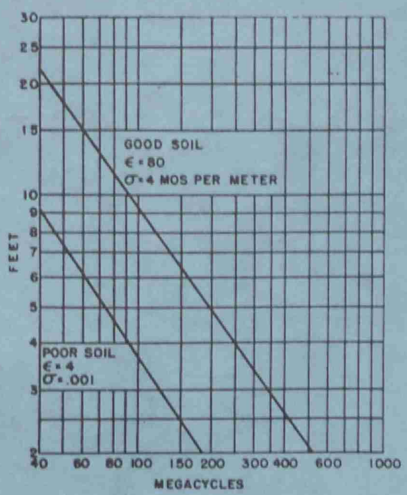


Fig. 7—Minimum effective antenna height for vertical polarization.

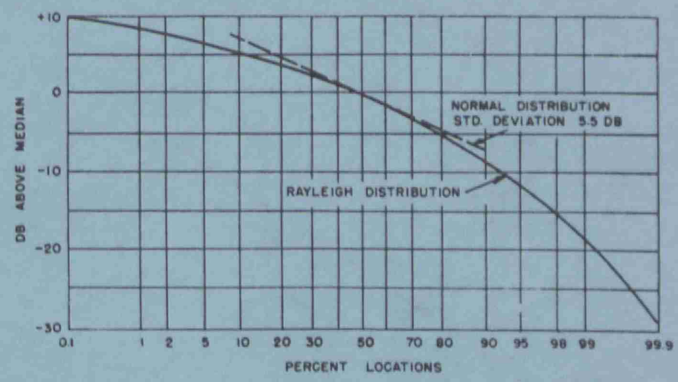


Fig. 8—Terrain-small sector variation.

proposed that when vertically polarized transmissions are under consideration, Fig. 7 be used in finalizing the effective height of low antennas.

In our problem at 150 mc with an antenna height of 10 feet it can be seen from Fig. 7 that even with vertical polarization this height is also the effective height. If the problem had been one of transmission at 40 mc, then in using Fig. 2 the height would have remained the same for poor soil conditions, but would have to be taken as 23 feet over good soil conditions.

Terrain-Small Sector Field Strength Variation

As noted earlier, there is a fine amplitude variation about the median in a small distance or area which is independent of the distance from the radiation source. Some studies indicate that these fine variations of field strength have a normal distribution[1] which appears to be independent of frequency with a standard deviation of 5.5 db. Other studies,[8] indicate a Rayleigh distribution, Fig. 8. The latter appears more likely because the studies which indicate a normal distribution were taken over distances which perhaps exceeded the small sector variation. However the Rayleigh type fading may only occur and be applicable in areas replete with buildings, etc. In open areas the distribution may be log-normal over a small sector. Between the 10 and 90 per cent values of these distributions there is very little difference in the two distributions. The amplitude distribution is the same at all frequencies indicating that the range of constructive and destructive phase interference or standing wave effects is complete. However, the number of constructive and destructive interferences increases in a given distance or area with frequency.

Tests[9] conducted in the Phoenix, Ariz. area indicate that the average vehicle travel between these fine signal minima is one wavelength in free space, while in the direction away from or toward the radiation, the distance between signal minima is the free space half-wave distance. With this information, in vehicular service the small sector amplitude fluctuations in received carrier level will increase in rapidity with frequency and the speed of the vehicle, or

$$A = \frac{v}{\lambda/2}, \text{ and in practical terms, } \quad A = 0.003\, fv \qquad (5)$$

where A is the average amplitude fluctuation rate in cps, f is the radio carrier frequency in mc, and v is the velocity of the vehicle in the direction of transmission in miles per hour. For ready use, (5) has been prepared in the form of a nomograph, Fig. 9. It shows, for example, that at 150 mc the received field in a vehicle traveling at 40 miles per hour in the direction of transmission would have an average fluctuation rate of 18 cps. For vehicular service, this is the rate which would have to be considered in the design of agc circuitry with the audio or intelligence pass band designed above this frequency.

The small sector variations at 90 mc[10] appear to be small in open flat country and much greater in built-up areas as might be expected. The variations in built-up and treed areas appear greater for vertically polarized transmissions than for horizontally polarized transmissions.

Another characteristic of these variations which one would expect is that the higher the frequency, the steeper the fall and rise in field strength. In general, the variations appear to be deeper with the time between rise and fall smaller. Maximum envelopes occurring during a test[9] are shown in Fig. 10. At 15 db down, the "outage time" on 459 mc may be in the order of a few milliseconds at vehicle speeds of 40 miles per hour with perhaps no noticeable effect on speech transmissions, whereas at 156 mc the outage time at this level could cause the loss of voice information.

