HDTV: Cable's Opportunity for the Future

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Abstract

High Definition Television (HDTV) will be available within this country by the early 1990's. All broadcast media including terrestrial broadcasters, cable operators, DBS and telco are formulating plans on how to best accommodate HDTV in their environments. At American Television and Communications (ATC) and Home Box Office (HBO) efforts are being made to encourage the development of HDTV systems that are optimized for CATV carriage. A cable aware HDTV system must take into account existing practices within the cable industry including satellite delivery, interconnect systems, scrambling and security concepts, in addition to the basic coax system and its inherent signal transmission characteristics[1].

What is HDTV?

High Definition Television (HDTV) has the potential to be the most significant development in the home-entertainment arena since the introduction of color television. A large-screen video medium, HDTV will be able to deliver a TV picture vastly superior to any picture on the air today, with multi-channel, digital-quality sound to match. The introduction of this advanced video technology will undoubtedly lead to new technical standards of quality in broadcast and cable.

Perhaps the best indication of the scope of HDTV's recent development can be measured by tracking the 35 equipment manufacturers currently selling second-generation HDTV production and studio display equipment, the adoption by the Advanced Television Standards Committee (ATSC) and the Society of Motion Picture and Television Engineers (SMPTE) of a HDTV Production standard, the ongoing work of at least a dozen transmission standards, and the FCC Advisory Committee on Advanced Television Systems (ATS). And if we track the evolution of the VCR and CD player, it appears likely that an HDTV system, composed of an HDTV television and VCR/optical disk player, will be introduced into the consumer marketplace within one to two years. Accordingly, some form of HDTV programming will be in consumer homes within two to three years, with software delivered via the same combination.

The potential impact of this new medium on the cable industry is largely in the hands of the industry itself. Clearly, the choice for the cable industry is to grow with the new medium or lose customers to it. Without the cable industry's involvement in the early developmental stages, HDTV technology will be defined by manufacturers or agencies not sensitive to cable's needs, which ultimately will result in the same kind of incompatibility problems we as an industry experienced with "cable-ready TVs," connection of VCRs in scrambled systems, and delivery of BTSC-MTS stereo.

To develop uniform TV standards, the first National Television System Committee (NTSC) was formed in 1940, and by mid-1941, the committee recommended to the FCC the basic black-and-white television format in use today: 1) 525 lines per frame, 2) 30 frames per second, 3) 2:1 line interlace of fields to frames and 4) a 4:3 aspect ratio of picture width to height.

In 1953 a second NTSC proposed to the FCC a color-television system that was compatible with the then existing black-and-white television transmission standards and the existing base of 25 million black-and-white television sets. To achieve compatibility, black-and-white television sets experienced a small loss in resolution and picture degradation. The FCC approved this compatible standard and 34 years later it continues to be the standard.

With the unexpected, rapid emergence of HDTV on the horizon, the FCC issued a Notice of Inquiry (NOI) on Advanced Television Services in July 1987 and formed the FCC Advisory Committee on Advanced Television Systems. The Advisory Committee has an 18 month life, during which it is to explore all issues relevant to improved television service and, if possible, specify the characteristics and attributes to be included in a such a system. It is possible that a standard to which broadcast ATS systems must be built will evolve through this process, or perhaps a single proposal will be chosen. It is very important to remember that the NOI and the FCC Advisory Committee are addressing transmission or delivery issues as they relate to the over-the-air broadcasters and Alternative Media Technologies such as Cable, Satellite, Fiber, Microwave (AML, FML, MDS) and VCR/Disk. The question of a single standard or multiple standards (one for each media) is also being considered.

Although the FCC and other organizations will be studying a possible range of ATS system performance, the ultimate goal is that of achieving what is commonly referred to as "HDTV". As one engages in discussion of what constitutes HDTV, it often seems as if HDTV stands for Hard to Define TV! However, to justify the expense of this service to programmers, consumers, and equipment manufacturers, it must offer substantive and highly visible improvements over the 34-year-old NTSC color system in use today. This distinction must be a least as dramatic as the difference between black-and-white television and color-television in 1953. These differences can be categorized as follows:

1. Increased horizontal and vertical detail and resolution: Increased horizontal and vertical resolution allow better image reproduction by displaying more detail and truer color rendition. The viewer experiences a sense of reality as if watching a live scene through a clean window. Picture detail is also important when the image is displayed on a large screen such as a home-projection television system or in a movie theater.

