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Before the
Federal Communications Commission
Washington, DC 20554

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JAN 23 1989

Federal Communications Commission
Office of the Secretary

In the Matter of	)	
Advanced Television Systems and Their Impact on the Existing Television Broadcast Service	)	
Review of Technical and Operational Requirements: Part 73-E, Television Broadcast Stations	)	MM Docket No. 87-268
Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules	)	

REPLY COMMENTS
OF
THE DAVID SARNOFF RESEARCH CENTER, INC.

on the

TENTATIVE DECISION AND
FURTHER NOTICE OF INQUIRY

January 9, 1989

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FURTHER NOTICE OF INQ

PREFACE

The David Sarnoff Research Center (Sarnoff) hereby submits Reply Comments related to the Federal Communication Commission's (Commission) Tentative Decision and Further Notice of Inquiry (Further Inquiry) in MM Docket No. 87-268, released September 1, 1988.

Comments filed on November 30, 1988 by Sarnoff strongly supported the Commission's position that maintenance of NTSC service by provision of a compatible Advanced Television (ATV) signal is essential. Sarnoff's comments also urged the Commission to establish a single standard for delivery of ATV to consumers' homes; to be suitable for the United States, this standard should be based on 1050 lines with a field rate of 59.94 fields/second. Sarnoff further encouraged the Commission to resist pressure for hasty decisions on any new spectrum assignments until the Commission's on-going studies have been completed and proposed new ATV systems have been tested.

Upon review of the wide-ranging comments received by the Commission on the Further Inquiry, Sarnoff would like to re-assert its position on several key issues. Sarnoff will also comment on some of the issues raised by others.

ATV ACHIEVED VIA COMPATIBLE SINGLE-CHANNEL PLUS AUGMENTATION VERSUS ATV ACHIEVED VIA SIMULCAST

Sarnoff supports the Commission's position that maintenance of NTSC service by provision of a compatible Advanced Television (ATV) format is essential. ATV proposals that require more than 6 MHz additional to a present TV channel are impractical for terrestrial broadcasting. Sarnoff believes further that an NTSC-compatible ATV service can begin by

effective use of the existing 6 MHz TV channels and has proposed Advanced Compatible Television-I (ACTV-I) to meet that challenge. ACTV-I offers an excellent mix of performance improvement over NTSC, bandwidth efficiency, trade-offs that match the human vision system, NTSC compatibility, and cost. ACTV-I can be augmented, compatibly, with an additional 3 or 6 MHz when the Commission has satisfied itself that such spectrum can be provided without harm to the existing broadcast service.

Some comments received by the Commission expressed concern about the quality of an ATV signal that could be delivered in a single 6-MHz compatible channel and about possible artifacts in the picture such a signal would display on NTSC receivers. It has been a point of Sarnoff's public demonstrations of ACTV to show that these fears can be allayed. Sarnoff has publicly displayed simulations of ACTV and NTSC reproduction of the same transmitted signal, has included test patterns and representative video in these presentations, has pointed out signals with potential to create visible artifacts, and has indicated the locations on the picture where the artifacts might be visible. In almost all cases, the audience, thus prepared and tutored, has failed to see anything other than clean NTSC or ACTV.

As these actions show clearly, Sarnoff agrees that a compatible system must be able to demonstrate that the added ATV information will not create objectionable artifacts. However, purity from all possible artifacts no matter how pathological the circumstances is not, and need not be, the goal of a practical and cost-effective television system. Exploitation of the nature and limitations of the human vision system is simply smart engineering. "Artifacts" that are invisible or that can occur only rarely or with unusual video sequences are an acceptable trade-off for an affordable and spectrum-efficient system. Such trade-offs are in the best tradition of proper and economic engineering, a tradition which brought about compatible color television.