Unfortunately, data were not found which would permit an expression either quantitatively or qualitatively as to the useful distribution or design point criteria of

[8] W. R. Young, Jr., "Mobile radio transmission compared at 150 to 3700 mc," *Bell Sys. Tech. J.*, vol. 31, pp. 1068–1085; November, 1952.

[9] C. F. Meyer and D. Soule, "Field Strength Study," Motorola, Inc.; February, 1956. Work performed under Signal Corps Contract DA-36-039-sc-64737.

[10] H. L. Kirke, R. A. Rowden, and G. I. Ross, "A vhf field-strength survey on 90 mc/s," *Proc. IEE*, vol. 98, part 3, pp. 343–359; September, 1951.

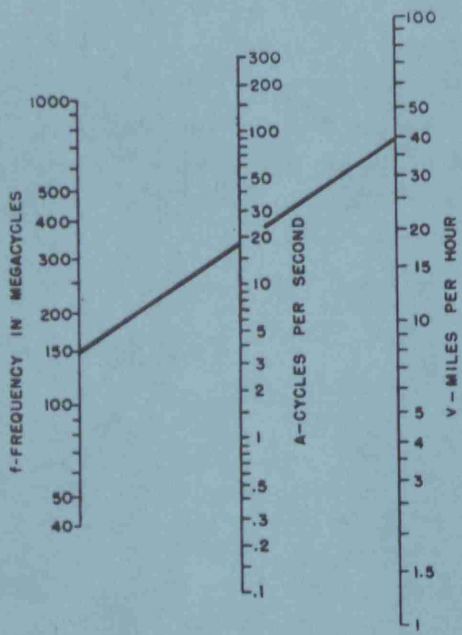


Fig. 9—Fluctuations in vehicles.

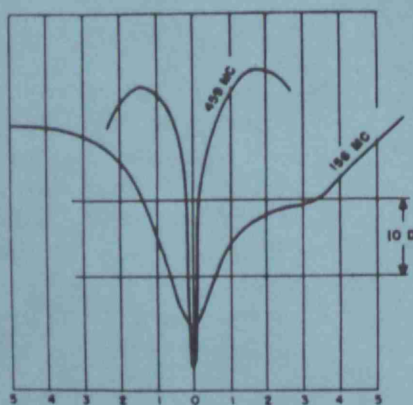


Fig. 10—Maximum small sector variation.

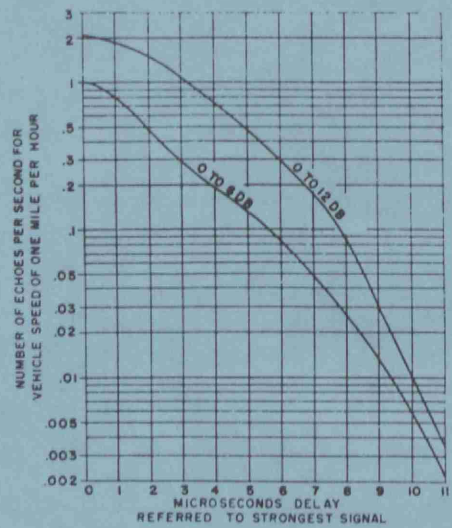


Fig. 11—Echoes in vehicles from a fixed transmission.

these small sector field strength variations. It may well be, at least for the present, that equipment should be designed to the median value of these find grain variations for the percentage of locations service desired.

Terrain-Wide Modulation Bandwidth Effects

The field strength variations discussed so far have been those taken over a very narrow bandwidth of the transmission frequency. On wide-band systems distortion effects may be introduced resulting from propagation via more than one path. These distortions may cause cross talk in multichannel voice systems, or shadows in television reception. This subject will be touched on lightly because not very much statistical data are available nor is literature available on the effects of multipath propagation on various types of modulation. The severity of multipath distortion[11] appears qualitatively to be independent of frequency and wave polarization, at least within the frequency range of 60 to 3300 mc. The consequences of multipath propagation are not serious for fixed transmission conditions, yet may be very serious in moving situations. For fixed service, movements of the receiving antenna either horizontally or vertically for a distance in the order of a few wavelengths ordinarily cleans up multipath distorted patterns in television reception. More multipath distortion appears in highly built-up and mountainous areas where large off-path reflecting surfaces are present. Directive antennas greatly reduce multipath effects,[11] which means that for equal antenna apertures, the use of the higher frequencies will result in less multipath distortion.

