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

MM Docket No. 87-268

In the Matter of

Advanced Television Systems and Their Impact on the Existing Television Broadcast Service — RM-5811

Review of Technical and Operational Requirements: Part 73-E, Television Broadcast Stations

Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules

NOTICE OF INQUIRY

Adopted: July 16, 1987; Released: August 20, 1987

By the Commission:

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I. INTRODUCTION

1. Numerous new television technologies designed to improve significantly upon television picture and sound quality are in various stages of planning and/or development. These systems use different amounts of spectrum and different transmission and reception methods, many of which, to some extent, cannot be decoded or displayed by existing television receivers. Many such advanced television systems could be used by either broadcast or non-broadcast media. In fact, there are indications that the use of at least one such system will be available to consumers in non-broadcast applications within the next five years.[1]

2. For these reasons, the Association of Maximum Service Telecasters, Inc., and 57 other broadcast organizations and companies filed a joint "Petition for Notice of Inquiry" (hereinafter referred to as "Industry Petition) on February 13, 1987, requesting the Commission to initiate a proceeding to explore the issues arising from the introduction of these advanced technologies and their possible impact, in either broadcast or non-broadcast uses, on the existing television broadcast service, especially as they relate to the Commission's spectrum allocation and television channel allotment policies. The industry petition asserts that the emergence of these new advanced television systems places traditional local television service at an historic crossroads. Without the opportunity to improve off-air television picture and sound quality in some manner, the industry claims that the television broadcast service could be shut out of the video marketplace to such an extent that it could be relegated to a second-class service, with serious implications for the future of off-air television service to the public.

3. Twelve parties commented on the Industry Petition.[2] On the basis of this record, we agree with the industry that the uses of advanced television (ATV) systems by television broadcast stations is a subject which is of utmost importance and is now ripe for consideration. Therefore,

we hereby initiate a wide-ranging inquiry to consider the technical and public policy issues surrounding the use of advanced television technologies by television broadcast licensees. Although the quality improvements possible with advanced TV technologies would appear to be beneficial, at this juncture it also appears that implementation of ATV would impose costs, due either to increased equipment costs, reduced availability of spectrum for non-broadcast uses, or both. Moreover, it appears that the greater the improvement in television quality, the higher these costs. It is the purpose of this Inquiry to acquire information that will help us better understand the advantages and disadvantages of the various terrestrial broadcast ATV implementation options. Having secured the information about the costs and benefits of the various ATV options, the Commission will then be in a position to decide whether adoption of some form of advanced broadcast television would be in the public interest, and, if so, what form the system should take. It is our initial view that in the event we authorize some form of advanced television system, we do it in a way that makes its benefits available to all viewers. Consequently, it would appear to be desirable to consider options which give all television licensees an opportunity to provide improved service. We believe that an industry advisory committee could assist us in gathering and processing much of the necessary information, and we have instructed the staff to empanel such a group.

4. The next section presents background information on the present NTSC television standard and the various other improvements now under development. Following this discussion, three general areas of inquiry are examined. First, in Section III, comment is requested on several alternative spectrum allocation arrangements to provide us with a better sense of the costs and benefits of making certain frequency bands available for ATV purposes. We next examine in Section IV the issues related to compatibility between NTSC and ATV and among ATV systems. Finally, in Section V we outline what we now see as the public policy issues raised in the context of advanced television systems.

II. BACKGROUND

A. NTSC Standard

(1) Evolution of the NTSC Standard

5. On July 1, 1941, the Commission made the first spectrum allocation for commercial television in the VHF frequency band (channels 1-13).[3] In the same proceeding, the Commission also adopted the first technical standard for transmission of black-and-white television. The standard, commonly referred to as NTSC,[4] comprises a number of technical features that have remained essentially unchanged for almost half a century.[5] In 1953, new technical features, mainly the color information, were added to the NTSC standard, and again in 1984 the standard was modified to add the stereo sound information. The adoption of a transmission standard by the Commission essentially fixed the basic engineering characteristics of the production, distribution, transmission and reception of television.

6. The NTSC system has been serving the American public for almost 50 years. While the NTSC transmission standard has proven to be remarkably durable and adaptable to changes over the years, it reflects the technological limits of the early days of television development, and is perceived today as limited in video quality and audio fidelity. More importantly, it no longer represents the limits of the present and anticipated future technological possibilities in the home video delivery service. Even with the various changes and improvements in the hardware over the years, the NTSC standard still suffers from a number of defects that are inherent in its design or are byproducts of adding color information to the black-and-white transmission without increasing the transmission bandwidth.

7. The television broadcast industry and equipment manufacturers, the academic community and leading broadcasting corporations in the United States and abroad have been studying for some time ways to upgrade the quality of television.[6] National and international committees, such as the Advanced Television System Committee (ATSC) and the CCIR,[7] have been aggressively reviewing the various improvements and enhancements to NTSC and other television systems, and are working toward agreement on recommending studio and program exchange standards for new television systems. All in all, the Commission believes that an advanced television systems inquiry is timely and should be viewed as a necessary first step toward bringing advanced broadcast television to the public.

(2) Limitations of the Current NTSC System

8. As mentioned above, the NTSC transmission standard suffers from a number of deficiencies that limit its video and audio quality. Specifically, the system suffers from two general categories of defects. The first category, known as interlace/color defects, can be directly observed by most viewers on a television screen and detracts from the picture. The second, known as quality defects, is more subjective in nature. A discussion of the interlace/color and quality defects in the NTSC system follows.

9. *Interline Flicker.* This defect is apparent when observing horizontal borders of objects on a TV screen. Because of the NTSC interlaced scanning fields process (60 per second, 2:1),[8] any scan line[9] that represents the horizontal borders of an object will only be flashed on the television screen half the time, or at a rate of 30 frames per second, thus creating a flickering effect around the borders of that object. This flickering effect is generally irritating to the eye.

10. *Line Crawl.* This defect is more predominant in modern television displays where the screen brightness decays more rapidly than in older displays. In an interlaced scanning process a new line appears on the screen every 1/60 of a second later than the one just above it (or below it), and so on. The net effect is that the human eye is fooled into thinking that a line is moving upward (or downward) on the screen at a constant motion. Once the eye locks on the pattern, it compensates for this artifact by mentally averaging the two lines, thus further reducing the resolution of the picture.

11. *Vertical Aliasing.* This defect is apparent when observing watery or wavelike patterns (Moire patterns), for example, like those on a tweed jacket. Because of the interlaced scanning process, a pattern with these characteristics that is created in one field[10] would be cancelled out by a similar pattern in the next field. The human eye

cannot adequately integrate the two fields, thus resulting in a unnatural cluttering effect where the pattern is observed on the screen.

12. *Large Area Flicker.* This defect is apparent when viewing bright images on a screen. The flickering effect is more visible for viewers who are watching a screen at distances less than the recommended normal viewing distances. Studies have demonstrated that the eye is capable of perceiving varying brightness levels at frequencies even higher than the 60 Hz NTSC field rate, thus noticing the flicker. This artifact, however, is generally accepted by most viewers.

13. *Static Raster.* This defect is more predominant in larger TV displays, such as projection television, where viewers are able to see the individual scan lines that make up the frame.[11] This may be objectionable to some viewers. While progress has been made in developing better large screen displays that minimize or compensate for this effect, static raster could be virtually eliminated by increasing the number of scanning lines in each frame.

14. *Temporal Aliasing.* This defect is apparent when viewing objects in motion on a screen. Again, because of the interlaced scanning process, the resolution of a moving picture appears to be lower and the scanning structure becomes more visible.

15. *Cross color.* This effect is apparent when viewing a scene that contains a detailed pattern like the one found on a striped shirt or a tweed jacket. The defect appears as a bizarre color pattern that does not belong over the area of detail. Cross-color defect is attributed to the make-up of the NTSC signal, which mixes the high luminance and chrominance information in the same composite baseband spectrum.

16. *Cross Luminance.* More generally referred to as "Dot Crawl", this defect appears as a dot pattern crawling up on the edges of color areas. Again, this defect is the result of the structure of the NTSC transmission standard where the color information leaks into the luminance signal. The effect is more visible on monochrome receivers.

17. With regard to quality deficiencies, psychophysical research has demonstrated that viewers obtain a greater sense of realism and involvement, as well as an illusion of depth, from a display widened to correspond more closely to the dimension of human field of vision as well as with sharper and brighter picture. Also, with the increased display of graphics and text on the screen, viewers are becoming aware of the limited resolution of today's television. Among the quality shortcomings of today's television are: a compressed aspect ratio (4:3) relative to a cinema like aspect ratio (2:1) which corresponds more closely to the human field of vision;[12] the limited horizontal, vertical, and luminance resolutions, which result in TV pictures that are lower in sharpness and brightness than in movie theaters; and a limited audio quality when compared to today's compact-disc sound quality.

B. Advanced Television (ATV) Technologies

18. The hardware part of a television system comprises generally the camera, recorder, the transmission equipment, the receiving equipment and the display. With the advances which have been made in technology, it is not necessary that the signal be carried in the same format at each stage. Of course, the amount of information present at each stage tends to limit the quality ultimately attainable at the display. Improvements to a television system could be limited to redesigning one or two components within the system or a wholesale redesign of all the components. Technical standards, such as the NTSC transmission standard, are usually established to insure connectivity and compatibility among the various components in a television system.

19. There are numerous potential ways of significantly improving the technical quality of television. At this juncture, we wish to consider any system(s) that improves television audio and video quality or enhances in any way the current NTSC system as an "advanced television system." A very broad and generic definition of ATV is appropriate so as to include all systems now under development or whose development are foreseen.

20. Developmental efforts for improving television audio and video quality have taken many forms and are constantly being challenged by expanding technologies. This is evident by the number and variety of proposals that have been developed over the years and the ones that are now being investigated. Some developmental efforts have focused on improving the current NTSC system, while others have elected to develop new transmission technologies which retain some features of the NTSC system such as the same number of scan lines. Still others have elected to develop new transmission technologies that would be able to process a larger number of scan lines. While some of the development efforts are farther along than others, it is generally agreed that developments of ATV technologies for terrestrial transmission and reception of broadcast signals are at an early stage and progressing at a moderate pace. A brief discussion of technology development follows.

(1) Improved NTSC Systems

21. There are a number of promising techniques that are under development to improve NTSC which would not require increases in bandwidth. These techniques attempt to correct for some or all of the interlaced and color defects described earlier, as well as improve on some of the quality deficiencies outlined above.

22. To correct for the artifacts that result from the interlaced scanning process, one simple technique, known as progressive scan at the display, converts the interlaced signal to a sequential (progressive) signal at reception. The conversion is made using a line or field store at the receiver.[13] This technique requires only modest changes to the design of a conventional NTSC receiver. Another, more complex technique, known as progressive scan in camera/display with interlaced transmission, uses a progressive scan camera to record the picture, convert the signal to an interlaced scan format prior to transmission, then convert the signal back to progressive scan at reception. The result is an improved picture with a perceived increase in the displayed vertical resolution or Kell Factor.[14] This technique requires modification at the camera and the receiver.

23. To correct for the artifacts that result from interference caused by the sharing of the same baseband spectrum between the luminance and chrominance information, a technique known as pre-combing has been developed. Precombing uses special filters, called comb filters, to separate the luminance and color information prior to NTSC encoding. Specifically, these filters would be placed in a component studio just prior to NTSC encoding for transmission and at the receiver prior to NTSC decoding. The

result is an improved TV picture with greatly diminished cross-color and cross-luminance artifacts. While some pre-comb filters have been developed, work is still underway to design more complex filters that further reduce these artifacts.[15]

24. To improve the limited luminance information of the NTSC signal, Dr. Fukinuki of the Hitachi Central Research Laboratory has proposed that a small amount of color information be sacrificed in exchange for higher resolution luminance information.[16] Specifically, Fukinuki proposed to interleave higher definition luminance with color in much the same way as the current NTSC format interleaves the luminance information. This technique, while it greatly improves the luminance resolution, produces motion artifacts that have to be corrected at the receiver. Thus, the technique requires a fair amount of signal post-processing at the receiver.