Sarnoff has acknowledged that single-channel compatible ATV systems do not produce full HDTV images, although their improvements over NTSC, which include wider aspect ratio and increased resolution, can be significant. (For this reason, Sarnoff has proposed an evolutionary ATV scenario that includes provision of full HDTV via ACTV-II.) To lump all single-channel compatible proposals together and denigrate them as EDTV, as some comments have done, is to miss the point. A well-designed compatible system can deliver excellent pictures -- as good as consumer wide-screen display technology is capable of reproducing presently and for some time into the future. Since a single-channel compatible system can be delivered in spectrum already assigned, it allows introduction of ATV at the earliest time, with the least expense, and with minimum disruption. A good single-channel compatible system is more than a poor imitation of HDTV; it offers the most rapid implementation of ATV and provides an evolution to HDTV when spectrum and display technology make the transition possible.

An evolutionary system need not preserve the limitations of NTSC forever. The second channel of an evolutionary system has no NTSC-compatibility constraints, and so its modulation can be as rugged and hospitable as that of any simulcast channel. The ruggedness of the original NTSC channel can be improved as well because not all of the information contained in the original channel is necessary for HDTV reproduction; special signal processing techniques allow recovery of the most useful portions of the signal. The augmentation channel contains most of the HDTV picture information at a relatively low temporal update rate; its performance for motion can be improved by using the selected portions of the NTSC channel. An augmentation scheme can improve the performance of HDTV over that possible with stand-alone (simulcast) systems; it can reduce motion artifacts caused by the temporal compression required by simulcast schemes in order to fit the 20 MHz (or more) HDTV video signal into a 6 MHz channel bandwidth. An augmentation scheme like this one allows the hope that, when the

performance of motion processing algorithms has improved and NTSC receivers no longer need support, the NTSC channel can be abandoned.

An evolutionary ATV scenario has been criticized as more costly to implement than a single step to full HDTV. Sarnoff does not believe that this criticism is correct and has shown in its planning and public presentations how hardware purchased for its entry level system (ACTV-E) can continue to be used should a station decide to upgrade to ACTV-I and how the utility of ACTV-I processing hardware will continue with the advent of ACTV-II. Rather than demand of a broadcaster a risky decision to invest heavily before an ATV market has developed or the alternative risk of being left behind by a popular new technology, the ACTV evolutionary scenario allows broadcaster participation in ATV at the earliest possible time with the minimum investment risk.

Sarnoff is concerned that ATV derived from a completely independent simulcast channel will encourage a two-tier television service. Augmentation schemes provide a technical imperative for common programming between ATV and NTSC receivers. Absent this imperative, broadcasters and their advertisers will have an economic incentive to exploit the wealthier demographics of the purchasers of ATV receivers by providing them with different programming or better signal delivery than that available to the less well-to-do owners of NTSC receivers. While such service might provide some narrow or short-term benefits to some of the populace, it diverges from the spirit and tradition of American broadcasting. Its possibility also indicates that public policy has a role with technical issues in the choice of ATV for the United States.

ROBUSTNESS AND TRANSMISSION PATH EFFECTS

Compatible ATV systems have been criticized for an expected lack of robustness compared with incompatible or simulcast systems. Compatible systems have also been said by their critics to preserve the vulnerabilities

of NTSC even after augmentation with a second channel. The veracity of this charge depends on the particular system being discussed. Sarnoff offers some countering observations that apply to its ACTV system.

ACTV-I offers significant picture improvement in a single compatible channel. Simulcast systems, by definition, require at least two TV channels in order to show any improvement, and both of these channels must be maintained for as long as today's NTSC receivers (and those which will still be purchased even after the advent of ATV) remain serviceable. This time is likely to be at least fifteen to twenty years, based on experience with black and white receivers. Sarnoff does not doubt that competent engineering should be able to produce a picture that has more resolution, or a signal that is more robust, if twice the bandwidth is devoted to the process. As an engineering choice, however, the ability of ACTV-I to match the best display technology for at least the next decade, its ability to begin service while spectrum for simulcasting is still being sought, and its overall efficiency in handling the scarce and valuable resource of spectrum make it the preferred method to begin ATV service.