The only good statistical results, unfortunately unrelated to all of the terrain data made use of herein and therefore not representative of all the conditions on which this paper is based, are based on tests in the New York area,[12] where one encounters considerable, and perhaps the worst, multipath propagation conditions. In order to understand the difficulties one may encounter in engineering vehicular wide band systems, the New York data,[12] have been altered (Fig. 11) to reflect the number of echoes per second for a vehicle speed of one mile per hour vs delay of these echoes with amplitudes between 0 and 6 db less than the strongest received signal. Thus a remote television transmitter installed in a vehicle patroling New York at 30 miles per hour would present to the fixed television receiver a picture with thirty, 0- to 6-db echoes per second having $\frac{1}{4}$-μsec delay, 9 shadows per second having 3-μsec delay, and so forth. Besides this ghosting of the picture that is taking place, the synchronous circuit of the television receiver is in essence flip-flopping from the direct signal path amplitude to

[11] D. W. Peterson, "Army Television Problems Phase II Tasks 1 and 2 Final Report," January, 1956, RCA. Work performed under a Signal Corps Contract No. DA-36-039-sc-64438.

[12] W. R. Young, Jr. and L. Y. Lacy, "Echoes in transmission at 450 megacycles from land-to-car radio units," Proc. IRE, vol. 38, pp. 255–258; March, 1950.

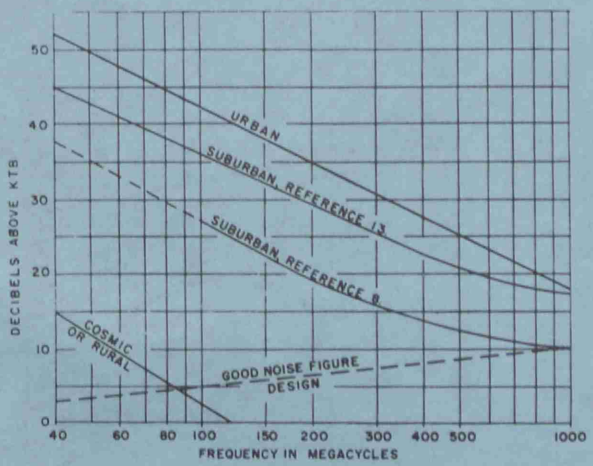


Fig. 12—Median indigenous noise.

the multipath signal amplitude when the ghost signal is the stronger of the two.

Indigenous Noise

While the relationship between received signal and frequency over irregular terrain has been covered pretty well, another important power balance factor in systems design is the establishment of the noise level of the receiver, or the signal required to assure satisfactory communication. Noise in the frequency range above 40 mc is mainly caused by man-made noise. The general classifications are rural, suburban or small town, and urban noise. Cosmic noise is still present up to 100 mc. Collectively this noise can be termed indigenous noise.

The extent to which this indigenous noise acts upon a receiver is shown in Fig. 12. Two curves have been drawn for suburban noise since the material for these curves have been drawn from two separate references.[8,13] The lower suburban noise curve is representative of the median indigenous noise experienced in areas suburban to New York, with extrapolated data shown by the dotted portion of the curve. The urban noise data taken from these same two references dovetailed into the same curve. The dotted curve represents the noise figure of a currently well-designed receiver and is shown only to give the figure perspective. The indigenous noise can be referenced with respect to the thermal noise, ktb, of a receiver and is shown in Fig. 12 as the correction factor which must be applied to ktb level, Fig. 13(b).

The difficulty in the use of these curves lies in just what level of noise should be applied in systems design work. Unfortunately indigenous noise data were not collected along with the field strength data. If this had been done a distribution of the magnitude of noise over the areas in which the field strength data were taken would have been available. It would appear that equipment designed for general use should at least consider the lower suburban curve of Fig. 11 with the thought that in urban areas advantage might be taken of the height-gain in these areas.

[13] Federal Telephone and Radio Corp., "Reference Data for Radio Engineers," 3rd ed., p. 442; 1949.

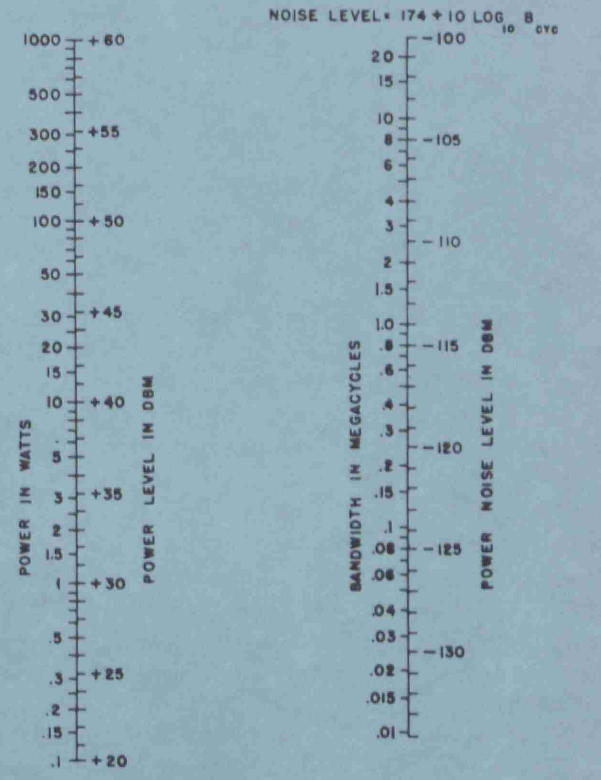


Fig. 13—(a) Conversion of power to dbm. (b) Conversion of bandwidth to thermal noise level.