25. In Japan, The Broadcasting Technology Association (BTA) is currently evaluating a number of different improved NTSC systems for terrestrial broadcasting. Among the systems being evaluated by BTA are systems developed by Asahi Television Corporation, Hitachi and NHK. The BTA intends to select one of these systems for implementation by terrestrial broadcasters in Japan in the early 1990s. A decision on a new transmission standard for an improved NTSC system is expected by 1988.

26. The above is not an exhaustive list. The Commission is aware that other efforts are being made to improve NTSC, some of which have neither reached the technical communities nor been published for proprietary reasons. For this reason, the Commission is requesting comments on the merits of the techniques mentioned above, and is soliciting further information on all possible techniques that would exploit the full potential of the existing NTSC standard.

(2) Other Enhanced TV Systems

27. One way of eliminating the cross-color and cross-luminance artifacts is to alter or redesign the current NTSC transmission standard. Development efforts have produced a number of so-called MAC systems[17] (Multiplex Analog Component systems) in which the luminance and chrominance information components of the video signal are separated in time. One such system, known as B-MAC, is currently marketed by Scientific Atlanta. The Scientific Atlanta B-MAC system,[18] intended primarily for use in satellite transmission but also available for terrestrial broadcast and cable use, uses a baseband bandwidth of slightly more than 6 MHz and requires a converter for viewing on a conventional NTSC receiver.

28. Other development efforts have focused on producing a better picture by sequentially scanning all 525 lines. Sequential scanning has certain advantages over interlaced scanning, but generally requires double the bandwidth. One such system is under development in the U.S. by North American Philips Corporation. The Philips system,[19] intended for use by all home video transmission media, including terrestrial broadcasting, uses two 6 MHz channels for transmission. The first 6 MHz channel transmits an NTSC signal which can be received by a conventional NTSC receiver without any loss in quality. The second 6 MHz channel, generally referred to as an augmentation channel, carries the extra video details for the additional resolution and the information necessary for a wide aspect ratio (16:9) as well as the additional data and sound information for improved fidelity. The augmentation channel does not have to be contiguous in spectrum, *i.e.*, adjacent to the first channel, provided there is comparable reception of both channels.

29. Another system is currently under development by General Electric. The GE system combines some of the techniques described above to improve large and small area flicker, and the chrominance and luminance resolution. The system is intended for terrestrial transmission and requires a frame store to reconstruct a 5:3 wide aspect ratio picture.

30. Still others have proposed to improve resolution by using techniques for recreating images similar in principle to the ones created by a personal computer on a CRT display, *i.e.* working with pixels and subpixels rather than lines or fields.[20] One such system is currently under investigation in the U.S. by Richard J. Iredale of The Del Ray Group. The Del Ray system,[21] sometimes referred to as High Definition NTSC (HD-NTSC), is intended for use by all home video transmission media. HD-NTSC uses one 6 MHz channel for transmission and can be displayed as conventional television on existing NTSC receivers with little or no loss in quality. A frame store is used in the HD-NTSC receiver to reconstruct a picture with an aspect ratio of 14:9.

31. Yet other development efforts have focused primarily on investigating various bandwidth compression techniques that essentially compress a wideband program production signal into a narrower bandwith.[22] The compressed signal can fit either on a single channel wider than the NTSC channel or on two separate channels that do not have to be contiguous. As a general rule, any compression of the production signal would affect the quality and purity of that signal. The challenge, then, is to find possible ways to reduce such effects to an unobservable level.

32. A principal developer of a compressed high definition transmission system is The Japan Broadcasting Corporation (NHK). The NHK system uses a bandwidth compression format known as MUSE (Multiple Sub-Nyquist Sampling Encoding), which compresses the signal to 8.1 MHz.[23] The NHK system, intended for use in satellite transmission in Japan, compensates for the loss of resolution that results from bandwidth compression by employing sophisticated frame stores and motion sensors at the receiver. This technique takes advantage of the fact that the human eye has a limited ability to resolve detail in moving objects. The MUSE signal could be displayed on an NTSC receiver, with some degradation, with the use of an add-on converter. The direct broadcast satellite service is expected to be operational in 1990 in Japan. NHK and its affiliated manufacturers intend to have home receivers and videocassette players/recorders ready for mass production in the same time frame. New receivers are designed to display both the enhanced and the NTSC pictures (aspect ratios 16:9 and 4:3, respectively).

33. Another system is under development by Dr. William Glenn at the New York Institute of Technology (NYIT). The NYIT system,[24] intended for use by all video media, especially terrestrial broadcasting, uses a composite bandwidth of approximately 9 MHz, which consists of one 6 MHz channel and an auxiliary channel which occupies about 3 MHz and does not have to be contiguous. The first channel contains an NTSC signal, while the auxiliary channel contains the higher frequency, lower temporal rate information which is used to increase the resolution and the information for the wide aspect ratio (16:9). The

NYIT system takes advantage of the properties of human vision to reduce the transmitted bandwidth and utilizes a frame store to increase the resolution. The NYIT system could be displayed as conventional television on an NTSC receiver without the use of an adaptor.

34. Bell Laboratories has proposed an HD system which requires approximately 12 MHz (two contiguous NTSC channels).[25] The first channel contains an NTSC signal, the second contains the additional signal for improved chrominance and horizontal resolution. A conventional NTSC receiver can display the single NTSC channel with only slight degradation. An HD receiver uses a frame store to produce a high resolution, wide aspect ratio (16:9) picture.

35. CBS Inc. also proposed an HDTV transmission system which is intended primarily for use by the DBS service.[26,27] The CBS system uses two DBS channels. Each channel carries a time multiplex component (TMC) signal. A time multiplex component signal is similar in structure to a MAC signal. The system can be received as conventional television by an NTSC receiver with the help of an add-on adapter. No frame store is required at the enhanced receiver.

36. Another system under development, that has been recently brought to the Commission's attention, is the Osborne Compression System. The Osborne system,[28] intended for use by all video media, uses a complex processing technique to compress the high definition signal into approximately 6 MHz for transmission and expand the compressed signal at reception. The transmitted signal does not require a frame store in the receiver to produce a high resolution picture. The system is not directly compatible with NTSC, but, through the use of a converter, slightly degraded video images could be received on conventional NTSC receivers.

37. Yet another system is under development by North American Philips Corporation. This Philips system, called MAC-60, is a MAC-based system that is intended for use by all video media but primarily by satellite broadcasting systems. This system is at an early stage of development and some of its features are still undetermined.

38. The above list is partial and incomplete. In order to develop the record on the present state of technologies on advanced television, we request comments on the merits of the systems/proposals mentioned above, and solicit further information on all possible proposals or new technologies that would exploit the full potential of an advanced TV service, or would strike a reasonable balance between improved performance and cost, especially opportunity cost.

(3) Questions on Advanced TV Systems

39. From the above discussion, it is evident that the present range of ATV technologies is broad, covering a great number of approaches and development strategies. While it is difficult at this stage to compare the relative merits and disadvantages of the different strategies or approaches, we can generally summarize that most of the work relating to ATV technologies is concentrated in one or all of these three areas; a) video/audio quality performance, b) compression of transmission bandwidth, and c) compatibility with the NTSC system. In general, most of the systems described above use a frame, field or line store at the receiver to reconstruct the picture, and most higher definition transmission systems trade off video/audio quality performance and increased receiver cost for reduced transmitted bandwidth. Some, however, attempt to minimize the loss of quality by using image enhancement or compensation techniques.

40. To assist us in our deliberations on the spectrum management and compatibility questions detailed below, we urge commenters to focus on these quality-for-bandwidth tradeoffs that distinguish the numerous advanced TV systems. Specifically, commenters should address questions of these kinds:

1. What criteria, such as video/audio quality performance, transmission bandwidth, NTSC compatibility, etc., should the Commission use to evaluate and compare the various ATV technologies? What are the appropriate trade-offs between the various criteria?

2. What changes in ATV technologies should be anticipated for the near future? For example, can ATV technologies be expected to develop so that the transmission bandwidth of a high resolution production source can be compressed to fit within 6 MHz channel without apparent loss of quality? At what stage is the development of an all-digital ATV system using digital signal processing and IC technologies?

3. How quickly are developments of the various ATV technologies progressing? Which are now operational? Which are in prototype stage? Developmental stage? How long until these systems are realized?

4. What are the relative costs of these new transmission systems for programming producers? For broadcasters? For consumers?

5. From a technical perspective, what are the advantages and disadvantages of augmenting the channel capacity of existing television assignments? What is the appropriate bandwidth for the augmentation channel? Must it be contiguous to the main channel?

III. SPECTRUM ALLOCATION ISSUES

41. The most important issues the Commission will address in this proceeding, which will unavoidably influence the development and use of advanced television systems, are those relating to the spectrum capacity which should be provided for these systems. We find it highly desirable to resolve these matters as quickly as possible, and after considering the comments received in response to this inquiry, we intend to resolve the spectrum-related issues in a rule making proceeding expeditiously.[29]

42. There are three general factors which we believe should be considered in analyzing the spectrum allocation questions. We must first establish whether advanced broadcast television systems should be separate from, or somehow consolidated with, the existing television broadcast service. We also must consider the technical planning factors (receiving system performance, coverage areas, etc.) that should be developed for advanced television systems. Third, we need to consider a variety of possible bands in the radio frequency spectrum which could accomodate additional capacity requirements of advanced television systems. In this regard, we offer the tentative results of some preliminary investigations that examined

the possibility of providing this capacity in the UHF band. As a final matter, because it offers the prospect of additional spectrum capacity which could be used for ATV, we also consider in this section the possibility of relaxing or eliminating the UHF channel assignment taboos.

A. The Anticipated Nature of Advanced Television Systems

43. The institution of advanced television systems could be provided in one of three ways: 1) as a new service separate and distinct from the existing television broadcast service; 2) as a service that augments wherever feasible existing NTSC service with no provision for full replacement of the NTSC service or, 3) as a service integrated fully with the existing television broadcast service which over time would replace entirely the NTSC service. To the extent that such an approach is both technically feasible and economically efficient, we now incline towards the view that, in the event we establish improved broadcast television systems, they should be implemented in a manner that allows eventually for the complete replacement of the NTSC, so that the benefits of improved off-air television service may be enjoyed by the Nation's viewers generally. However, we solicit comments on all three alternative approaches.

B. PLANNING FACTORS

44. In the *Sixth Report and Order*,[30] the Commission adopted basic technical parameters that essentially established the maximum coverage and quality of service for terrestrial broadcasting. The Commission based the television channel allotment table on the premises that each city or community could be adequately covered by a single high power transmitter and that a service area would extend as far as 50 or 60 miles. On the fringe of the service area, viewers could be expected to utilize better receiving installations, such as high gain outdoor antennas, than the ones used close-in, where rabbit ears or loop antennas are sufficient.

45. While these technical planning considerations have been instrumental in the modelling and development of the current television broadcast service, we are not obligated to use the original technical planning considerations described in the *Sixth Report and Order* in implementing any new service. In fact, we are interested in determining whether stations which propose to transmit advanced TV systems should be modelled on the same technical planning considerations used for the NTSC service, such as a single transmitter per area, a 50- to 60-mile service contour, etc., or whether we should select different technical planning considerations, such as smaller service contour, multiple transmitters to cover a larger service area, outdoor receiving installations only, etc. We are also interested in comments on the desired technical features for this new service.

C. Spectrum Options

46. As is evident from the discussion in Part II, above, some of the ATV transmission systems currently under development would require spectrum capacity greater than that now assigned to TV broadcasters. We wish to develop a full record regarding the advantages and disadvantages of implementing these systems. Therefore, we examine in this section several alternatives for providing additional spectrum capacity for ATV systems.

47. Spectrum decisions could have enormous implications for the structure of future regulatory decisions involving advanced television systems. For example, if we decided not to provide additional spectrum for advanced television systems, future research would likely concentrate on finding ways to make improvements to systems now under development and further reduce advanced television signals to "fit" within the 6 MHz bandwidth. However, by maintaining the *status quo*, we might also be tacitly encouraging the use of an advanced television system that would be the most easily coordinated with the existing allotment scheme, but may not yield quality comparable to other present or future advanced television systems that use greater bandwidths.

