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

In re Impact of Advanced Television Technologies on the Local Broadcast System	)	
In the Matter of Further Sharing of the UHF Television Band by Private Land Mobile Radio Services	)	General Docket No. 85-172 RM-3975 RM-4823

PRELIMINARY AND PARTIAL STUDY OF THE USE OF THE UHF BAND TO ACCOMMODATE LOCAL HIGH DEFINITION TELEVISION

I. INTRODUCTION AND SUMMARY

The transition to high definition television (HDTV) or other high quality video transmission systems[1/] threatens the survival of the consumer's universal, free and locally-oriented television service. Local stations have, accordingly, asked the Commission to conduct an inquiry into the serious issues raised by this transition.[2/] They have also asked that during the pendency of the inquiry the

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1/ "HDTV" is used hereafter as an umbrella term for both technologies regarded as "true" HDTV and other new high-quality technologies.

2/ MST, et al, Petition for Notice of Inquiry (February 13, 1987) ("Petition").

Commission suspend its proceeding on land mobile sharing of the UHF band that could preclude local television stations from implementing HDTV in the most likely, and perhaps only feasible, spectrum for such services.[3/]

Much of the response to the broadcasters' requests has been positive. Government officials are increasingly aware of this threat to local broadcast service and the public's existing receiving equipment, both of which, but for an appropriate regulatory response from the Commission, could be obsoleted by HDTV. In some quarters, however, there is a persistent uncertainty about how the UHF band could accommodate HDTV in the major markets, how such uses would affect land mobile sharing and what the interference consequences of such arrangements might be.

These are difficult and important questions, the answers to which no one knows for sure. Indeed, the purpose of the inquiry sought by the Association of Maximum Service Telecasters (MST) and 57 other broadcast organizations was to develop answers to these and other crucial questions.[4/]

3/ MST, et al, Petition for Special Relief (February 13, 1987).

4/ It puts the cart before the horse to ask that these questions be answered before the proceeding can be launched. Nevertheless, the MST study described herein provides one set of possible and preliminary answers to illustrate how HDTV might be accommodated in the UHF band.

But because of the uncertainty described above, MST has felt it necessary to undertake a preliminary and partial study to respond to these concerns and here submits the results of that study.

The MST study shows that under one set of reasonable assumptions there is sufficient spectrum in the UHF band to permit the conversion of all or virtually all existing stations in six of the "worst case" markets to at least one form of NTSC-compatible, HDTV system now being developed. It appears that, generally, such a system could be achieved without (i) substantially cutting back on today's NTSC service areas, (ii) without causing significant interference to existing services and (iii) without requiring existing television stations to shift channels. The study further reveals that this goal can be achieved only if the Commission does not adopt its present land mobile sharing proposals.

This last statement does not mean, however, that local-station implementation of HDTV in the UHF hand would necessarily preclude all land mobile use of UHF spectrum.

It does mean that the amount of and specifications for such usage would have to await the outcome of the HDTV inquiry.[5/]

II. THE MST STUDY: OBJECTIVES AND ASSUMPTIONS

A. Objectives

The objectives of the MST study were 1) to ascertain whether and how the UHF television band (470-806 MHz), as it is occupied today by broadcast and land mobile licensees and permittees, could be effectively utilized by local broadcast stations for the provision of a wideband (greater than 6 MHz) high quality television system, and 2) if it could be used for high quality television, the impact of the proposal to reallocate UHF spectrum to land mobile radio in eight major markets.

5/ MST recommended various innovative proposals in the land mobile sharing proceeding to show how, for example, 14.0 MHz (580 channel pairs) of UHF spectrum could be used for land mobile operation in New York and 71.5 MHz (2860 channel pairs) in Dallas, without causing interference to the public's existing television service. MST Comments in Gen. Dkt. 85-172 at 17-21, July 11, 1986. The same sort of approach could yield some UHF spectrum for land mobile uses without compromising proper engineering standards, even if local stations used supplementary channels in the UHF band to implement HDTV. This issue could be considered in the land mobile sharing docket as soon as the HDTV inquiry has been completed or even as one element of the requested notice of inquiry.