2. Aspect ratio or screen shape: NTSC televisions' pictures are almost square, with an aspect ratio (picture-width to picture-height) of 4:3. This shape is a carry over from television's early development when movie theaters showed films with that frame shape. The aspect ratio of films today is about 1.85:1. By incorporating this aspect ratio into the HDTV system, existing film product can be displayed in its original composition without the need to make editorial judgements, such as pan and scan, over the product. What's more, this aspect ratio opens up interesting possibilities for today's programming - particularly sports - by providing a more compelling view of the event.

3. Large television screens: The emergence of large-screen television has virtually dictated demand for HDTV. The current NTSC system displays a fuzzy, less than ideal image when displayed on a large screen. In contrast an HDTV image can be expanded considerably before detail is lost, which makes it particularly well suited for consumers' large-screen televisions, theatrical display and audience presentations.

4. High-quality multi-channel sound: High quality multi-channel sound enhances the viewing experience. Surround sound concepts are already available for advanced quality consumer VCR and Disk systems. With the popularity of digital audio, as the Compact Disc and the upcoming Digital Audio Tape systems have illustrated, the consumer will expect digital audio in the next generation TV system.

5. Reduction of artifacts found in the current television system: The current NTSC system is plagued with image degradation called "artifacts", which greatly reduces the picture quality. These artifacts result from the NTSC 1953 requirement to have compatible color and black-and-white systems. Some of these artifacts, such as the rainbow effect seen on plaid jackets, are visible to the untrained viewer. Today's technology coupled with the overall movement to improve television transmission systems provides an opportunity to recover from the compromises made in 1953.

Market Research

Market research regarding US consumers general interest in HDTV systems has been conducted by several organizations, such as MIT, over the period of the last few years. Recently, cable customer oriented research has been conducted by ATC and HBO. HBO conducted a series of demonstrations coupled with specific questions during October 1987, with ATC conducting focus groups in February 1988. Both these efforts must be considered preliminary because, as with any new consumer technology, appropriate testing methods are still being understood by the research community. It is particularly difficult to separate variables such as screen size and picture brightness from the overall perceived quality of the image. Sound reproduction also plays an important role in the quality of the viewing experience.

HBO has analyzed its side by side test of very high quality NTSC vs. the MUSE HDTV system, displayed on the same height screens (26" NTSC and 28" HDTV). The following trends were determined based on viewer perceptions of two "new" television formats:

- Interest in HDTV was high
- Possible pay cable lift
- The price must be right (<20% increase)
- Males rate HDTV higher than females
- Picture viewing size plays an important role

ATC conducted focus groups with side by side comparisons between studio quality NTSC and the SMPTE HDTV production standard, once again as viewed on the same height screens. The groups were separated into basic, pay, former and never subscribers to cable. The members of the group were encouraged to interact and move around the room during approximately one half hour of demonstrations. At the end of the session they were shown a 110" HDTV projection system. Similarly, there were trends evident in these groups:

- Amazement at HDTV quality
- Growing awareness of HDTV
- Pricing is a major issue

The results of these initial research results support our belief that HDTV will have a positive impact on consumers, and therefore cable must take a leadership role in its development.

Transmission Issues

The transmission of HDTV from the origination point to the viewer is the component of the introduction of HDTV into the U.S. that will have the greatest impact on the cable industry, as well as most other media. Once originated, the HDTV signal may be delivered to the final user in one or more of the following ways:

- Over-the-air broadcast
- Cable delivery
- Satellite delivery
- Fiber
- MDS
- VCR or video-disk player

The transmission format is still to be defined. Various agencies in the U.S., most notably the FCC and ATSC supported by many industry associations are attempting to resolve the following issues:

- Should an HDTV format be compatible with the existing NTSC standard?
- To what extent should the format approach the absolute quality of the SMPTE HDTV production standard?
- How much bandwidth is acceptable in the transmission of HDTV signals?
- Due to bandwidth compression techniques required, how much degradation (due to motion, etc.) will the viewer accept?
- Is one standard required across all distribution media?