48. In the event that we conclude that providing additional spectrum capacity for ATV is in the public interest, the Commission has three options in deciding where in the spectrum to authorize the use of ATV systems for broadcasting: use of the existing VHF and UHF television allocations, use of unallocated spectrum or re-allocation of existing spectrum, or some combination of the two approaches.[31] These options are discussed in detail below.

(1) Use of Existing Broadcast Television Allocations

49. It may be possible to implement an ATV service within the existing VHF and UHF spectrum under current or modified technical criteria. Additional spectrum capacity could be obtained through the adjustment or elimination of the current broadcast-to-broadcast interference protection standards, such as the co-channel or adjacent channel protection at VHF and UHF and the UHF taboos channel protections. (*See* the discussion in the following section.) Moreover, as suggested in the MST petition, additional spectrum capacity might be obtained through partial or total "repacking" of the VHF and UHF bands, *i.e.*, rearranging the existing channel assignments, using existing or modified protection criteria, to accommodate new, wider channels or augmentation channels. While these options are feasible, they have not been fully investigated to determine the amount of spectrum that would be made available and how it may best be used for advanced television. Any estimate of the impact of these options on the existing television service must necessarily depend upon the results of this prior investigation. It is important to note, however, that it may be more difficult from technical and spectrum perspectives to accommodate existing VHF licensees within the present broadcast television allocations.

50. Specifically, the Commission is soliciting comments with regard to this option on the following questions:

6. Should the Commission implement ATV service at UHF only or at both VHF and UHF in a comprehensive plan?

7. What are the technical and economic advantages and disadvantages of this spectrum option?

8. How much additional bandwidth could be made available for ATV, and what would be the interference implications if the Commission:

a. Adjusted the co-channel interference protections ratio?

Adjusted the adjacent channel protection ratio?

Established standards to permit TV licensees to access a channel (or part of a channel) adjacent to their assignment?

b. Modified or eliminated some or all of the UHF taboos channel protection standards?

c. "Repacked" the VHF and UHF spectrum using adjusted protection criteria to accommodate (for example) 9, 10 or 12 MHz-wide channels?

9. What would be the technical and economic impact on existing NTSC service if the Commission modified or eliminated the existing protection criteria?

(2) Use of Microwave Frequencies

51. ATV services might also be accomodated by allocating presently vacant frequencies or by sharing frequencies now allocated to other services. Spectrum below 1 GHz, while best suited for terrestrial broadcasting, is already extensively used by broadcast and other non-broadcast services,[32] and any reallocation of existing non-broadcast spectrum could adversely impact upon existing operations in that portion of the spectrum.

52. Above 1 GHz, there are a number of possible spectrum resources for ATV. For example, spectrum in the 2.5 to 2.69 GHz band could possibly be shared between the existing ITFS/MDS services and ATV. Another possibility is to provide for the sharing of the 12.2 to 12.7 GHz band between ATV and direct broadcast satellite services. Still another possibility is the sharing of some of the spectrum allocated for point-to-point purposes at 22 and/or 23 GHz. These spectrum possibilities have not been fully investigated to determine their suitability and desirability for terrestrial broadcasting as well as their overall economic impact on existing television broadcasting.

53. The Commission is therefore soliciting comments on the following questions:

10. Should the Commission accommodate ATV in non-broadcast spectrum allocations? If so, in what portion of the spectrum and how much?

11. What are the technical and economic advantages and disadvantages of this spectrum option under the various scenarios described above?

12. How well do the technical and economic advantages and disadvantages in this spectrum option compare with the other options described above?

13. If ATV is implemented outside the conventional TV bands should we also pursue proposals to adapt conventional TV to ATV? Is it worthwhile to pursue ATV at both UHF and microwave?

14. What technical problems, such as propagation or equipment development, could impede implementation of a terrestrial ATV service at 2.5 GHz, 12 GHz, 23 GHz, or other portions of the spectrum?

15. What is the impact of sharing non-broadcast spectrum with ATV on the non-broadcast services?

(3) Use of New and Existing Allocations

54. Some combination of the two spectrum approaches outlined above could be employed. For example, if the augmentation channel concept were used in initiating advanced TV service, we could possibly authorize that "second channel in some newly allocated spectrum, especially if little or no additional spectrum proves to be available in the existing VHF or UHF television bands. Advanced TV stations could also be authorized both in existing and, when necessary, in new spectrum. We encourage commenters, especially those supporting advanced TV proposals which would employ additional spectrum, to consider spectrum options of these kinds (or any others) in their proposals.

(4) Illustrative Approaches for Advanced Television

55. Although we encourage commenters to offer alternatives, at this juncture we foresee spectrum capacity for advanced TV use coming from either the existing VHF and UHF TV allocations or microwave allocations above 1 GHz. Moreover, based upon our current knowledge of advanced TV systems and of the general approaches towards modification of the UHF taboos, it appears that there are promising approaches for the implementation of advanced television service that utilize frequencies already allotted for television broadcast use. Such approaches would encourage existing broadcasters to participate in the provision of such ATV services, would foster compatibility with the existing NTSC service and would promote more intensive use of the existing broadcast spectrum.

56. One approach, of course, is to use a 6 MHz channel; changes under this approach would be minimal. However, there might be some impact upon existing coverage areas. Another approach is the use of existing unoccupied UHF spectrum. Specifically, the Commission staff is investigating an approach under which existing broadcast stations would be allotted an additional 3 MHz of spectrum. The Commission's goals and objectives in investigating this approach are to maximize the number of broadcast outlets, both VHF and UHF, that could be accommodated with an additional 3 MHz of augmentation spectrum and to minimize the impact on existing broadcast station service areas. Accomplishing this may entail relaxation of existing UHF taboos and rearrangement of the present UHF television assignments.

57. While the staff's investigation is still in the very preliminary stages, our initial findings relating to the number of licensees that can be accommodated with an additional 3 MHz allotment are quite encouraging. For example, on the basis of a limited initial study, it appears as if all existing VHF and UHF stations operating within 20 miles from New York City could be assigned an additional 3 MHz each, with only a moderate reduction in the advanced TV service area relative to the existing NTSC service of currently operating stations. The NTSC coverage areas would also be maintained.

58. To further investigate these approaches, we require public comments on a number of issues. For example, should the Commission trade off service area coverage to increase the number of ATV outlets? If so, what is the minimum acceptable coverage area? In allotting additional spectrum should the Commission give preference to stations with small or large service areas, to major markets over smaller markets, VHF stations over UHF stations etc.? The Commission therefore solicits public comments on these issues as well as the value of the approaches described above in addition to any other proposals or observations.

D. Advanced Television and the UHF Taboos

59. As indicated above, among the spectrum capacity options we wish to consider for ATV are the UHF assignment proscriptions, known as the "UHF taboos," which have resulted in many unallotted channels in local television markets. These taboos limit the maximum number of UHF allotments in any community to 9 out of the possible 55 UHF channels. Since the implementation of the UHF taboos, the Commission has attempted on a number of occasions to assess the need to retain these restrictions in light of continual changes and improvements in television receiver design. In this proceeding, we wish to:

> reexamine the extent to which the UHF taboos continue to be necessary for the protection of existing service; focus on the effects the taboos may have on the implementation of advanced television systems; and consider what effect the development of improved receivers (those associated with advanced TV systems) may have on the need for maintaining the current UHF taboos or introducing new taboos.

(1) Background

60. The UHF taboos were established by the Commission in 1952, and were intended to avoid certain interference effects due to television receiver design characteristics of that time, more specifically, their inability to reject signals on other than the desired channel. The current taboos were formulated in the *Sixth Report and Order*, at which time there were 70 channels allotted for UHF-TV use, as compared with the 12 channels allotted for VHF-TV.[33] In establishing the UHF-TV table, the Commission gave greater weight to the interference susceptibility of UHF-TV receivers than was given in allotting the narrower VHF-TV band.[34] Consequently, when allotting channels in the UHF-TV spectrum, the Commission imposed additional distance and channel separation requirements, which led to restrictions on UHF-TV channel assignments throughout the United States.[35] The taboos take into account the following receiver characteristics: adjacent channel response, sound and picture image ratios, intermediate frequency (IF) response, level of local oscillator (LO) radiation, and channel intermodulation (IM) effects.

61. Unwanted television receiver responses are predicted to occur when specified combinations of required distance and channel separations are violated.[36] A summary of these unwanted receiver responses and their respective channel and distance separations are listed below, with "n" representing the channel to which a receiver is tuned.

a. Intermodulation (IM) --- (n + 2, 3, 4, 5 channels) (31.4 kilometers or 19.5 miles separation)

b. Intermediate frequency (IF) beat -- (n + 8 channels) (31.4 kilometers or 19.5 miles separation)

c. Sound image --- (n + 14 channels) (95.7 kilometers or 59.5 miles separation)

d. Picture image --- (n + 15 channels) (119.9 kilometers or 74.5 miles separation)

e. Local oscillator (LO) radiation --- (n + 7 channels) (95.7 kilometers or 59.5 miles separation)

f. Adjacent channel[37] --- (n + 1 channel) (87.7 kilometers or 54.5 miles separation)

(2) Description of the Taboos.

62. Most of the taboo related interference can be associated with one or the other of two television receiver attributes--the use of an intermediate frequency (IF) and non-linearities in amplifier sections or other non-linear components. The taboos are intended to limit the amount of interference to a receiver tuned to a susceptible channel to that which would be received from a co-channel station at minimum separation between the desired and interfering stations. Interference is controlled by insuring that television receivers tuned to a given channel are not exposed to strong signals on any channel or combination of channels at levels capable of producing interfering products in the receiver.

63. A television receiver works on the superheterodyne principle. It translates an incoming radio frequency (RF) signal to a fixed intermediate frequency (IF), which is then amplified and demodulated. The translation is accomplished in a "mixer", whose output frequencies are sums and differences of integral multiples of its input signals. One input signal to the mixer is generated by the local oscillator (LO) of the receiver. A second input signal is the desired television signal. In television receivers the LO signal is higher in frequency than the desired TV signal by an amount equal to the IF and beats with the desired signal to produce a signal in the IF band (LO frequency minus tuned frequency equals IF). The IF band in a modern receiver is 41-47 MHz. The translated picture carrier is at 45.75 MHz and the translated sound carrier is at 41.25 MHz.

64. *Sound and Picture Images.* Undesired sound and picture image frequencies lie 14 and 15 channels above the desired channel. Signals on these frequencies beat with the LO frequency in the mixer to produce signals which fall within the IF band (image frequency minus LO frequency equals IF), where they interfere with the translated desired signal. Because the sound carrier image signal has a lower amplitude and its IF translation falls further from the desired picture IF frequency, its required taboo separation is less than that of the picture carrier image.[38]

65. *Local Oscillator Radiation.* The frequency of the local oscillator of a receiver is located in the seventh channel above the channel to which the receiver is tuned. Radiation from a receiver's local oscillator can be picked up by nearby receivers tuned seven channels above that of the first receiver.

66. *IF-Beat.* IF-Beat interference occurs when two signals separated by 7 or 8 channels mix in a nonlinear element (such as in the mixer) to form a new signal in the IF band. The 31.4-kilometer (19.5-mile) taboo separation for stations on frequencies 7 and 8 channels removed is intended to insure that no location receives signals strong enough to produce the IF beat. The effects of the 7th channel IF-beat are overshadowed by the radiation of the local oscillator of a television receiver to a victim receiver tuned 7 channels above. The 95.7-kilometer (59.5-mile) separation required to protect against oscillator radiation therefore provides protection against the 7-channel IF beat.

67. *Intermodulation.* Intermodulation (IM) products are produced in amplifiers and other non-linear components of a television receiver when certain combinations of fre-

quencies are present at high levels. IM interference can result from the third order products (fx=2fa-fb) of two unwanted signals, fa and fb. The 31.4 kilometer (19.5 mile) minimum separation between stations on the IM taboo channels is intended to insure that a receiver tuned to a given channel will not be exposed to strong signals on a combination of frequencies capable of producing the interfering products.