B. Markets Studied

Six markets were selected for examination: New York, Los Angeles, Chicago, Philadelphia, Baltimore and Washington. The first three markets were selected because they are the largest markets in the country. Without the ability to serve these markets, a local-station HDTV system could not be viable. These markets were also selected because they have the most intensive television-station usage of any markets in the country. Cf. UHF TV Band, 101 F.C.C. 2d 852, 857 (1985). If the study revealed that it would be plausible to use the UHF band for HDTV in these markets, this would be strong evidence that there is sufficient spectrum in all markets in the country.[6/] There are also the cities in which land mobile interests claim the greatest congestion.

The second three markets were selected because they are markets with heavy station occupancy and adjacent to other heavily occupied markets, a fact which further reduces the availability of UHF spectrum in those markets. Here again, the assumption is that if it is likely that HDTV can be implemented in these "worst case" markets, then it is

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6/ MST's analysis assumed that all stations currently authorized in the studied markets would be maintained but that no new 6 MHz stations would be authorized.

also likely that there would be sufficient spectrum in all other markets in the country.

C. The Wideband High Quality Television System Used For the Study

To study the possible use of the UHF band for local-station HDTV, it was, of course, necessary to make certain assumptions about the likely features of a local broadcast HDTV system. MST chose a type of system for its study that is under development by two different organizations, that would be compatible with the public's investment in existing receivers and that would be very spectrum-efficient. There is no guarantee at this point, however, that either organization will successfully bring its system to the consumer marketplace or that its system will conform to all of the characteristics assumed for purposes of this initial study.7/

1. System features

The MST study assumed that local broadcast HDTV will be transmitted by means of two channels that do not have to be contiguous. The first channel will be the existing NTSC channel, either VHF or UHF. The second

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7/ Since numerous other HDTV systems are being explored and developed world-wide, the requested inquiry should solicit information about each of the principal systems under development and about their spectrum and other implications.

channel will be in the UHF band and will be 3 MHz wide. The second channel will carry supplementary information providing the additional chrominance and luminance information necessary to produce a wide aspect ratio HDTV picture when combined with the primary NTSC channel.[8/]

The two channels will be integrated by a sophisticated receiver that will automatically select the second channel as directed by a digital code inserted in the vertical blanking interval of the NTSC channel. The receiver is expected to employ field stores to convert the NTSC signal from interlaced to progressive scan to improve the vertical resolution. The result will be greatly improved picture and sound comparable to compact disk quality. See Petition at 15-16. Consumers who have conventional NTSC receivers will continue to receive NTSC service from the primary channels; hence this system will be compatible just as color television is compatible with black-and-white.

8/ As explained below, the second or supplementary channel will be quite different in its content and its interference effects than the current NTSC channel. It will not, for example, have a "sync pulse," a short burst of high carrier power which locks the picture on NTSC receivers to the transmitted signal, and as described below, it can be designed in advance to avoid altogether or minimize interference to other television operations on "taboo" channels.

2. Underlying assumptions

The system assumed for the study is based in large measure on two systems now in development, those of North American Philips and the New York Institute of Technology. See Petition at 15-16. These two-channel systems were chosen as appropriate models because 1) they are now being developed and 2) they are compatible with existing NTSC receivers. Although MST has kept in contact with both Philips and NYIT, it cannot say with certainty that these systems will achieve 3 MHz bandwidths[9/] for their supplementary HDTV channels or the interference characteristics described below.