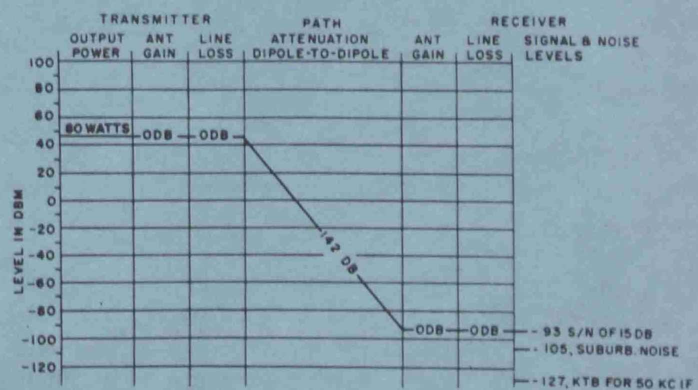


Fig. 14—Power level diagram.

Problem Solution

The entire problem is reviewed in Fig. 14 in the form of a power level diagram. Working the level diagram from the ktb level of -127 dbm obtained from Fig. 13(b), for a 50 kc IF, suburban noise and not noise figure plus approximately 12 db, establishes the lowest rf signal, -93 dbm, for an acceptable signal-to-noise ratio. Assuming no transmission line losses to the two dipole antennas and with the path attenuation loss over 10 miles of irregular terrain to the 90 percentile location of 142 db, one arrives at a required transmitter power of 49 dbm or 80 watts, Fig. 13(a).

Vehicular-to-Vehicular Transmissions

The entire discussion thus far has dealt with the subject of fixed-to-vehicular, or fixed-to-mobile transmissions over irregular terrain. It is in these subjects that data exist, while in the field of vehicular-to-vehicular transmission good statistical data are nonexistent, at least to the knowledge of the writer.

If one makes the reasonable assumption that the terrain factor will not change whether we deal with the moving-to-moving, fixed-to-fixed, or fixed-to-moving situations, then the median signal received by a vehicle in motion from another vehicle in motion is precisely that given in Fig. 4. However, by statistical theory,[14] it would appear that the standard deviation would be the square root of the sum of the variances of two fixed-to-moving distributions which in this type of transmission can be considered of the same magnitude. Thus the standard deviation for vehicular-to-vehicular transmission is the $\sqrt{2}$ times the standard deviation for the fixed-to-vehicular transmission. This is in essence the correction factor which must be applied to Fig. 6, in order to obtain the vehicular-to-vehicular received power terrain factor shown in Fig. 15. If the given problem were a vehicular-to-vehicular system, fictitiously assuming antenna heights were maintained for this service, the path attenuation at 10 miles to the 90 percentile location would be 119 db, from Fig. 2, plus 32.5 db, from Fig. 15, or 151.5 db compared to a path attenuation of 142 db derived earlier in this paper for the fixed-to-vehicular or mobile transmission. The transmitter power level of 49 dbm, on Fig. 14, must be raised to 58.5 dbm or 700 watts for vehicular-to-vehicular equivalent service.

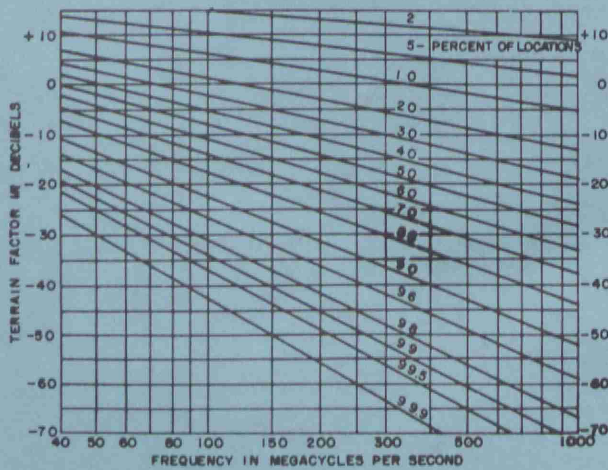


Fig. 15—Vehicular-to-vehicular received power terrain factor.

Remarks

The statistical method of handling propagation over irregular terrain can be used in frequency assignment studies to determine the number of rf channels which should be designed into equipment for cochannel and adjacent channel field service. It has important usage in vulnerability studies of mutual interference, intentional and unintentional jamming, and countermeasures. It also appears to have application in spectrum allocation studies.