(3) Efforts at Reevaluation

68. Due to the relationships among the taboo restrictions, the first UHF-TV channel assigned to a city can restrict as many as 18 other channels within the respective distances as described above. Thus, as a result of the increased demand for spectrum in other radio services over the years, considerable interest has been expressed for sharing the use of these vacant channels. In fact, among the assumptions used in establishing the taboos was that the interference susceptibilities of television receivers would be improved eventually and that many of these channels could be allotted. We have, therefore, continued to reevaluate the UHF taboo criteria to determine to what degree they remain necessary, given the interference immunities of modern receivers.

69. This ongoing evaluation has relied to a great extent on the data base of receiver performance relative to the taboos. The Commission's first published reevaluations of the UHF interference immunities in 1974 included forty-seven TV receivers.[39] These data were also referenced in a *Notice of Inquiry* to reevaluate and revise the UHF-TV taboo table.[40] The data from the test evaluation of the forty-seven receivers were used as bases for performance criteria for an advanced technology prototype television receiver. These data and comments submitted by interested parties were subsequently folded into a new proceeding and accompanying report in 1978, which were centered on interference immunities of advanced technology television receivers.[41,42]

70. Inasmuch as the 1974 data had not supported the relaxation of all of the taboos, the Commission wished to consider the improvements which could be achieved by an advanced state-of-the-art TV receiver. Consequently, pursuant to a contract with the Commission, a prototype of such an advanced receiver was built by the Texas Instruments Corporation (TI). Tests revealed that the prototype receiver was markedly superior to most conventional receivers in the sample with respect to adjacent and image channel rejection. However, the TI receiver was not significantly better with respect to all the other taboos.

71. To further explore possibilities for improved receiver performance, the Commission contracted in 1979 to have a second prototype receiver built by RF Monolithics, Inc. (RFM). Testing of the RFM receiver and subsequent computer modelling analyses resulted in the issuance of two reports in which it was concluded that reductions in taboo channel spacings based on the performance of the RFM receiver could allow an increase of UHF-TV allotments.[43] The analysis indicated, however, that those receiver immunities, as related to the new design of its IF stages, would be of only limited benefit in the ten largest television markets because of existing channel congestion. Moreover, if new distance separation requirements were enacted on the basis of the performance of the RFM receiver, some viewers using existing receivers would be subjected to interference.

(4) Discussion

72. In the present reexamination of the UHF taboos there are new elements to be considered, including additional receiver test data and possible re-interpretation of the relationship between the test data and the taboos. Also to be considered are the effects of less than full power operation by many UHF television stations and the potential introduction of new advanced television receivers with characteristics quite different from those of present vintage.

73. As a result of a preliminary laboratory study, the Commission is placing additional television receiver test data into the record in this proceeding. Some changes in receiver designs over the years appear to have had salutary effects. For example, a general lowering of oscillator radiation levels can be attributed to the dominance of electronic tuners; this would reduce the need for the oscillator UHF taboo.[44] Of greater interest are preliminary comparisons between UHF performance and "VHF reference performance," which seem to support relaxation of the UHF taboos.[45]

74. Existing TV operations on Channels 7 through 13 could result in interference if actual VHF receiving system performance characteristics were similar to those now assumed for UHF.[46] Therefore, an understanding of the relative performance of VHF receivers can provide insights into the actual effects of reducing or eliminating the taboos. In practice, the comparison is made as follows: First, the VHF reference performance of a sample of television receivers is determined. Then the performance of the sample is determined for a certain combination of UHF channels, representing a UHF taboo. A comparison of the UHF with the VHF receiver performance has one of three outcomes:

(a) The UHF performance is better than the VHF performance. This is interpreted as suggesting relaxation of the UHF taboo.

(b) The UHF performance is about the same as the VHF performance. This is interpreted as suggesting modifying the UHF taboo with a prohibited zone stipulation, meaning locating stations adequately close together (almost equal signal levels) or adequately far apart (desired signal sufficiently greater than undesired).

(c) The UHF performance is poorer than the VHF performance. This is interpreted as suggesting that the UHF taboo should be maintained.

75. On the basis of preliminary results using the new concept, changes to the UHF taboos appear to be feasible. These results suggest that the following UHF taboos could be relaxed: IF Beat (n + 8 channels), intermodulation (n + 2, 3, 5 channels) and oscillator radiation (n + 7 channels). Relaxation of the oscillator radiation taboo is based on analyses of receiver local oscillator radiation levels in addition to the VHF reference concept.

76. Evaluation of newer receiver data further indicates that the sound image taboo (n + 14 channels) and the newly named half-IF taboo (n + 4 channels), which was originally included with the intermodulation restriction, could be modified but with a prohibited zone stipulation. The results of the VHF reference analysis also suggests that adjacent channel restrictions (n + 1 channel) could be modified for UHF. On the basis of the preliminary

data, it appears that the picture image taboo (n + 15 channels) should be maintained for full power UHF television stations.

(5) Questions

77. The ultimate effect on the existing television broadcast service of modifying or eliminating some or all of the UHF taboo restrictions depends on the complex interrelation among numerous factors. These factors include:

*Which taboos are changed and to what extent.

*The varied characteristics of TV receivers now in use.

*The present geographical distribution of operating stations.

*The spacing of communities to be served by any new stations.

*The effect of receiving antenna directivity and local propagation factors.

*Commission-established priorities concerning the number of channels available in a community as a function of population size, desirability of local stations, availability of new channels, etc.

*The value of additional channels relative to the cost of interference to existing service.

78. Any general discussion of the impact of the existing or modified taboos on the implementation of future advanced television systems and the impact of improved advanced television receivers on the need for the UHF taboos would be premature at this time. A valid evaluation would have to include all of the factors listed above as well as new ones concerning the susceptibilities of new transmission modes and new receivers. Therefore, in view of the foregoing, this proceeding solicits constructive responses to the UHF taboo issue in general, and in particular to the following questions:

16. The present taboos were adopted in 1952 and have remained unchanged since that time. What taboos should be eliminated or modified and what impact would this have on existing television service?

17. In reevaluating the effect of taboos generally, what percentage of viewers should be protected?

18. Are the conclusions concerning the "VHF reference" criteria described in this proceeding justified? Should the taboos be modified as suggested in this proceeding?

19. Because of the taboos, only 9 (at most) UHF channels can be assigned to any given city.

a. To what extent could broadcasters take advantage of the "gaps" in the allocation table to transmit auxiliary information for advanced TV systems?

b. Should new assignments made possible by elimination or modification of taboos be reserved for advanced TV system use, opened for licensing to new full service stations, or used for other purposes?

20. a. How might future improvements in television receivers affect susceptibility to taboo frequencies?

b. Are advanced TV signals (including any auxiliary signals or augmentation channels) likely to be more, or less, susceptible to current taboo frequencies? Will new taboo frequencies arise?

c. Are changes in receiver designs likely to cost-effectively reduce the susceptibility of receivers to taboo frequencies for NTSC signals?

d. What are the anticipated costs of taboo-immune TV receivers and the time frame for significant market penetration?

21. Should the Commission take action now to encourage reduced generation of and susceptibility to taboos, either on channels used for NTSC or auxiliary advanced TV signals? If so, what action is appropriate, *e.g.*, spectrum allocation, interference criteria, or other?

79. Many matters raised in this inquiry will have to be resolved before the taboos are modified. Thus, we invite comments from all interested parties on the issues identified and discussed above. Further, we encourage commenters to address issues that we have not identified. The record established in this proceeding will allow the Commission to determine the impact of relaxing the UHF taboo criteria, and will facilitate any subsequent rule making proposals, including our decisions on spectrum for advanced television.

IV. ADVANCED TELEVISION COMPATIBILITY ISSUES

80. Compatibility is a term which may be used to describe one of two sets of relationships. It is used generally by the various proponents of ATV technologies to describe their systems in relation to the current NTSC system. It may also be used to describe the ability of a receiver designed to display one ATV format to also display a signal using another advanced television format. Both meanings of the term are considered in this section.

A. NTSC Compatibility

81. Some have used the term compatibility to describe the relationship between their transmission system and the NTSC standard, while others use it to describe whether their system could be received by an conventional NTSC receiver or whether it could be operated within a 6 MHz channel. To eliminate this confusion, the term "compatibility" will be used for the purposes of this proceeding in a specific sense so as to establish consistent guidelines for evaluation and comparison of the various ATV technologies. An ATV system will be considered to be compatible with the existing television channel allotment plan if it operates consistent with the present 6 MHz channelization scheme. Similarly, an advanced TV system will be considered to be receiver compatible if the advanced signal can be decoded and viewed on a conventional NTSC receiver. In considering the evolution to advanced broadcast television, we are especially interested in soliciting comments on how well the various ATV technologies fit this definition of compatibility, and if incompatible, what would be required to make these systems compatible.

82. A related matter which we discuss below concerns the continuation of mandated NTSC transmission standards.[47] As important as these requirements may have

been over the years, their continuation may no longer be necessary and may be counterproductive in some instances.

(1) Transitional Issues

83. Inasmuch as the introduction of an ATV system which is not viewable on NTSC receivers could be costly to viewers, we consider the potential compatibility of any new ATV system(s) with the existing NTSC system to be an important consideration in this proceeding. We are concerned that future improvements to broadcast television, especially if "advanced" or "improved" signals are unviewable on NTSC receivers, may result in temporary dislocations of service for the great majority of video consumers; for that reason, we specifically request comment on issues relating to the transition from NTSC transmission standards to a television broadcast marketplace in which advanced television systems could be transmitted. In particular, we are seeking advice as to how much decisional significance to accord the compatibility or viewability of any improved or advanced signal on an NTSC receiver. As a presumptive matter, we attach great weight to the ability of an ATV system to be viewed on an NTSC receiver.

84. An NTSC-compatible advanced system could also prove to be inferior within a short time to other advanced television systems that make more dramatic picture and sound improvements while using little additional spectrum. It may also be possible that maintaining compatibility with the NTSC system would impose a spectrum cost. That is to say, an incompatible system might be designed to use spectrum more economically than a compatible system of comparable quality.

85. In light of these possibilities, we request comment on ways of eliminating viewers' dislocations in the transition to ATV other than maintaining compatibility with NTSC. One approach is to allow for the simultaneous broadcast (simulcast) of programming in both NTSC and ATV formats. Of course, this alternative may also result in short term uneconomic spectrum use.

86. Alternatively, receivers with the built-in ability to decode and display advanced television signals broadcast with different transmission standards and/or using different channelization schemes may be desirable and could promote the utilization of advanced television systems while retaining the capability of receiving programs transmitted in the NTSC format.[48]

87. In addition, we seek comment on whether the availability of inexpensive converters that could decode and display an advanced television signal on existing receivers could instead prove to be the most practical and cost-effective way for consumers to make the eventual transition to an advanced TV system.

88. Finally, advanced video services may become available in the non-broadcast video marketplace shortly. Therefore, comment is requested on the resulting impact of marketplace choices in this area on the receivers available in the future for the reception of advanced television broadcasting.[49] By way of background, we note that all these non-broadcast outlets currently employ the NTSC system in the U.S. For example, VCRs of both the VHS and BETA type record a baseband NTSC signal and provide an NTSC output to receivers or receiver/monitors, which must decode the NTSC output of the VCR to display the recorded program. Video player units work in the same way. Thus, a decision on the format of the advanced video signal to be recorded by VCRs could have a significant effect on the type of receiver required by the viewer. However, if advanced video VCRs could provide a decoded output, then they would be able to work with an advanced video display device (such as a wide screen RGB input). Comment is also requested on the desirability of encouraging the production of this type of advanced video VCR and/or player compared to the type requiring a receiver based upon the same advanced video system.