It should also be emphasized that, despite the fervent wishes of local broadcasters to the contrary and after 10 years of closely monitoring HDTV and other technological improvements, MST believes that local broadcast HDTV cannot be carried over existing 6 MHz broadcast channels but will require additional spectrum. The reasons for this assumption are detailed in the Petition (at 20-21; App. A at 1-3). In brief, this belief is based on the facts that: 1) none of the systems now under development would

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9/ NYIT is currently working on 3 MHz bandwidths for its system, while Philips' system, currently designed for 6 MHz bandwidths, is "malleable" and hence may offer reasonable prospects for implementation with 3 MHz bandwidths.

fit in a 6 MHz channel; 2) many engineers believe that it is theoretically impossible to compress an HDTV signal into 6 MHz; and, 3) even if it were possible to fit HDTV into a 6 MHz channel, the signal would not be compatible with existing NTSC receivers, a hurdle which is insurmountable for local broadcasters.[10/]

D. Interference-Protection Standards

Using the assumed features of the hypothetical two-channel HDTV system, MST then derived station separation standards similar to those developed for existing NTSC stations.[11/] It was also assumed that it was desirable to protect the existing NTSC service areas from additional interference. In addition, all of the standards derived below were premised on the assumption that the supplementary HDTV signals would be the equivalent of an NTSC transmission with maximum transmitter power (5 megawatts) and height (600 meters).

10/ As explained in the Petition at 20, this hurdle is unique to local broadcasters because they alone have one transmission channel and, thus, to begin a 6 MHz HDTV service they would have to terminate their existing NTSC service. Competitive media such as cable will be able to make the HDTV conversion by "simulcasting" in HDTV and NTSC.

11/ Because the supplementary channel is in the UHF band, the HDTV service areas of existing VHF stations may not be fully co-extensive with their current NTSC service areas.

1. Co-channel interference standard

The starting point of this analysis is that existing NTSC channel separations can be reduced for a number of reasons relating to the specific features of the supplementary HDTV signal and the receivers designed to accept those signals. The conventionally-recognized 28 dB desired-to-undesired co-channel separation ratio has been employed as a base for the interference calculation.[12/]

First, the HDTV signal will not contain a synchronizing pulse, the point of maximum power delivery in the NTSC signal. As a result, the assumed maximum transmitted power of the HDTV signal can be approximately halved (reduced 3 dB). Second, the supplementary channel will also differ from the main channel in that the "white level" will be at zero carrier and "setup" will not be required.[13/] The lack of sync pulse and reduced white level permit a total reduction in the co-channel D/U ratio of 4 dB. Third,

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12/ As demonstrated by the tests conducted at the CBS Laboratories under the sponsorship of the Joint Broadcast/Land Mobile Technical Advisory Committee, improved receiver performance and rising viewer quality demands have rendered this standard obsolete. Joint Broadcast/Land Mobile Technical Advisory Committee Report, Doc. No. WG-1.55. However, in the absence of any systematic test aimed specifically at arriving at a new standard, no attempt has been made to estimate what that new standard should be.

13/ "White level" is 12.5%; "setup" is 7.5%.

broadcasters operating on the same channel can use very precise frequency control (keeping their frequencies at the optimum offset for interference avoidance) to reduce the required D/U ratio by another 10 dB.[14/]

The result is a co-channel D/U ratio reduced from 28 dB to 14 dB and the following mileage separations between HDTV transmitters and co-channel HDTV or NTSC transmitters:

	Spacing	
Zone	(km)	(miles)
I	180.5	112.2
II	208.5	129.6
III	250.0	155.4

2. Adjacent-channel protection standard

Derivation of the appropriate adjacent-channel interference protection standard was premised on a "base-line" -12 dB desired-to-undesired ratio. This is the ratio currently applied to protect NTSC signals from upper adja-cent-channel interference. The lower-adjacent channel interference standard of -6 dB D/U results from the fact that the visual carrier in the NTSC signal is located in the

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14/ These and other techniques described are not available in land mobile equipment to reduce the interference that land mobile operations would cause to the public's tele-vision service under the UHF sharing arrangements proposed in General Docket No. 85-172.

lower third of the channel and is sensitive to adjacent-channel interference from the sound carrier in the lower adjacent channel. The supplementary HDTV channel will contain no sound carrier and thus should cause less interference to upper adjacent signals.