We believe that one point is clear - each distribution medium must be allowed to deliver the best possible HDTV service it is capable of delivering[2]. This may imply a family of HDTV transmission standards with a corresponding multi-standard HDTV receiver.

Cable HDTV System

It appears reasonable to assume that a family of distribution media optimized HDTV standards will be developed. If this does happen, the following attributes should be considered for a Cable HDTV delivery system (C-HDTV).

1. Provide at least 850 lines of Horizontal and Vertical resolution in both static and moving images. The C-HDTV format shall be designed and implemented so that it does not present a limitation to the quality of the HDTV signal the cable subscriber will receive. Particular attention needs to be paid to the tradeoff of resolution which occurs in moving images when using bandwidth reduction techniques. While initial implementations may not completely achieve this level of performance, the system should be designed with the expectation of delivering this level of clarity in more advanced designs.

2. Occupy one 6 MHz RF channel. Although a cable plant is a closed circuit system and its use of frequencies and bandwidth are not as restricted as that of the over-the -air broadcaster, it does not generally have significant available bandwidth, nor is it electrically transparent to the signals it is carrying. Whatever bandwidth might be available is not likely to be located in a contiguous band, and may have limitations as to its signal carrying quality capability. Cable systems are configured around 6 MHz RF television channels that carry both the visual component and the audio component of a standard television transmission. Various channelization plans (IRC and HRC) were developed to reduce the effects of amplifier distortions in the delivered signals. A HDTV transmission system that does not operate in the existing 6 MHz plan can potentially create distortions in the remaining conventional television channels as well as being degraded itself by distortion products from conventional channels falling into the HDTV signal.

3. Operate in typical U.S. cable systems with little or no rebuild of the system. If the C-HDTV format is to be accepted and used by the cable industry at large, it must be designed to operate in typical U.S. cable systems without requiring major cable rebuild or modification.

4. Co-exists with NTSC and other C-HDTV channels. The envisioned C-HDTV format shall 1) not require a redefinition of the cable channelization plan, 2) not require readjustment of cable signal parameters, 3) not require existing NTSC channels to be removed for technical reasons, and 4) will allow the replacement of any number of NTSC channels with C-HDTV channels.

5. Provides "hooks" to allow future evolutionary improvements of the system. It is reasonable to assume that technological improvements over the next 10-20 years will allow even better HDTV signals to be delivered by cable than possible with the C-HDTV format. C-HDTV shall be developed and implemented in such a manner that allows upgrades to any such advanced HDTV systems with ease and with no disruption to the existing base of HDTV receivers.

6. Allows real time transmission of programming. The C-HDTV system must accommodate real time, live, HDTV programming. Bandwidth compression or conservation techniques that require non-real time processing are not acceptable. While this point may seem obvious, it is not a constraint placed on all media (for example tape and disk).

7. Easily interfaced to the SMPTE approved production standard or to an intermediate satellite transmission format. The SMPTE approved 1125 line, 2:1, 60 HDTV production format is gaining acceptance in North America for film and tape applications. In fact, to date, there have been no other HDTV production

standards successfully demonstrated and supported with readily available hardware. Therefore, it is reasonable to believe this format will be the system of choice for HDTV programming, whether originating live, from film, or videotape. The C-HDTV format must allow an easy interface to this production format directly. In addition, the C-HDTV format must allow an easy interface to an intermediate satellite distribution format which is used for program delivery to cable headends.

8. Uses scan rates and other parameters that allow reasonably priced multi-standard NTSC/HDTV television sets to be produced. For HDTV to be successful, consumer equipment must be readily available and reasonably priced. Furthermore, the consumer HDTV set must readily interface with all television formats it will be expected to receive. The formats include: 1) NTSC, 2) C-HDTV, 3) VCR-HDTV and 4) Broadcast EDTV. Therefore, it is a necessity that the developers of the HDTV formats and the consumer electronics industry maintain close contact to ensure feasibility.