(2) Relaxation of the Mandatory NTSC Standard

89. The terrestrial TV broadcast system is large and well established, with an estimated 130 million NTSC TV receivers in U.S. households. The NTSC standards were established when the industry was very young and arguably required universal compatibility standards in order to develop a national television broadcasting system in a timely manner. The substantial growth of that system may be attributed in part to the fact that there was one television transmission standard, and therefore, all consumer television receivers were manufactured to receive NTSC signals off the air. A receiver manufacturer could design his product to display an image from the standard NTSC signal with the knowledge that his receiver would function with any television broadcast transmitter.

90. As important as these mandatory standards may have been, their continuation may no longer be required and may, in some instances, be counterproductive. There are three factors which suggest that the public interest may be best served by making these rules voluntary.

91. First, relaxation of the NTSC standards could facilitate the introduction of some ATV systems. As discussed in Part II above, some proposed advanced TV systems would retain a certain level of signal compatibility with current consumer TV receivers.[50] Improved NTSC systems, such as the proposed Fukinuki system, would be viewable (without improvement) on the standard NTSC receiver. This system would enhance some aspects of NTSC receiver images and provide higher resolution images on receivers with improved display processing circuitry. The proposed Glenn system would also be viewable on NTSC receivers, and, in addition, could display a high resolution wide screen image on an enhanced television receiver. Although the programming on such advanced systems could be viewed with typical consumer receivers, the signal formats may not fully conform to all aspects of the NTSC standard.

92. Second, technological improvements in receiver design reduce the need for broadcasters to adhere rigidly to the NTSC format. As mentioned previously, the NTSC standard has been modified on several occasions to accommodate special needs of the broadcaster and its audience. In such instances, even though the transmitted signals may have been different from the original NTSC format, they were compatible with then current consumer TV receivers. Certain other parameters of the original NTSC standard can probably also be relaxed because of the evolution in design and improvements in each new generation of TV receivers. Manufacturers frequently take advantage of new technologies, such as integrated circuitry, that help to correct impairments inherent in the transmission of the TV signal. These features also make receivers more tolerant of minor deviations of the TV signal from the NTSC standard.

93. Third, with the very large population of existing consumer NTSC TV receivers, broadcasters should have a strong incentive to maintain compatibility with those receivers. Deviation from the NTSC standards could have definite economic implications for the broadcaster that weigh heavily in the selection of any alternative transmission format (including advanced TV systems), particularly if that system is not compatible with currently existing TV receivers.

94. Although it appears that no adverse effects on the delivery of broadcast television would result if the NTSC standard were now made voluntary, we request comment on the need to maintain some technical specifications in the rules to ensure service is continued to viewers. We would expect a gradual transition of some stations to advanced TV systems as the use of advanced systems becomes more economically feasible. For example, depending upon the cost, availability, features, and selection of advanced TV receivers, many viewers may choose to defer purchase of such a receiver until some period of time after the introduction of advanced television in their area.

95. Rather than amending the mandatory NTSC transmission standard on a case-by-case basis to accommodate enhancements to TV signals, we could employ the standard as a guideline and make it voluntary in nature.[51] This is not meant to minimize the important role that the standard has played and is playing. This action would merely remove constraints that might hinder the development and implementation of advanced television systems.

96. Although the current TV stereo sound standards are gaining more widespread use, as evidenced by the growing number of stations broadcasting programs in that format, it may be premature to modify that standard at this time. If this is the case, we could make only the visual NTSC standard voluntary and retain the aural standards intact for stations using separate aural and visual carriers. Comments are solicited on these ideas.

B. ATV Compatibility Standards

97. In addition to NTSC compatibility, we also wish to consider the desirability of encouraging compatibility among advanced television transmission systems. There may be substantial benefits to consumers if ATV compatibility standards are adopted, either through formal Commission action or through voluntary standards organizations. Nevertheless, we are also mindful of the benefits that could come about through improvements in technology made subsequent to the establishment of standards, and we do not wish to foreclose these possibilities.

98. We see at least three different ways of achieving the benefits of ATV compatibility while not precluding the introduction of future technical improvements. First, we could adopt, as voluntary guidelines, the results of an industry consensus. Alternatively, we could establish detailed compatibility criteria only for a short period of time *(e.g.,* five years). Finally, if the systems prove adaptable to this approach, we could protect a key frequency component of the modulated baseband in much the same way we did for multi-channel television sound.[52]

V. POLICY ISSUES

99. In this section we consider a variety of matters relating to the public interest implications of providing for advanced television systems and the advantages and disadvantages of various implementation options.

A. Public Interest Issues

100. The industry petition asserts that the institution of non-broadcast advanced television (MUSE-encoded VCRs, for example) could place the television broadcast service at a distinct competitive disadvantage because of its potential popularity, because non-broadcast services may simulcast programs in advanced television and NTSC formats, and because advanced television receivers will likely be engineered to display NTSC signals as well. Without improvements to the NTSC transmission system, the industry claims, this situation could result in the economic disruption of the industry with a concomitant loss of service from the public's only source of off-air, local television.

101. In light of the assertions made in the Industry Petition, we request that commenters address the following questions:

> 22. What are the possible consequences, for terrestrial broadcasting, of the non-broadcast uses of advanced television?
>
> 23. What is the expected effect of these consequences on the overall quality, quantity and value of video programming delievered to American viewers?

B. Spectrum Allocation Issues

102. Giving all terrestrial broadcasters an opportunity to provide improved television images to viewers would appear to be a worthy public interest goal. However, many of the improved television transmission systems now under consideration would require spectrum capacity greater than that now assigned of terrestrial broadcasters. Inasmuch as there are both other attractive uses of spectrum in addition to improved television and many different ways of delivering improved television images to viewers, the overarching question we must address in this proceeding is how to provide for the optimum mix of advanced television (in terms of quality and quantity) and other communication uses. Answering this question will require an understanding of the value of employing a particular portion of spectrum for advanced television use relative to other purposes. Would consumers be better served, for example, by employing vacant UHF frequencies for improved television, new TV outlets using present day standards, additional land mobile radio services, or some combination of these? Accurate judgments on this question require, among other things, information on the cost and performance tradeoffs involved in using different amounts and regions of spectrum for various purposes, and in the discussion above we have asked commenters to provide us with this information.

103. On the basis of the information we develop in this proceeding, we could evaluate the various tradeoffs using our traditional spectrum allocation decision making framework.[53] It is at least conceivable that circumstances will present us with relatively easy spectrum allocation decisions. If it is established, for example, that substantial improvements in television images can be achieved at reasonable cost using only the existing 6 MHz channel assignments, there may be no compelling need to consider

altering the present allocation arrangement. A similar decision is possible if the record convinces us that the demand for improved broadcast television is extremely weak.

104. In the event that these, or similar, circumstances do not obtain, however, we will be faced with decisions to adjust the allocation arrangements. In this instance, the existence of several factors make these decisions particularly difficult. First, it may be virtually impossible to assemble all the information necessary to arrive at a globally optimum decision. In addition to the complexity of the body of information required for such a decision, a significant fraction of the needed data may be obtainable only by observing what consumers are willing to purchase. Moreover, improvements in technology and changes in consumer demand could have substantial effects on what would be the best use of spectrum over time.

105. In the event that we ultimately find it in the public interest to allocate spectrum capacity for the provision of advanced broadcast television, it is our initial view that all television licensees should be allotted such additional capacity and thereby given the opportunity to provide improved service to their audiences. In light of this, and the difficulties described above, we seek comment on an approach that would provide spectrum capacity for advanced television systems, and would also provide licensees with the opportunity and incentive to utilize portions of this capacity in non-ATV uses. Under this approach, we would grant licensees an additional allotment of channel capacity as described above. All uses of the augmented channel capacity would be governed by certain interference restrictions, but within these limits usage would be governed by rules analogous to those which govern subcarrier operations for TV and FM licensees.

106. We see at least two instances in which providing broadcast licensees with freedom to utilize augmented channel capacity would be advantageous to licensees and consumers. First, it is conceivable that demand for ATV service may not be uniform across all regions of the country. For example, while all stations in a small market may find it beneficial to provide ATV service to their viewers, large market stations with small viewing audiences may not benefit substantially from employing ATV. These stations may be more willing to utilize the augmented spectrum capacity for non-broadcast services. Second, even if all stations ultimately chose to provide ATV services, the timing of these decisions may vary from station to station.[54] Therefore, providing licensees the freedom to use the augmented capacity for alternative uses would prevent the frequencies from lying fallow prior to its use for advanced television.

107. We acknowledge that there exist technical differences between the capacity employed for SCAs and the augmented channel capacity provisions considered herein. These differences notwithstanding, we find that the public interest benefits which accrue from the enhanced efficiency resulting from the freedoms we provide broadcasters with regard to subcarrier usage provide a basis for tentatively concluding that a similar approach to regulating augmented TV channel assignments would likewise be in the public interest. Under this approach, no Title III broadcasting obligations would attach to ancillary broadcast *(e.g.,* improved video) and non-broadcast services provided on the augmentation channel. Commission notification of all such uses of these frequencies would be required, however, as would compliance with all rules governing the provision of these services in other frequency bands.

108. In the context of addressing the desirability of this general approach and the utility of the provisions outlined above, we request that commenters respond to the following questions:

> 24. Under what circumstances would the public be disadvantaged under a regime, such as the plan discussed above, where television licensees were authorized some discretion in the deployment of any augmented spectrum capacity they might be assigned?
>
> 25. As compared to the plan offered above, what are the relative advantages and disadvantages of providing for "non-conforming" use on augmented channels in a manner similar to that used for such operations in the Direct Broadcast Satellite service?[55]

C. Interference Rights and Responsibilities

109. In the discussions above, we have examined relaxation of both the mandatory NTSC standards and the UHF taboos. In this section, we consider in the context of these two issues, the desirability of giving licensees some freedom to alter the interference protection established by Commission rules.

(1) Relaxation of the Mandatory NTSC Standard

110. The NTSC transmission standard now in the rules is an input in our establishment of interference protection for viewers. Inasmuch as different transmission formats may cause or receive interference levels which are different than NTSC, we wish to consider authorizing alternative interference arrangements in cases where the affected licensees or applicants reach a private agreement. If an existing licensee that wished to transmit in an advanced TV format would be precluded from a site on the grounds that part of the protected coverage area would receive interference from an existing station or stations, we could entertain a request from the applicant to relinquish interference protection in that particular zone. Likewise, if an applicant would be precluded from a site on the grounds that the transmitter would not afford proper interference protection to an existing station or stations, we could entertain a request from the applicant, to waive specific provisions for interference protection if supported by proper documentation of agreements between all affected parties that they would accept the interference, in that case. Comments are solicited on this proposal. In particular, we are interested in evaluating whether broadcasters could be expected to reach arrangements which would tend to maximize the public interest benefits derived from the modification of the broadcast facilities involved.

(2) Relaxation of UHF Taboos

111. To the extent that some UHF taboo requirements must be maintained, we also wish to consider a procedure whereby taboo channels may be used when such use represents a net gain to the public. We therefore seek comment on the desirability of allowing affected stations to operate contrary to the taboo restrictions and accept any potential interference conditions by mutual agree-

ment. While the UHF taboos are currently set forth in our rules as channel preclusions both above *and* below the assigned channel, in many cases, actual interference to an existing station would only occur if a new station were authorized either above *or* below, not on both sides of the assigned channel. These one-way taboos include those related to sound and picture image, oscillator radiation, and, in some cases, IM taboos. In these one-way taboo cases, we could allow the precluded channel to be used on the grounds that any service provided on these frequencies would represent a net gain to the public, even if coverage was somewhat limited due to interference. Moreover, certain uses of these channels (*e.g.,* as augmented capacity for ATV) may be made immune to the interference mechanism in question.

112. We also wish to consider the desirability of allowing for some use of taboo channels even in those situations where such use might be expected to create interference. In some cases, by virtue of the technical characteristics involved, the adverse effect may be relatively slight when compared to the public interest gains of such operation. Under either of the possibilities considered herein, we request commenters to address whether the public interest would be benefited by permitting private arrangements among affected licensees.