As with co-channel interference, the baseline D/U ratio was then reduced by another 4 dB because of the lack of sync pulse and white level modulation. Furthermore, if transmitters are co-located, as at the New York World Trade Center and at many other locations, add-on channels adjacent to existing NTSC channels could likely be used without causing interference. Experimental verification of this proposition might well be necessary but, at the least, the 3 MHz portion of the adjacent channel farthest from the existing channel could be utilized for HDTV.

The result is an adjacent-channel D/U of -16 dB and a minimum separation of 81.8 km or 50.8 miles.

3. Taboos

The existing interference protection standards also protect against a variety of UHF "taboos," interference from the second, third, fourth, fifth, seventh, eighth, fourteenth and fifteenth adjacent channels in the UHF television band. Until we know the modulation scheme and specific characteristics of the proposed HDTV scheme, we cannot know for certain which, if any, of these taboos will

have to be taken into account in spacing HDTV add-on channels. There is reason to believe, however, that all or virtually all of them can be avoided.

To begin with, there should be no need to be concerned with HDTV-HDTV taboos. These add-on channels will be received only on the more sophisticated HDTV receivers which almost certainly can be engineered to preclude such problems.

With respect to the NTSC receivers, the second, third, fourth and fifth adjacent-channel taboos are based on intermodulation effects which, although real, would not be severe, particularly if transmitter locations are selected to minimize intermodulation effects. Interference from the seventh channel is a function of radiation from the receiver local oscillator. This phenomenon appears only if the interfering receiver is tuned to the seventh channel above the channel being viewed and is transmitting a high level of radiation from a very close distance. HDTV receivers are not likely to operate with the same intermediate frequency (IF) as NTSC receivers so no significance attaches to the seventh channel.

It is possible that IF interference to the eighth adjacent channel and image interference from the upper half of the upper adjacent fourteenth channels and lower half of the upper adjacent fifteenth channels will still be a

problem. Again, it will not be possible to measure this potential problem with any degree of accuracy outside the context of specific modulation schemes. And, again, engineering an HDTV system with the goal in mind of avoiding these effects and careful control over site and power should eliminate or substantially mitigate the problem.[15/]

For these reasons, the study assumed that none of the current UHF taboos will inhibit the use of the UHF band for HDTV add-on channels. (This conclusion in no way supports the notion that land mobile operations also can be interspersed into the UHF band without regard to the taboos, as proposed in the Commission's Notice. Unlike the signals of the assumed HDTV transmissions, the characteristics of land mobile transmissions are well known and their effects on existing receivers have been thoroughly investigated. Report of Joint Broadcast/Land Mobile Technical Advisory Committee, III.B.) This is clearly an area of considerable uncertainty, however, which will have to be investigated further in the requested inquiry on HDTV.

15/ If the eighth, fourteenth and fifteenth adjacent-channel taboos would have to be complied with, further spectrum analyses along the lines of this study should be conducted.

III. STUDY RESULTS

Employing the assumed HDTV system and interference-protection standards described above, each of the six "worst case" major markets was analyzed. Using the constraints outlined in Section II, there is sufficient spectrum to permit every existing station in each of the six markets, UHF and VHF, to upgrade their operations to HDTV. And this upgrade could be accomplished in a manner which would not obsolete existing NTSC receivers or require that broadcasters alone initiate HDTV service at the expense of discontinuing current NTSC service. Table 1 also makes it apparent that the proposed reallocation of spectrum to land mobile would render it virtually certain that there will not be sufficient HDTV spectrum for each existing station.[16/]

In New York and Philadelphia, for example, there are currently ten VHF stations and ten UHF stations, a total of 20 stations. The MST study reveals that there are 22 3 MHz channels available for HDTV use by these stations.

16/ However, as pointed out above (at 4), it is possible that some of the UHF spectrum MST earlier identified as being available for land mobile sharing without causing interference to the public's television service could still be used for this purpose. This subject needs further study, particularly taking into account whether such sharing would impact adversely on supplementary HDTV channels.