Of course the burning question of how well a particular piece of equipment will act in a given environment is difficult to answer. If the terrain is less irregular than the statistical irregular terrain, then better than predicted performance should result. On the other hand, in terrain more irregular than the statistical, a poorer performance should result. However, field operational procedures should be developed which permit a rapid evaluation of the service coverage from a given location. A possible technique for rapid evaluation is one based on a system utilizing the "ground clutter" pattern seen on the radar (PPI) scope.[15]

Conclusion

This paper is considered a modest start in the direction of supplying irregular terrain propagation information applicable to systems engineering. The author encourages constructive criticism or the supply of data which may be beneficial for deriving better statistical data. For example, much data are required on frequencies above 1000 mc; the nature of the fine variations and their effects upon types of modulation; propagation data on vehicular-to-vehicular transmissions; good statistical small sector variation data; and so forth.

Acknowledgment

The author wishes to express his gratitude to all those referenced authors who have made this paper possible by their efforts in collecting propagation data.

[14] A. Hald, "Statistical Theory with Engineering Applications," John Wiley and Sons, New York, N. Y.; 1952

[15] R. E. Lacy and C. E. Sharp, "Radar-type propagation survey experiments for communication systems," 1956 IRE Convention Record, part 1, pp. 20–27.

EXHIBIT 11

THE AMOUNT OF SPECTRUM RELIEF PROVIDED BY THE PROPOSED GEOGRAPHIC REALLOCATION

1. DISCUSSION OF CURRENT USE OF SPECTRUM

Table 1 shows the percent of the 450-470 MHz spectrum for base stations and for mobile units, that is typically used with various authorized land mobile powers and antenna heights. A comparison of these typical applications with the power and antenna height restrictions set out in the Notice of Proposed Rule Making indicates that many of the actual operating needs of land mobile radio users will not be met.

For example, consider the Los Angeles - Long Beach, California area. The maximum proposed permissible power for base stations is 100 watts ERP, and this is for only 50% of the proposed additional spectrum; the other 50% of the spectrum is limited to only 25 watts ERP. Referring to Table 1 for base stations, it can be seen that only 3% of the land mobile requirements are satisfied by the 50% of the spectrum limited to 25 watts ERP; only a portion of 27% of the needs are satisfied by the 50% of the proposed spectrum with 100 watts ERP (only part of the users in the 95 to 630 watt ERP category are satisfied by 100 watts ERP or less).

Two other factors show the proposed relief for the Los Angeles area as even less useful. First, the antenna height restrictions shown for Los Angeles are 200 ft. AAT. Many of the land mobile users in this area employ antenna heights much in excess of 200 ft; a more typical height is 1000-2000 ft. AAT, because of the topography of that area. Few of the users could achieve the coverage necessary for their everyday operations if the antenna height were restricted to 200 ft.

Secondly, the use of the proposed spectrum is further limited in a geographic sense. Specifically, the use of 476-482 MHz for land mobile base stations is prohibited in the southern one-half of the Los Angeles - Long Beach area due to co-channel separation requirements from channel 15 in San Diego.

As a second example, consider the New York, Northeastern New Jersey area. The base station power restriction is 400 watts ERP. However, as indicated in table 1, 62% of current land mobile users needs are for powers in excess of this limit. Beyond this, some portion of the 23% of those users indicated in the 95 to 630 watt ERP category also require more than 400 watts. Thus, between 62% and 85% of the needs in the New York area will not be met. This same criterion is also applicable to Detroit, Michigan, and generally to all of the 25 metropolitan areas.

Table 1 indicates that only a very limited amount of land mobile needs are met with an antenna height restriction of 50 ft. However, such regions as Chicago, Minneapolis-St.Paul, and Cincinnati are proposed to be subject to this restriction. Spectrum relief in these cities, therefore, is certain to be inadequate.

Finally, this data indicates that all but 7% of the current mobile spectrum is typically used with powers in excess of 100 watts ERP as shown in the table. However, the Notice of Proposed Rule Making allows only a maximum of 100 watts ERP for mobiles, and this for only 6 of the 25 top cities; none of the top 5 cities are allowed to use more than 50 watts ERP.

In summary, the proposed powers and antenna heights are inadequate for the majority of land mobile needs when compared with the typical facilities currently employed by the land mobile services to satisfy their coverage requirements.

11. DISCUSSION OF DATA SOURCES FOR TABLE 1

The numbers indicated in table 1 were derived primarily from the FCC Rules and Regulations and available data. The numbers in the first column were calculated using the 450 MHz channel assignment data from parts 89, 91 and 93 in the Rules and Regulations. Likewise, the input powers shown (and one output power) were extracted from this source. As indicated in note 2, however, 52% of the 450 MHz mobile spectrum may be used with input powers of 600 watts; this is not typical, and a value of 120 watts has been used.