113. To provide us with both the legal and policy analysis necessary to consider the advantages and disadvantages of permitting privately negotiated levels of interference by licensees, we request that commenters address the following questions:

26. What are the public interest gains and losses of giving licensees greater discretion in determining the levels of interference they wish to tolerate?

a. Under what circumstances would application by the Commission of a uniform interference protection policy be adverse to the aggregate best interests of viewers?

b. Under what circumstances would an arrangement beneficial to all affected licensees be, nonetheless, adverse to the best interests of all affected viewers?

c. To what extent is the issue of allowing licensees to privately negotiate and agree upon levels of interference necessary for the development of advanced broadcast television?

d. What is the possibility that contracts or negotiated agreements would result in the practice of excluding less desirable demographic areas from receiving service?

27. With regard to the Commission's legal authority:

a. To what degree, if any, is implementation of the concepts discussed above dependent upon additional statutory authority?

b. Are contracts or private licensee agreements for levels of interference inconsistent with Section 307(b) of the Communications Act?

28. The facilities changes which would result from private interference agreements would require license modification. In light of this,

a. To what extent would the Commission be required under Section 309 of the Communications Act to review and approve the specifics of the arrangement?

b. What criteria should the Commission consider in making such an evaluation?

29. To what degree should the Commission be involved in either prescribing contract duration or enforcing breaches in private contracts?[56]

VI. CONCLUSION

114. Diverse paths to the future of television have been described and discussed in this document. At the beginning of this *Notice*, we acknowledged the significant interrelationship between the complex spectrum utilization and interference protection issues that must be considered in any attempt to improve the television broadcast service. To assist us in our decisions on these important issues, we urge that commenters similarly consider the broad context within which action may soon be taken to bring the benefits of advanced television technology to the public.

VII. ADMINISTRATIVE MATTERS

115. Accordingly, the Commission adopts this *Notice of Inquiry* pursuant to the authority contained in Sections 1, 3, 4(i) and (j), 303(g) and (r), 309, and 403 of the Communications Act of 1934 as amended.

116. Pursuant to procedures set out in Section 1.415 and 1.419 of the Commission's Rules, interested parties may file comments on or before **November 18, 1987,** and reply comments on or before **January 19, 1988.** All relevant and timely comments will be considered by the Commission before final action is taken in this proceeding. In reaching its decision, the Commission may take into consideration information that is placed in the public file, and provided that the fact of the Commission's reliance on such information is noted in a *Notice of Proposed Rule Making*, a *Report and Order*, or any other documents adopted in this proceeding.

117. For purposes of this nonrestricted notice and comment rule making proceeding, members of the public are advised that *ex parte* contacts are permitted from the time the Commission adopts a Notice of Inquiry until the time a public notice is issued stating that substantive disposition of the matter is to be considered at a forthcoming meeting or until a final order disposing of the matter is adopted by the Commission, whichever is earlier. In general, an *ex parte* presentation is any written or oral communication (other than formal written comments/pleadings and formal oral arguments) between a person outside the Commission and a Commissioner or a member of the Commission's staff which addresses the merits of the proceeding. Any person who submits a written *ex parte* presentation must serve a copy of that presentation on the Commission's Secretary for inclusion in the public file. Any person who makes an oral *ex parte* presentation addressing matters not fully covered in any previously filed written comments for the proceeding must prepare a written summary of that presentation. On the day of oral presentation, that written summary must be served on the Commission's Secretary for inclusion in the public file, with a copy to the Commission official receiving the oral presentation. Each *ex parte* presentation described above must state on its face

that the Secretary has been served, and must also state by docket number the proceeding to which it relates. *See generally* Section 1.1231 of the Commission's Rules.

118. To file formally in this proceeding, participants shall file an original and five (5) copies of their comments and other materials. Participants wishing each Commissioner to have a personal copy of their comments should file an original and eleven (11) copies. Members of the general public who wish to express their interest by participating informally may do so by submitting one (1) copy. All comments are given the same consideration, regardless of the number of copies submitted. All documents will be available for public inspection during regular business hours in the Commission's Public Reference Room at its headquarters, Room 239, 1919 M Street, N.W., Washington, D.C. For general information on how to file comments, please contact the FCC Consumer Assistance and Information Division at (202) 632-7000.

119. For further information regarding this proceeding, contact Terry Haines, Policy and Rules Division, Mass Media Bureau, (202) 632-7792, or Victor Tawil, Office of Engineering and Technology, (202) 653-8162.

FEDERAL COMMUNICATIONS COMMISSION

William J. Tricarico
Secretary

APPENDIX A

SUMMARY OF COMMENTS

A) Commenters

Satellite Broadcasting and Communications Association (SBCA)

Consumer Electronics Group of the Electronic Industries Association (EIA/CEG)

Hughes Communications Galaxy, Inc. (HCG)

Home Box Office (HBO)

American Petroleum Institute (API)

Corporation for Public Broadcasting (CPB); National Association of Public Television Stations (NAPTS); and Public Broadcasting Service (PBS)

Motorola, Inc. (Motorola)

Buffalo Broadcating Co., Inc. (WIVB-TV)

U.S. Advanced Television Systems Committee (ATSC)

Land Mobile Communications Council (LMCC)

National Association of Business and Educational Radio, Inc. (NABER)

Telecommunications Research and Action Center (TRAC)

B) Comments in Response to the "Petition for Notice of Inquiry Satellite Broadcasting and Communications Association SBCA "

SBCA is a trade association made up of all segments of the home satellite industry, including C-band and both low and high powered Ku-band DBS. Its members include satellite manufacturers, satellite system operators, earth segment equipment manufacturers, retailers and distributors of home satellite receiving equipment, and satellite television programmers. SBCA's comments concern the issue of reallocating part of the 12.2-12.7 GHz DBS service band for terrestrial broadcasting. It opposes the initiation of an inquiry looking into the reallocation of the DBS spectrum. It contends that the usage of 12 GHz for terrestrial broadcasting is ill-conceived because of its technical infeasibility and economic impracticality as well as the detrimental effect such a reallocation would have on the future feasibility of DBS service.

SBCA states that the Commission, in its *Report and Order* establishing the DBS service, allocated the entire 500 MHz bandwidth in the 12.2-12.7 GHz band for DBS service and declined any allocation of this kind to terrestrial broadcasting. Following the *Report and Order*, the ITU Regional Administrative Radio Conference of 1983 (RARC-83) developed a plan of frequency and orbital position assignments for all countries in the Western Hemisphere, which was incorporated in the Radio Regulations at WARC-ORB-85 and thus has the status of an international treaty. Therefore, any examination of the possible reallocation of spectrum requires consideration of the international ramifications.

SBCA contends that the 12 GHz band is technically and economically infeasible for use in terrestrial broadcast ATV service. It quotes the industry petition where the petitioners acknowledge that many broadcasters believe that it will never be technically feasible to use the 12 GHz band for terrestrial broadcasting due to coverage, frequency coordination and mutual interference problems. SBCA agrees with the petitioners that the 12 GHz band would be vulnerable to blockage and rain attenuation and that "cost considerations might make this option wholly unfeasible." SBCA states that there are six coverage problems associated with ATV transmission in the 12 GHZ band: (1) rain attenuation; (2) multipath propagation; (3) blockage or shadowing within the coverage area; (4) the small size of the coverage area; (5) the characteristics of the transmitting antenna; and (6) the characteristics of the receiving antenna.

SBCA states that while rain attenuation can be virtually ignored in the VHF and UHF bands, it can be very significant at 12 GHz. Consequently, its effects must be considered in determining the cost and feasibility of broadcasting in this band. Rain has very little impact in DBS since the satellite signal must pass through usually no more than one mile of rain. However with VHF and UHF delivery, the signal might have to pass through 20 to 30 miles of rain. In order to overcome this rain attenuation problem, SBCA believes that broadcast stations would require significantly more transmitter power and better locations than acknowledged by the petitioners. The Technical Committee of SBCA believes that each broadcast station would need as many as 25 separate transmitters in each service area to provide enough power to overcome the rain attenuation problems.

Multipath propagation causes the "ghosting" of television images. SBCA acknowledges that this problem also exists within the UHF band. However, it states that this problem is far more acute at 12 GHz and that this problem was confirmed in the January, 1987, demonstration of the MUSE HDTV system on two UHF TV channels by AMST and NAB.

In contrast to VHF and UHF broadcasting or DBS, SBCA states that blockage (or shadowing) is a significant problem for terrestrial usage at 12 GHz. It believes that it would be virtually impossible to design a system in a manner which would provide for the avoidance of trees, hills, buildings and other obstacles. However, such a design would be crucial since terrestrial broadcasting at 12 GHz requires true line-of-sight; "a tree or building blocking line of sight could be fatal." Therefore, the effective isotropic radiated power (e.i.r.p.) must be increased significantly in order to provide the required signal level to the potential receiver locations throughout the service area. However, since the power loss through blockage is much higher at 12 GHz, the necessary power increase to overcome the blockage is far greater and can reach levels beyond any transmitters now available or under development.

In order to overcome the limited service area of terrestrial stations operating at 12 GHz, SBCA states that at least twenty-five 12 GHz supplemental transmitting stations would be needed to meet the coverage provided by one local broadcast station. This limited service area arises because of the rapid reduction of field strength with distance from the transmitter associated with terrestrial broadcasting at 12 GHz.

The transmitting antenna is another problem. Transmission lines and waveguides at 12 GHz introduce power loss as much as 4.5 dB per 100 feet. For a transmitter located at the base of the high towers needed for coverage in flat portions of the country (*e. g.*, 1000 ft.), the loss would be tens of dBs. Heat dissipation in waveguides would limit the RF power to only 3000 watts, far less than that needed for transmission. Alternatively, transmitters located at the top of towers would present structural, maintenance, regulatory and safety problems which would be totally unacceptable.

The characteristics of the receiving antenna also must be considered. VHF dipole and UHF loop antennas extract less power from a radio wave as frequency increases. However, the power reduction from VHF to 12 GHz may be as much as 60,000 times *(i.e.,* 48 dB). This reduction must be compensated by an increase in transmitter power, use of a more expensive high-gain antenna, or both. SBCA believes that the reception of 12 GHz broadcast signals would require the use of highly directive parabolic dish antennas requiring costly installation at the top of masts to obtain true line-of-sight, rigid mounting and accurate positioning. The installation of the dish antennas might also present problems with local zoning ordinances. SBCA acknowledges that similar installation and positioning problems exist with dishes for DBS but maintains that the problems are less severe and that the consumer chooses to receive the DBS service. It opposes the imposition of these problems on the general public for reception of off-air broadcast signals.

Reallocation of the 12 GHz band to terrestrial broadcasting must also consider the effect upon broadcast satellite service (BSS) receivers in Canada and Mexico. In order to avoid mutual interference problems, SBCA maintains that 12 GHz terrestrial transmitters should be prohibited in those areas within 180- 200 miles of the Canadian and Mexican borders. SBCA argues that the reallocation of any portion of the 12 GHz band would be detrimental to the development of DBS. It cites the direct broadcast satellite *Report and Order* where the Commission stated that DBS service could benefit the public and that use of the 12 GHz for such service could constitute a valuable use of the spectrum. SBCA believes that technical advances such as high powered DBS service and smaller dishes will make the ownership of TVRO systems attractive to a significantly higher population than at present.

SBCA states that there are presently five permittees holding licenses for construction of DBS systems. Current operational fixed service stations operating in the DBS band must vacate by 1988 or become secondary users. The RARC-83 Plan, to which U.S. use must conform, divided the 12.2-12.7 GHz band into 32 channels, each 24 MHz wide. Although the U.S. received all 32 channels at each of eight orbital positions, only three orbital positions offer national coverage and eclipse protection. According to SBCA, all 32 channels at four key orbital positions have been assigned or requested and at two of these positions, the total number of assigned and requested channels exceeds the total number available for use. In order to reallocate half of the DBS band, SBCA maintains that the Commission could not simply eliminate half of the applicants by taking away all the channels assigned to them but would in most cases take away half the channels assigned to each applicant. It states that the majority of DBS permittees consider such a limit to have an unacceptable impact on their business plans. It contends that some permittees would be forced to "scrap" large investments in satellites planned to deliver the present number of channels authorized by the FCC and the public would lose the choice of channels offered by DBS.