The proposed reallocation of UHF channels to land mobile in these cities would eliminate eight of these 22 identified HDTV channels, leaving only 14 supplementary channels.[17/]

In Los Angeles, 22 3-MHz-wide supplementary channels were identified, enough to accommodate the 18 area television stations. But eight or ten of these 3-MHz channels are targeted for land mobile use under the Commission's proposals. Not all eight (ten) can be reallocated to land mobile use without precluding some existing television stations from participating in HDTV. But possibly some could be made available for land mobile use under proper interference standards once a configuration of HDTV add-on channels is decided upon.

It must be reiterated that, while reasonable, the characteristics of the hypothetical wide band HDTV system assumed for this study are by no means certain to come to pass. And different assumptions as to the characteristics of the proposed system[18/] will, of course, yield different

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17/ New York and Philadelphia must be considered together due to their proximity. See Table 1.

18/ MST is particularly concerned about the avoidance of interference, especially with respect to eighth, fourteenth and fifteenth channel taboos. However, even if these taboos had to be observed the lower half of the fourteenth adjacent channel and upper half of the fifteenth adjacent channel would be available as 3 MHz add-on channels without causing

(footnote continued)

results as to the amount of spectrum needed by broadcasters for HDTV, the amount of spectrum available in the UHF band and the possibility of some land mobile sharing of the UHF band. These issues also deserve further study.

IV. CONCLUSION

The foregoing study demonstrates that at least certain kinds of local-station, high-quality television systems -- systems similar to some of those now being developed -- almost certainly can be implemented through the use of UHF frequencies. The study also shows that the proposed reallocation of frequencies to land mobile operations would make this approach to implementing local-station, high-quality television impossible. However, some forms of land mobile sharing might be possible but not until the Commission has developed appropriate allocations policies to

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(footnote continued)

interference. This is because the interfering portion of the signal is transmitted in the upper half of the fourteenth adjacent-channel station and in the lower half of the fifteenth adjacent-channel station.

MST is also concerned that the HDTV add-on channel may have to be wider than 3 MHz. The allocations, interference and other implications of wider HDTV add-on channels may also warrant further study.

accommodate local-station implementation of HDTV technologies.

Respectfully submitted,

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APPENDIX 1

STUDY OF ADDITIONAL UHF SPECTRUM AVAILABLE FOR HDTV

TABLE 1

(Assume use of 3 MHz add-on channels for HDTV protecting only co-channel and first adjacent-channel stations)

Market	No. of Stations	Add-on Channels Available for HDTV	No. of 3 MHz Channels	Excess of 3 MHz Channels	Channels in Col. 3 Proposed for Land Mobile	Excess (Shortage) if Assigned to Land Mobile as Proposed
New York	12	27, 32, 33, 34, 40, 42, 45 & 46	*/ 22	2	27, 33, 34, 26/32, or 42/46	(8)
Philadelphia	8	18, 26, 30, 32, 42 & 46				
Los Angeles	18	21, 25, 26, 27, 32, 33, 48, 60, 65, 66 & 67**/	22	4	26/32 or 32/36 & 48, 60 & 66	(4 or 6)
Chicago	14	19, 21, 25, 27, 29, 31, 40, 41, 42, 43, 45, 47, 48 & 68	28	14	41, 47, 68	8
Washington	9	15, 16, 19, 30, 36, 39, 40, 48, 51 & 59	*/ 28	11	36/30 or 39/35	7 or 9
Baltimore	8	16, 30, 36, 41, 46, 52 & 63				

*/ Because of the proximity of these markets, the same HDTV add-on channel may not be used in both places, and the assignment of channels for land mobile use in one market blocks their availability for HDTV in both markets.

**/ Use of 21, 27, 33 and 67 would require Mexican concurrence.

APPENDIX C

"Preliminary and Partial Study of the Use of the UHF Band to Accommodate Local High Definition Television Through the Allocation of Additional 6 MHz Channels"

This study is an extension of the "Preliminary and Partial Study of the Use of the UHF Band to Accommodate Local High Definition Television," Gen. Docket No. 85-172, RM-3975, RM-4823 (filed March 10, 1987) (Appendix B). In this study the spectrum available to allocate an additional 6 MHz channel was examined.