The robustness of ACTV-I is expected to be roughly comparable to NTSC, although this has not yet been tested. Tests in the presence of noise, non-linearities, and multipath must be undertaken both for over-air transmission and for delivery by cable. ATV receivers, which will undoubtedly employ digital signal processing, carry an interesting ancillary benefit. Given that digital circuits and A/D and D/A converters will already exist in ATV receivers, digital signal processing can be employed to improve robustness of the recovered signal. For example, Sarnoff is developing hardware to cancel multipath signals (ghosts) in ATV receivers. The same technology could be applied to NTSC receivers, but the relative economics are not presently so favorable.

A variety of options exists when single channel compatible systems are augmented with a second channel. As has been discussed previously in these Reply Comments, the second channel need have no NTSC-

compatibility constraints and can be at least as robust and hospitable as any stand-alone simulcast signal. The vulnerability of the HDTV picture to transmission defects in the original NTSC signal can be mitigated by using selected portions of the NTSC signal, with special processing, to create HDTV.

A SINGLE ATV STANDARD

Sarnoff urges that, upon completion of testing, the Commission establish a single standard for delivery of ATV to consumers' homes. The standard should allow both broadcast and alternate media to deliver an NTSC-compatible signal. For a production standard, Sarnoff recommends the NBC proposal, which is based on 1050 lines with a field rate of 59.94 fields/second, as best matched to the needs of the United States. Standards based on the 1125/60 interlaced format are not well suited for ATV in the United States.

Sarnoff believes that a single standard for home delivery, applicable to all media, will offer the most cost-effective and least confusing approach to ATV. Sarnoff also recognizes that all ATV proponents have the burden to demonstrate that their systems will work in the environments of all media. If different media believe that their own interests are served best by a different ATV system, then they will have to bear the economic burden of its lower manufacturing volume. An interface standard would be helpful in achieving interoperability, although the cost and complexity of converter boxes is unattractive.

THE UNSUITABILITY OF 1125/60

The proposed 1125/60 production format is not a good match to the ATV needs of the United States. It certainly must not be the only signal source format used for testing of ATV systems. Its advocates claim that it

can be transcoded to other formats. While, at some performance level, this is undoubtedly true, transcoding has not yet been demonstrated for all ATV formats, where the transparency of the transcoding will be more critical than, for example, with NTSC. Standards based on multiples of 525 lines at a field rate of 59.94 are necessary and compatible with NTSC.

Probably the most awkward aspect of 1125/60 is that it is an interlaced format. Most ATV systems prefer progressively scanned sources because they are more amenable to the modern techniques of temporal image processing that are a mainstay of ATV, because they offer better motion rendition, and because of their freedom from line flicker. Progressively scanned sources are also much easier to transcode without artifacts. Sources and transcoding among them is an important issue for comparative testing of proponent systems; Sarnoff notes that systems can only be tested fairly if they are supplied with a source that is matched to their format and that does not impose artifacts of transcoding.

The existence of 1125/60 equipment has been important in the development of ATV to its present state. Its existence also shows the practicality of ATV technology. This does not make it the only suitable ATV equipment. Equipment for other formats fits within the bandwidth and technology shown practical by 1125/60. Examples of such alternative formats include 525/59.94 progressively scanned and 1050/59.94 interlaced. Both of these formats have been proposed by NBC. Some equipment for these formats already exists; the rest is achievable with minimal re-design of 1125/60 equipment. Both formats are a better match to transmission standards being proposed for the United States than is 1125/60.