Consumer Electronics Group of the Electronic Industries Association (EIA/CEG)

EIA/CEG supports the request of AMST, *et al.* EIA/CEG believes it important for the Commission to have a better understanding of developments in advanced television technologies and how these developments may affect other regulatory decisions, such as the pending UHF-land mobile proceeding (Gen. Docket 85-172).

Hughes Communications Galaxy, Inc. (HCG)

HCG, one of the five permittees which have authority to construct a DBS system, opposes the reallocation of the 12 GHz band to advanced TV use. It raises many of the same concerns raised by SBCA, such as rain attenuation problems, blockage, the need for above tree-top installation of receivers with its attendant zoning, environmental and aesthetic concerns, as well as the costs involved. It believes the reallocation and reservation of this spectrum to serve as supplemental HDTV channels, "just in case the admittedly 'major technological breakthroughs' necessary for such use may someday be realized to be unacceptable. HCG states that the 12 GHz band is technically unsuitable for HDTV terrestrial service as well as being prohibitively expensive and impractical. In particular, it states that AMST's proposed use of the 12 GHz band is based on two fundamentally flawed conclusions: (1) use of one-half of the DBS band would provide over 40 3 MHz-wide channels and 14 8.1 MHz-wide channels for local broadcasting; and (2) the use of supplemental terrestrial HDTV service in the 12 GHz band would require as many as ten transmitters to cover the service area now covered by a single VHF or UHF station.

Based on the experience of CBS, which found that HDTV transmission in the 12 GHz band required approximately three times as much spectrum as the same trans-

mission in the VHF or UHF bands, HCG concludes that only thirteen 9 MHz channels would be available for supplemental HDTV use, and that five 24 MHz channels would be available for complete HDTV use. HCG goes on to state that AMST's contention that upwards of 10 transmitters could cover the same area as a VHF or UHF station ignores the need to overlap the coverage areas of these transmitters in order to avoid interstitial pockets with no service. It provides a showing that 25 precisely located 12 GHz stations providing the 20 mile coverage radius assumed by AMST would be needed to serve completely all of the area within a typical 65-mile radius Grade B contour of a full service TV station. It also argues that even assuming AMST is correct about the 3 MHz of bandwidth necessary for supplementary service, the total number of channels would be exhausted before two TV stations in a market could implement HDTV service. Using the CBS 9 MHz figure, the number of channels would not be sufficient for even one station, thus requiring the station to use a complicated frequency reuse plan to transmit HDTV supplemental signals on the thirteen available channels. From a spectrum utilization standpoint, HCG states that it would very impractical, if not impossible, for all the stations in a medium or large market to provide HDTV service using 12 GHz supplemental channels.

Home Box Office (HBO)

HBO supports the commencement of an inquiry on advanced TV systems. In addition to the areas of inquiry raised by the petition, it requests the addition of the following questions:

(1) How can we improve on today's television technology?

(2) How can the television industry achieve a wider aspect ratio?

(3) How do we make the highest possible audio quality, with multiple channel potential, available to the consumer?

(4) What can we do to see that this technology is made available to consumers at reasonable prices?

(5) How can consumer equipment be designed so as to be backward compatible?

(6) How do we select the optimum HDTV frequency plan and exploit the current spectrum allocation to the maximum extent?

(7) How do we ensure that HDTV will be compatible with cable television systems?

HBO also urges that the inquiry be based on the underlying premise that the marketplace should dictate the evolution of any technical standards that may be required to implement an improved television system.

American Petroleum Institute (API)

API is a national trade association whose membership is representative of all sectors of the petroleum industry which are engaged in the exploration, production, refining, marketing, and transportation of petroleum, petroleum products, and natural gas. API members include Commission licensees which operate two-way land mobile radio communications facilities in the Petroleum Radio Service and other categories of the Private Land Mobile Radio Services (PLMRS). API does not oppose the initiation of an inquiry into HDTV and other advanced television technologies. However, it urges that this inquiry not be allowed to delay action in the pending land mobile/UHF-TV sharing rule making, General Docket 85-172. It disagrees with the petitioners that the two proceedings are "inextricably related." It contends that the Commission has ample documentation concerning land mobile's need for additional spectrum, the feasibility of further land mobile/UHF-TV sharing and the benefits and requirements of HDTV to decide the issues raised in Docket 85-172.

Corporation for Public Broadcasting (CPB); National Association of Public Television Stations (NAPTS) and; Public Broadcasting Service (PBS)

CPB is the private, non-profit corporation authorized by the Public Broadcasting Act of 1967 to facilitate and promote a nationwide system of public broadcasting. NAPTS and PBS are non-profit membership organizations which represent public television affiliates and distribute programming and other program-related services to the nation's public television stations, respectively. These organizations filed jointly with CPB. CPB supports the AMST petition for inquiry as well as its request that the Commission defer action in the land mobile/UHF-TV sharing proceeding, General Docket 85-172. CPB is concerned that sufficient spectrum be available for local television stations, including local public broadcasting stations, interested in using HDTV. It states that the likely source of additional spectrum for broadcasters lies within the UHF band and that its reallocation to land mobile radio use at this time could preclude its use for HDTV, especially in larger markets where spectrum is scarce. Without the protection of this spectrum, CPB is concerned that only alternative distribution systems, which are likely to be pay services, will be able to provide HDTV services, to the detriment of local broadcasters, local public television stations, and their listening public.

Motorola, Inc. (Motorola)

Motorola has no objection to the initiation of an inquiry concerning HDTV. However, it believes that there is no reason to delay a decision in the land mobile/UHF-TV sharing proceeding, General Docket 85-172. It contends that the unused UHF-TV spectrum in major markets is inadequate to support HDTV use by all existing broadcasters (based on the stated requirement of an additional 3 MHz per station); techniques have been developed which offer the promise of a vastly improved television picture without requiring additional spectrum and; the growth of HDTV is limited more by television picture tube considerations than by spectrum.

Buffalo Broadcasting Co., Inc. (WIVB-TV)

WIVB-TV is the licensee of Station WIVB-TV, Buffalo, New York. It fully supports the request of AMST to institute an inquiry into HDTV and other advanced television technologies. It believes that the most critical issue is that of spectrum availability. WIVB-TV notes that prototype equipment has been developed which is capable of delivering the high resolution, better color and wider picture of HDTV programs by satellite, cable, disc and cassette tape. It states that without the allocation of

additional spectrum space, local broadcasters would be effectively shut out of the HDTV marketplace, possibly relegating them to second class status.

United States Advanced Television Systems Committee (ATSC)

ATSC was established by the Joint Committee on Intersociety Coordination (JCIC) to coordinate and develop voluntary national standards for advanced television systems. It supports AMST's petition for inquiry and for special relief. Since its inception, ATSC states that it has been involved in standards coordination and development in three areas: improved NTSC systems; enhanced 525-line systems; and HDTV systems. It states that in the coming months it will be involved in activities directly related to the testing of HDTV transmission systems in both the UHF and the 12 GHz portions of the spectrum. It believes that these activities can be accomplished within a reasonable time period. Thus, it urges that the Commission grant the relief sought by petitioners.

Land Mobile Communications Council (LMCC)

LMCC acts on behalf of public safety, business, industrial, land transportation and common carrier land mobile radio users as well as land mobile service providers and equipment manufacturers. It opposes any delay in a decision in the land mobile/UHF-TV sharing proceeding, General Docket 85-172. LMCC states that in June, 1985, the Commission initiated the proceeding proposing to expand the shared use of UHF-TV spectrum by land mobile stations operating in Los Angeles, New York, Baltimore/Washington, Philadelphia, Chicago, San Francisco, Dallas and Houston by identifying several UHF channels in each of these areas which could be made available for private land mobile radio use. The Commission in particular noted the possible impact on HDTV and requested comments concerning the issue. In response, the Commission received detailed comments from both broadcasting and land mobile advocates. It contends that no purpose would be served by rearguing that issue in another proceeding. It reiterates the arguments which it advanced in Docket 85-172 concerning the immediate need for additional spectrum for land mobile use predicting that a further delay would almost certainly cause serious spectrum shortfalls and congestion.

LMCC focuses on the AMST study which indicates that all of the existing television stations in the combined New York City/Philadelphia and Los Angeles markets would not be able to upgrade to advanced TV if the UHF sharing proposal in Docket 85-172 is adopted, while other cities are shown to have sufficient spectrum for both HDTV and land mobile use. However, LMCC states that "even with all the assumptions behind AMST's table. . .there is not *nearly* enough spectrum in the UHF band to provide for an upgrade to HDTV for every television station in the markets surveyed, *regardless* of the outcome of General Docket 85-172." Specifically, LMCC states that AMST recognized 20 stations in the New York City/Philadelphia market as needing HDTV spectrum but failed to recognize 19 additional stations within the co-channel reuse spacing of 112.2 miles used by AMST in its study. It argues that these stations would also require an additional 3 MHz of spectrum for HDTV use, bringing the total number of stations needing HDTV spectrum to 39. With only 22 3 MHz channels available in this area, according to AMST, LMCC contends that 17 stations could not upgrade to advanced TV even if all the channels are used for HDTV and none for land mobile. In Los Angeles, AMST listed 16 stations. LMCC says another 20 domestic stations, 2 Mexican stations and 5 Mexican allotments need to be considered as they are within the reuse distance used by AMST. Thus, it contends that 43 3 MHz channels would be required with AMST acknowledging the availability of only 22 such channels. LMCC paints a similar picture for Chicago where it states that 33 3 MHz channels would be required with only 28 available.

LMCC does not oppose efforts by the broadcasting industry to improve television picture quality. However, it notes that the industry today uses the same 6 MHz-wide television channels agreed upon in 1936. Meanwhile, LMCC states that during the same period, the land mobile community has reduced its bandwidth requirements.

According to the petitioners, NHK, a broadcasting corporation owned by the Government of Japan, is the principal proponent of HDTV. LMCC states that NHK has been studying HDTV for 15 years, pointing out that the petitioners acknowledge that NHK "has made no effort to try to develop an HDTV system which could be transmitted in 6 MHz-wide channels." (Comments, p. 21) Thus, it states that implementation of NHK's HDTV system would make obsolete the hundreds of millions of television receivers currently in the U.S. marketplace today. However, LMCC states that there are other possible methods of improving the quality of broadcast signals which do not require additional spectrum and which will not obsolete existing television receivers, such as "Enhanced NTSC" developed by Yves Charles Faroudja. It believes that exploration of this and other techniques promising to make better use of television broadcasting's existing 6 MHz channels would be worthwhile.

It concludes that the Private Land Mobile Radio Services "urgently need access to the UHF spectrum and thus the land mobile/UHF-TV sharing proceeding should not be delayed pending a resolution of advanced TV.

National Association of Business and Educational Radio, Inc. (NABER)

NABER is a national non-profit association representing members who are primarily licensees in the Business Radio Service as well as licensees in other Private Land Mobile Radio Services. NABER states that it participated in the drafting of and supports the LMCC comments. It urges that the Commission not delay a decision in Docket 85-172 but begin a separate inquiry into the use of the 12 GHz band for HDTV use should the Commission find such service feasible.

Telecommunications Research and Action Center (TRAC)

TRAC supports commencement of an inquiry into the potential uses of advanced television technologies in the existing television broadcast service. TRAC believes it would be premature for the Commission to allocate additional UHF broadcast spectrum for either advanced TV or for land mobile radio usage at this time, since such decisions would be based on an incomplete record. Rather, the Commission should obtain as much information as possible on advanced TV and on projected land mobile radio needs so that it has all relevant information to make future spectrum decisions without prejudgment. Caution is advised by TRAC especially because employment of these

new advanced TV technologies may assist in retaining community-based, over-the-air broadcasting as the public predominant source of news and information and may be essential to the continued vitality of over-the-air broadcasting.

FOOTNOTES

[1] *See*, paragraph 32, *infra*.

[2] A listing of the commenters and a summary of their submissions is in Appendix A.

[3] Channel 1 was re-allocated to land mobile radio in 1948. *See Report and Order* in Docket No. 8487, 39 FCC 336 (1948).