The same six markets were selected for examination: New York, Los Angeles, Chicago, Philadelphia, Baltimore and Washington. In this study it was assumed that the additional 6 MHz would be used as an augmentation channel to carry supplementary information that would be integrated with a station's current NTSC transmission by a sophisticated receiver to produce a wide aspect ratio HDTV picture, Appendix B, at 6-9; or, alternatively, the additional 6 MHz channel could be used for an advanced, single-channel 6 MHz HDTV transmission that would simulcast the programming of the station's existing NTSC programming for reception by advanced HDTV receivers.

As in the previous study, these assumptions were made because they reflect the characteristics of systems that are now under development or have been proposed. Both the North American Philips Corporation and New York

Institute of Technology[1] systems described in the previous study contemplate the possibility of using 6 MHz augmentation channels to provide HDTV-quality service while retaining compatibility with existing receivers. The development of single channel, 6 MHz HDTV-quality systems that would not be compatible with existing receivers has also been discussed, but it is uncertain whether, or when, such a system might be developed and available for testing.[2]

The same assumptions for interference protection standards that were adopted in the previous study were adopted for the 6 MHz augmentation channels assumed in this study. Appendix B, at 9-14.
[3]

1/ The system being developed by the New York Institute of Technology would use a 2.75 or 5.3 MHz augmentation signal depending on the sampling rate of the additional detail information transmitted to upgrade the NTSC signal. W.E. Glenn, "New Developments in a Compatible High Definition Transmission System." [1987].

2/ W.F. Schreiber, "6-MHz Single-Channel HDTV Systems," Proceedings of the Ottawa HDTV Symposium, October, 1987.

3/ It should be noted that both this study and the previous study on the availability of 3 MHz augmentation channels do not take into account unusual propagation characteristics but assume uniform channel spacings can be applied. The presence of such propagation phenomena may increase interference or preclude the use of certain channels.

As in the previous study, it is important to emphasize that there is no way to know whether HDTV systems that fulfill the assumptions made here can or will be developed. The assumptions regarding interference protection, in particular, are based on speculation about the characteristics of hypothetical HDTV transmissions and reasonable, but untested, assumptions about the interference standards that might be applicable. It is by no means certain that these systems will come to pass or that, when tested and evaluated, they will have the characteristics assumed.

The results of the study are set forth in the attached chart. In addition to the number of additional channels and shortfall given the present allocations, the chart also sets forth the number of channels available and the resulting shortfall that would result if the land mobile

sharing proposals in General Docket 85-172, 101 F.C.C. 2d 852 (1985) were adopted.

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APPENDIX C

STUDY OF ADDITIONAL UHF SPECTRUM AVAILABLE FOR HDTV

Market	No. of Stations	Add on Channels Available for HDTV	No. of 6 MHz Channels	Excess (Shortage) of 6 MHz Channels	Channels in Col. 3 Proposed for Land Mobile	Excess (Shortage) if Assigned to Land Mobile as Proposed
New York	12	27, 32, 33, 34, 40, 42, 45 & 46	*/ 11	(9)	27, 33, 34, 26/32, or 42/46	(14)
Philadelphia	8	18, 26, 30, 32, 42 & 46				
Los Angeles	18	21, 25, 26, 27, 32, 33, 48, 60, 65, 66 & 67**/	11	(7)	26/32 or 32/36 & 48, 60 & 66	(11 or 12)
Chicago	14	19, 21, 25, 27, 29 31, 40, 41, 42, 43, 45, 47, 48 & 68	14	0	41, 47, 68	(3)
Washington	9	15, 16, 19, 30, 36, 39, 40, 48, 51 & 59	*/ 14	(3)	36/30 or 39/35	(4 or 5)
Baltimore	8	16, 30, 36, 41, 46, 52 & 63				

*/ Because of the proximity of these markets, the same HDTV add-on channel may not be used in both places, and the assignment of channels for land mobile use in one market blocks their availability for HDTV in both markets.

**/ Use of 21, 27, 33 and 67 would require Mexican concurrence.