The output power was derived from the input power by applying typical transmitter efficiency factors. The effective radiated power (ERP) was then calculated by multiplying the output power by the typical antenna gain listed.

Finally, the antenna heights shown were determined by analyzing data available on specific users antenna heights in several major metropolitan areas.

TABLE I

CURRENTLY USED LAND MOBILE POWERS AND ANTENNA HEIGHTS IN THE 450 MHz BAND

PERCENT OF 450 MHz SPECTRUM (%)	INPUT POWER (WATTS)[1]	OUTPUT POWER (WATTS)[1]	ANTENNA GAIN (db)	POWER (WATTS ERP)	ANTENNA HEIGHT (FT. AAT)[3]
			BASE STATIONS		
23	(POWER MUST BE SPECIFIED BY LICENSEE)	15 to 100	8	95 to 630	150 to 600
22	(600)	330	8	2080	300 to 600
40	(180)	100	8	630	150 to 600
11	(120)	60	8	378	150 to 600
1	(60)	30	0	30	30 to 50
3	40	(20)	0	20	30 to 50
			MOBILE UNITS		
41	(180)	100	5	315	6
52	120[2]	60	5	189	6
1	(60)	30	5	95	6
6	(3)	1.5	0	1.5	6

NOTE:

1. Numbers in parenthesis are as specified in the F.C.C. Rules and Regulations. Output power and ERP are derived from input power. All other numbers are typical.

2. In 52% of the 450 MHz mobile spectrum, the maximum permissible input power is the same as for base stations (600 w). However, a more typical value of 120 watts has been used.

3. These are typical values for relatively flat areas. In mountainous areas such as Seattle, Washington, a typical value is 1000-2000 ft.

LEGEND:

◉ Ch. 14 WFAN-TV

● Land Mobile 464-470 MHz

EXHIBIT 12

Land Mobile Usage in Washington, D.C.

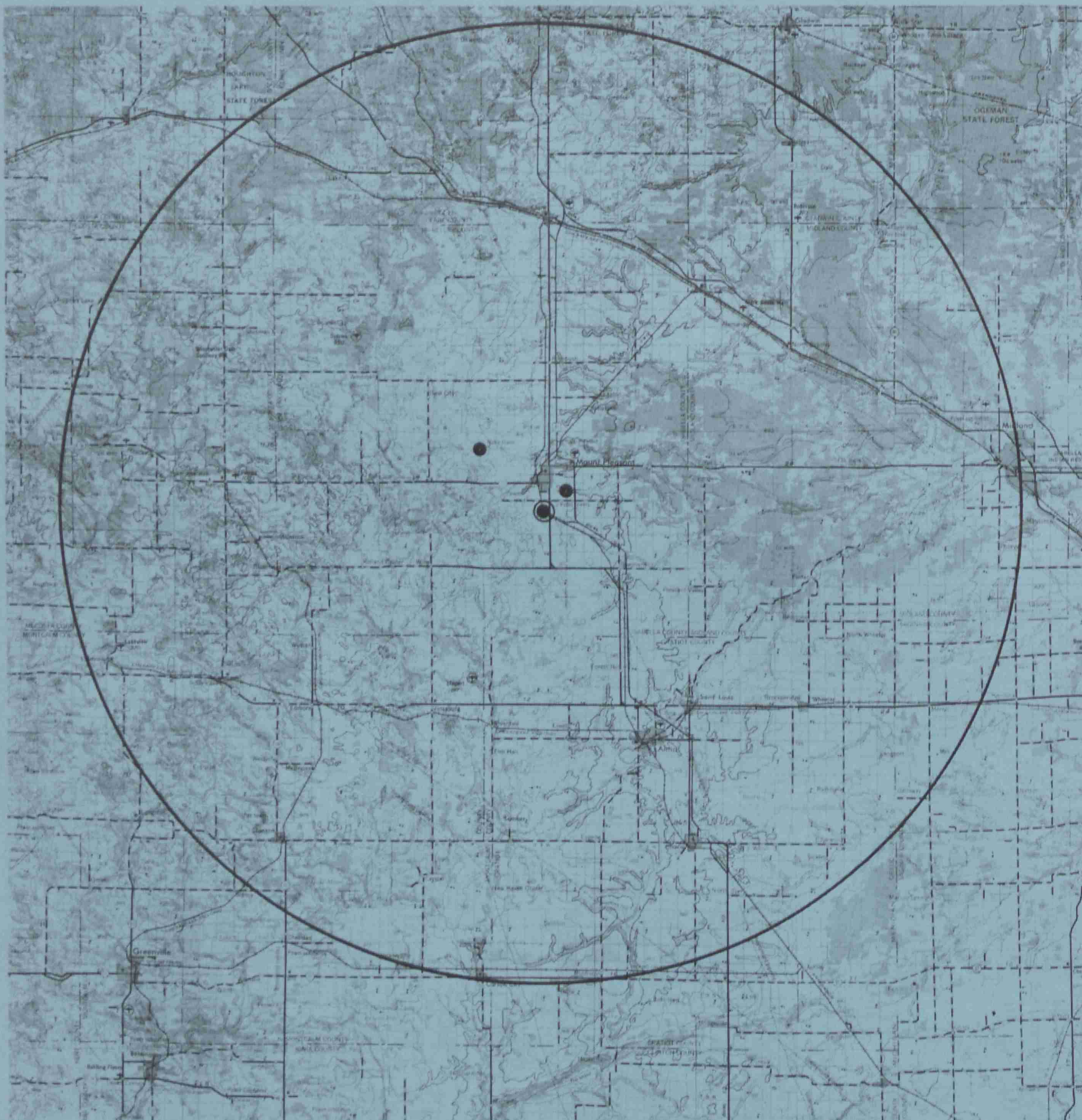
LEGEND:

◉ CH. 14 KCSM-TV

● Land Mobile 464-470 MHz

EXHIBIT 12

Land Mobile Usage in San Mateo, Calif.



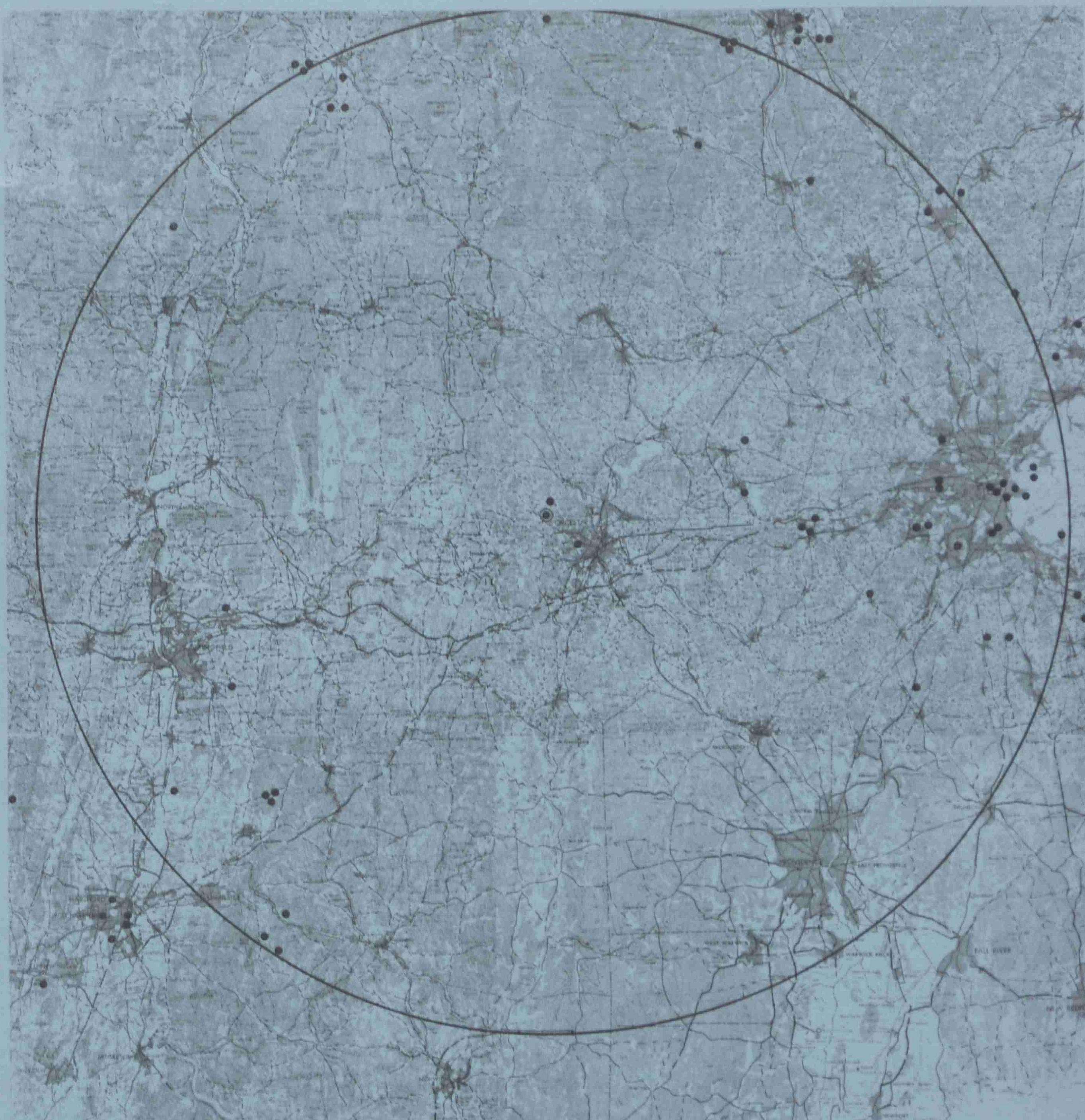
LEGEND:

◉ Ch. 14 WCMU-TV

● Land Mobile 464-470 MHz

EXHIBIT 12

Land Mobile Usage in Mt. Pleasant, Mich.