[4] NTSC is the acronym of the National Television System Committee, a committee that convened in 1940 to establish technical standards for production, transmission and reception of an American monochromatic television system. The Committee reconvened in the early 1950s to establish color standards.

[5] Among the features that were specified in 1941 are: the width of the television broadcast channel (6 MHz), the precise frequencies for the visual and aural carriers (1.25 MHz and 5.75 MHz respectively from the lower edge of the channel), the number of lines per frame (525 lines), the scanning rate and method (60 fields per second, 2:1 interlaced), the aspect ratio or the width-to-height ratio of the picture (4:3) and the audio mode (monophonic). In 1953, the NTSC standard was modified to add the chrominance subcarrier frequency (3.5795454 . . . MHz) and the composition of the color signal.

[6] For example. the Japan Broadcasting Company (NHK) has been studying high definition television for almost 20 years. The RCA Laboratories has been studying ways to improve the U.S. television system since its foundation in the early 1930's. The Massachusetts Institute of Technology has been conducting research since 1983 into the perceptual and technological basis for improved television systems. etc.

[7] The ATSC is a group of approximately 50 member and observer organizations which coordinates and develops voluntary national standards for advanced television systems. The CCIR is the International Radio Consultative Committee, an organ of the ITU which studies technical and operational questions relating specifically to radiocommunications.

[8] The NTSC interlaced scanning process is a process which successively scans every other line in each field cycle. Adjacent lines are scanned during the next cycle of the field frequency.

[9] A scan line is a single continuous narrow strip of a picture area containing highlights, shadows and half-tones, determined by the process of scanning.

[10] For NTSC, an interlaced scanning process, a field is a one time scan of the alternate lines in a picture.

[11] A frame is a one time scan of a picture. In an NTSC interlaced scanning process, a frame consists of two fields.

[12] The aspect ratio is the relationship between the picture width and height.

[13] Line or field store is a microprocessor memory device used in the receiver to reduce the perceptibility of certain picture defects. By averaging picture elements from two consecutive lines or displaying every scan line twice during a normal scan period, these devices help improve the signal resolution without the need for additional transmitted information.

[14] The Kell factor represents the ratio of the actual vertical resolution of a TV picture to the total number of scan lines that are displayed (483 lines is the NTSC standard). The actual vertical resolution capability of transmitted NTSC signal ranges between 290 and 338 lines, which translates to a Kell Factor between 0.6 and 0.7. The technique described above allows the vertical resolution to approach the full 483 lines of active video; consequently, the Kell factor approaches unity with such a system.

[15] Faroudja Laboratories of Sunnyvale, California, has developed a number of these pre-comb filters and is pursuing development to design more complex filters.

[16] This technique is described in detail in a paper entitled: "Experiments on Proposed Extended-Definition TV with Full NTSC Compatability" by Fukinuki, Hirano and Yoshigi; presented at the IEEE Communications Society Global Telecommunications Conference, December, 1985.

[17] Among the systems that have been proposed and/or developed for audio/video transmission are: A-MAC, B-MAC, C-MAC, D-MAC, D2-MAC, HD-MAC and MAC-60. With the exception of MAC-60, these systems are being developed primarily in Europe.

[18] This system is described in detail in a paper entitled: "B-Mac: A transmission for Pay DBS" by Lucas; SMPTE Journal, November 1985.

[19] This system is described in detail in three papers which were presented at the International Conference on Consumer Electronics, June 1987. The first paper is entitled: "Philips NTSC- Compatible Two-Channel Television System by M. Tsinberg, the second paper is entitled: "Channel Matching Techniques for Two-Channel NTSC Television" by C. Basile, The third paper is entitled: "Transmission and Reception of Widescreen Television Signals Using Two 6 MHz Channels" by A.P. Cavallerano.

[20] A pixel is the smallest addressable point or area in a CRT display. A subpixel is a subdivision of a pixel.

[21] This system is described in detail in a paper entitled: "A Proposal for a New High-Definition NTSC Broadcast Protocol" by Richard J. Iredale, presented at the 128th SMPTE Technical Conference, October 1986.

[22] A studio production system with quality comparable to 35mm film requires over 30 MHz of spectrum to contain detail fully.

[23] This system is described in detail in a paper entitled: " A Single Channel HDTV Broadcast System - The Muse" by Ninomiya, Ohtsuka and Izumi; NHK Laboratories Note 304, September, 1984.

[24] This system is described in detail in a paper entitled; " Compatible Terrestrial HDTV Transmission', Glenn 1986 NAB Engineering Conference Proceedings.

[25] This system is described in detail in a paper entitled:" A Compatible High Definition Television System" by Rzeszewski, Bell System Technical Journal, September, 1983.

[26] This system is described in detail in a paper entitled: " A Compatible HDTV Broadcast System" by Rossi, Goldberg and McMann, ATSC Document T3/23, May, 1984.

[27] A DBS channel is 24 MHz wide.

[28] The Osborne Compression System is described in detail in a United States Patent entitled "Narrow Bandwidth Signal Transmission". Patent Number 4,665,436 dated May 12, 1987.

[29] We observe that we have recently initiated a "freeze" on the acceptance of applications for new TV assignments and petitions for new TV allotments pending a more complete understanding of the spectrum requirements of improved TV systems. Similarly, we recognize that serious questions have been raised about the relationship between the issues considered in this proceeding and those in General Docket 85-172 where additional sharing of the UHF-TV band by land mobile services is being considered. Our interest in exploring the full scope of this interrelationshipled us to grant interested parties additional time to file comments on a

request to hold these reallocation decisions in abeyance pending consideration of the spectrum requirements of improved TV systems. *See, Order Extending Time for Reply Comments*, General Docket 85-172, RM-3975, RM-4829, adopted June 26, 1987. Inasmuch as the pleading cycle on that Petition did not conclude until July 31, 1987, it would be premature to act on that request herein. However, we expect prompt resolution of this issue once we have completed our review of the record on that Petition.

[30] *Sixth Report and Order* in Docket Nos. 9736 *et al.*, 41 FCC 148 (1952).

[31] Under any of these approaches, we recognize that it will be necessary to discuss the range of possibilities with neighboring countries so as to provide for the implementationof ATV systems in the border areas covered by bilateral arrangements.

[32] Approximately 60% of the spectrum set aside for non-government use below 1 GHz is allocated to the broadcast services.

[33] The 14 uppermost UHF channels, *i.e.* Channels 70 through 83, are now allocated to the land mobile radio services. Television translators previously licensed in that band may, however, continue to operate on these frequencies on a secondary basis. In addition, Channel 37 is now reserved for radio astronomy.

[34] The VHF-TV channel frequency spectrum is noncontinuous and has considerably less overall spectrum bandwidth than that for UHF-TV channels. The VHF-TV band is comprised of two small, widely separated groups of frequencies: low-VHF, 54.0-72.0 MHz (channels 2-4) and 76.0-88.0 MHz (channels 5 and 6), and high-VHF, 174.0-216.0 MHz (channels 7-13). The UHF-TV band, in contrast, is a large contiguous group of frequencies (470-806 MHz).

[35] As stated earlier, the taboos currently limit the maximum number of UHF assignments in any one locale to 9 channels out of the 55 possible UHF channels.

[36] The distance in question is that between an affected TV transmitter location or the geographical reference point for a TV allotment and another such location or reference point.

[37] The adjacent channel restriction is not strictly a UHF taboo, since VHF assignments are similarly restricted. In both television bands, this taboo is based upon a receiver's ability to select the complete desired channel while rejecting the spectrum of the undesired adjoining channels.

[38] For example, assume the desired signal is on channel 30 (566 - 572 MHz). The channel 30 picture carrier is 567.25 MHz and the sound carrier is 571.75 MHz. The undesired signals are on channels 44 and 45. The channel 44 sound carrier is 655.75 MHz and the channel 45 picture carrier is 657.25 MHz. The oscillator frequency of the receiver tuned to channel 30 will be 613 MHz and the picture carrier IF will be 45.75 MHz. The undesired sound carrier of channel 44 mixes with the oscillator output to produce an image on 42.75 MHz (655.75 - 613.00 MHz) which is 3.0 MHz away from the desired visual carrier on 45.75 MHz. The undesired picture carrier of channel 45 mixes with the oscillator ouput to produce an image on 44.25 MHz (657.25 MHz - 613.00 MHz) which is 1.5 MHz away from the desired visual carrier on 45.75 MHz.

[39] *See* "A Study of the Characteristics of Typical Television Receivers Relative to the UHF Taboos," FCC Report LAB 74-01, 1974.

[40] *See Notice of Inquiry* in Docket No. 20485, 53 FCC 2d 411 (1975).

[41] *See Notice of Inquiry* in Gen. Docket No. 78-392, FCC 2d (1978). (Docket No. 20485 was closed and its comments were considered part of the record of Docket 78-392).

[42] We will close Docket 78-392 and incorporate its relevant materials in the instant proceeding. Presentations made in this docket, as well as those submitted in Docket 20485, need not be resubmitted.

[43] "Advanced Technology Receiver Study, Part I, Receiver Performance Measurements," FCC Report FCC Post R-83-1, 1983; and "Advanced Technology UHF Receiver Study, Part 2, Effect on UHF Television Allotments", FCC Report FCC/OST R-84-1, 1984.

[44] However, these tuners have been demonstrated to be poorer generally with respect to other UHF interference immunities.

[45] *See* Technical Memorandum, "A Study of UHF Television Receiver Interference Immunities", which has been placed in the official docket file in this proceeding.

[46] For example, operations on channels 7,9,11 and 13 are common in large markets. Co-located assignments on every other channel are prohibited at UHF due to interference concerns.

[47] It should be noted that relaxation of the mandatory NTSC transmission standard, so as to provide for implementation of ATV, is not necessarily inconsistent with retaining a requirement that ATV be viewable on NTSC receivers.

[48] In this regard, we seek comment on the desirability of and our ability to require that TV receivers be able to display multiple television transmission formats.

[49] In this connection, we solicit views on the implications of these technologies and their possible broadcast and non-broadcast uses on issues which affect both broadcasting and cable television.

[50] *See Advanced Television Systems, FCC Tutorial*, January, 1987, Robert Hopkins, United States Advanced Television Systems Committee. This paper describes "levels of compatibility" for advanced TV systems mentioned in the following text. For brief descriptions of the systems themselves, *see* discussion *supra* at Part II.

[51] To a significant degree, the present TV interference protection criteria are based upon a transmitted carrier amplitude modulated with an NTSC signal. If we were to relax the NTSC transmission standards, it might be best to require initially that a station transmitting non-NTSC signals maintain the equivalent interference protection to other stations that would be afforded if it were transmittingNTSC signals. This might be accomplished by reduction of actual operating power by an appropriate amount below maximum power. Under this approach television applicants or licensees wishing to use non-NTSC transmission systems would be required to demonstrate that the proposed transmission systems provide this equivalent interference protection. After a particular non-NTSC system has been approved as affording other stations the proper interference protection, other applicants proposing the same system could simply make reference to that arrangement, thereby avoiding submission of a duplicate showing.

[52] *See, Second Report and Order* in Docket No. 21323, 55 RR 2d 1642 (1984).

[53] Among the factors we have considered significant in evaluating previous spectrum allocations matters include: the dependence of the service on radio rather than wire lines; the expected number of people who will receive benefits from the service, and: the relative social and economic importance of the service; and the suitability of the spectrum involved. For a detailed exposition of our historical spectrum allocation decisionmaking framework, see, "Spectrum Management Policy in the United States: An Historical Account," John O. Robinson, OPP Working Paper No. 15, April 1985.

[54] Following the Commission's 1954 action that authorized color television, for example, more than a decade passed before a substantial portion of television stations could relay and originate color programming.

[55] *See, Memorandum Opinion and Order* in File No. DBS-DR-1, 1 FCC Rcd. 977 (1986) *(DBS Declaratory Order)*.

[56] In responding to these questions, commenters may also wish to consider the issues raised in several other questions which have been asked in the context of the AM service. *See, Notice of Inquiry in* MM Docket 87-267, FCC 87-245, adopted July 16, 1987.