9. Provides 4 CD quality audio channels. At least 4 high quality digital audio channels are needed. The channels should be dynamically reconfigurable to allow any of the following configurations: 1) 4 independent channels, 2) 2 stereo channels, 3) 1 stereo,1 surround, and 1 independent and 4) a 4 channel surround system.

10. Includes a "built-in" high security audio/video scrambling and addressing system. The C-HDTV format shall include a method of high video security and very high audio security. Complete addressability is needed, including access from the program origination point and/or the cable headend. Of course, an intermediate satellite format will also require full security and addressability.

11. Capable of being delivered by satellite to a variety of receive locations. The C-HDTV format or its intermediate satellite format shall not require a total C/N of more than 15 dB to perform satisfactorily. Since a variety of satellite transponder configuration exist, the design of the system must address the typical transponder bandwidths of 27 MHz, 36 MHz and 54 MHz.

12. Recordable on VCRs and optical disks. It is required that the C-HDTV format, and any intermediate satellite formats, be capable of being recorded on consumer VCRs and optical disks. Further, it is desirable that professional VTRs also be capable of supporting C-HDTV.

R&D Efforts

HBO and ATC are jointly investigating methods of HDTV delivery as they relate to cable. These efforts include supporting programs which conduct R&D towards development of C-HDTV and NTSC compatible HDTV systems. We are also participating in NCTA Engineering Committee work characterizing cable equipment and systems.

One R&D effort, funded by HBO and ATC through the Center for Advanced Television Studies (CATS), is occurring at the Advanced Television Research Project facilities of MIT. This program is intended to determine the feasibility of the C-HDTV transmission system as described above. This effort, expected to take 2 years, will produce computer simulations by the end of the first year and implementable designs by the end of the second year. At that time, a decision to go forward will be based on the level of success in reaching the C-HDTV goals and consideration of the results of the FCC ATS process.

A second effort is being planned in cooperation with the David Sarnoff Research Center (DSRC), with respect to the single channel Advanced Compatible Compatible TV (ACTV) system they developed for GE/NBC[3]. This system provides a wide screen improved resolution display by adding augmentation information to the present NTSC system. HBO and ATC are working with DSRC to ensure that ACTV is compatible with satellite and cable distribution. The concern is that, given the additional complexity of the ACTV system over conventional NTSC, it will not be able to withstand the rigors of cable and satellite delivery. This is a defensive project for HBO and ATC. It is in our best interest to ensure that any advanced transmission system that has the potential of broadcast industry acceptance is cable compatible. Beyond fundamental compatibility, it is necessary to investigate how to best carry this transmission format in the cable environment, with any corresponding receiver design requirements identified at this early stage in the development. We have also initiated discussions with DSRC with regard to including signal encryption as an inherent feature of their system.

The NCTA Engineering Committee has appointed a subcommittee, headed by Nick Hamilton-Piercy to investigate cable system performance as related to HDTV systems. Both headend equipment and plant electronics are being considered in this effort. It is expected that knowledge will be gained which can improve performance of our current systems as well as provide valuable insight for HDTV system developers. As both part of an internal quality program and as a contribution to this effort, ATC intends to visit all of its major systems (>30) and measure headend signal characteristics by 3Q88.

Finally, HBO and ATC are active members in the NCTA, FCC, ATSC and CATS organizations as they promote the development of HDTV systems. We encourage all cable industry organizations to play an active role in supporting these efforts.

Conclusion

In summary, ATC and HBO believe that consumers will perceive HDTV as a significant enhancement to the television viewing experience, and therefore it is critical that cable participate in the emergence of the technology. There are major issues currently under debate in anticipation of the availability of consumer HDTV equipment within the next few years. Perhaps the most significant of these is how to transmit HDTV to the home. Cable must work actively with the pertinent governmental and industry committees considering the development of HDTV. Further, we believe it is necessary to work directly with R&D groups to look at opportunities for cable optimized HDTV systems.

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[1] "Cable System Overview - 1988" available from the authors.

[2] Time Inc. Comments and Reply Comments submitted for the FCC NOI on ATS.

[3] "A Single Channel, NTSC Compatible Widescreen EDTV System", David Sarnoff Research Center, HDTV Colloquium, October 1987.