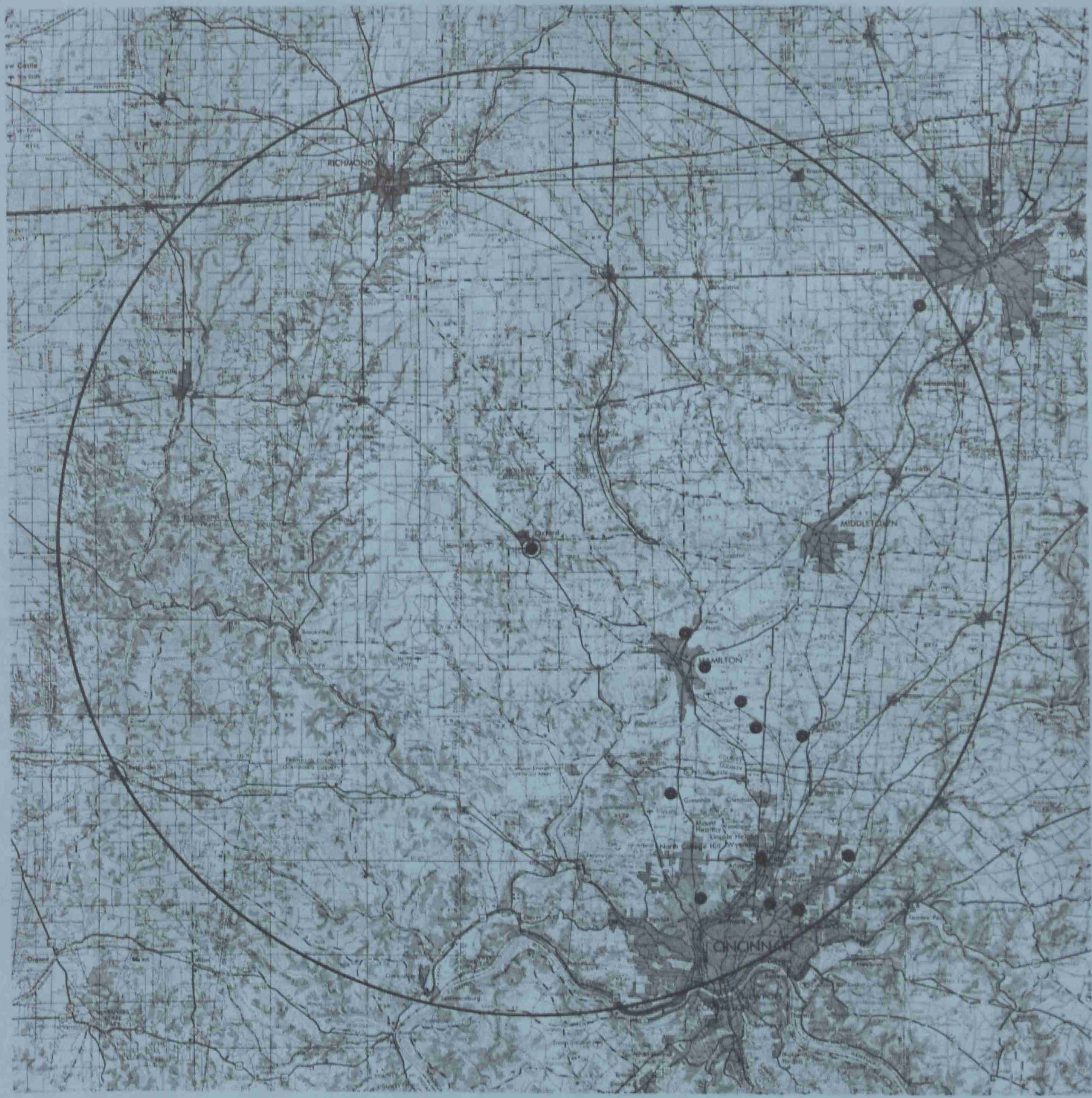
LEGEND:

◉ Ch. 14 WJZB-TV

● Land Mobile 464-470 MHz

EXHIBIT 12

Land Mobile Usage in Worcester, Mass.



LEGEND:

◉ Ch. 14 WMUB-TV

● Land Mobile 464-470 MHz

EXHIBIT 12

Land Mobile Usage in Oxford, Ohio