SPECTRUM ISSUES

As the words above have made clear, Sarnoff is concerned about the availability of spectrum for ATV and about usage of that spectrum that

preserves the functionality of today's NTSC television receivers. Such receivers will be in consumers' homes for several decades regardless of steps manufacturers may take in response to decisions about ATV. In order to optimize use of existing television spectrum, Sarnoff believes that augmentation schemes must not require two **contiguous** channels. Sarnoff believes that it is possible to use non-contiguous channels and even channels in different bands. Use of non-contiguous channels imposes several requirements on system design: (1) there should be a means to cancel multipath; (2) it may be advantageous to use only a portion of the NTSC signal; (3) there must be accurate timing information sent as part of the signal so that the two channels may be unified; (4) the second, non-NTSC, channel must be more robust and hospitable than NTSC. All these necessities are planned parts of Sarnoff's ACTV.

Despite Sarnoff's efforts to optimize the use of the NTSC channel and to maximize flexibility in augmentation channel assignments, Sarnoff urges the Commission to defer any decision on re-assigning or sharing existing UHF and VHF television frequencies with other services until the ATV studies have been completed. Sarnoff believes that better displays will be available at consumer brightness, contrast, and cost in the future. For over-air television to remain competitive when these displays are used to advantage by other video delivery technologies, broadcasters will need at least all the spectrum presently assigned to television.

Augmentation and simulcast proposals must be properly designed to be robust and hospitable **in an environment of NTSC television signals**. This does not necessarily mean that they can tolerate interference from other services. Conclusions to the contrary drawn by those seeking to make a business using spectrum presently assigned to television are at least premature and possibly unwarranted. Moreover, the use of VHF and UHF TV spectrum by other services will continue to have the same deleterious effects on NTSC receivers that it always had. It is commendable that ATV proponents are designing systems to be spectrum-efficient and compatible with existing NTSC service; this fact

must not be used incorrectly to argue that ATV will be resistant to all types of interference.

Sarnoff objects particularly to citation of its (single) 6-MHz channel system by the Land Mobile Communications Council in support of the argument that broadcast spectrum can be assigned to Land Mobile. As Sarnoff's submissions have consistently made clear, ACTV is an evolutionary system that begins with a single channel but will not reach full HDTV performance without a second channel.

Sarnoff repeats its urging that the Commission resist the temptation to share spectrum "temporarily" with other services for some limited period of time. Sarnoff fears that the return of such re-assigned spectrum is uncertain or unlikely. The need for all existing TV spectrum by broadcasters is clear. The present studies are necessary to find ways for broadcasters to deliver ATV within the limits of that present spectrum. It is a misunderstanding of on-going ATV research to characterize its intent or early results as diminishing the broadcasters' need for spectrum or allowing the possibility of spectrum sharing with non-TV services.

CONCLUSIONS

Sarnoff believes that a compatible and evolutionary approach to ATV offers the easiest and most rapid introduction for both broadcasters and consumers, the best match to evolving display technology, the most effective use of spectrum as its availability changes, and the highest performance in both the short- and long-term. An augmentation approach to full HDTV can create a second channel at least as robust and hospitable as that of a simulcast approach; techniques exist to increase the robustness of the original NTSC channel.

A single standard for ATV delivery to consumers' homes is more desirable than different standards for different delivery media for reasons of consumer acceptance, lowest manufacturing cost, and freedom from converter boxes. Delivery and production formats for the United States should be based on 1050 or 525 lines at 59.94 fields per second. The proposed 1125/60 interlaced production format is unsuitable for American television systems; its use with transcoders for testing of ATV proposals will seriously jeopardize the results.

Broadcasters need all the spectrum presently assigned to VHF and UHF television if they are to remain competitive with other media in delivery of HDTV. This spectrum must not be shared with other services. Single-channel ATV systems serve as a bridge while displays improve and spectrum utilization is studied. There are no known techniques that achieve full HDTV performance **and** preserve NTSC service in a single 6 MHz channel.

Sarnoff continues to develop and demonstrate its Advanced Compatible Television (ACTV) system because it believes that ACTV is the best match to the needs and goals of ATV in the United States.

Respectfully submitted,

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by:

January 9, 1989

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