Funding Partnership Formed to support American HDTV System Development

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Marina del Rey, California

The formation of a limited partnership among several key members of the television broadcast and cable industry was announced today by Richard J. Iredale, founder of the Del Rey Group of Los Angeles, California. The purpose of the new partnership, to be known as the Compatible Video Consortium (CVC), is to aid the development of a new high definition broadcast system that operates over a single television channel yet is compatible with existing consumer receivers and studio equipment.

According to Mr. Iredale, "There is an urgent need for an HDTV transmission technology that reflects the unique characteristics of the North American environment. We are pleased to see that members of the broadcast and cable industry are stepping forward with funding assistance, and are delighted that others believe in the potential value of the Del Rey Group's system, known as HD-NTSC™. We urge all interested parties to join us in this effort."

Iredale mentioned "There are three reasons why membership in the CVC is attractive. First, it provides the funding that moves our single-channel compatible protocol development along. Secondly, since HD-NTSC promises to dovetail beautifully with the existing NTSC broadcast, cable, and studio environments, our solution protects the current enormous financial stake that organizations have already made in NTSC. Last but certainly not least, investment in CVC is just that, an investment. It is possible that significant returns in the future may result from a relatively modest capital outlay today. In total, we think this is a partnership that makes a lot of sense."

The establishment of this partnership in the North American broadcast industry may be seen as a very positive response to the challenge issued by the United States Department of Commerce in its recent

comments to the FCC Notice Of Inquiry regarding Advanced Television Systems. Those comments state a clear preference for a single-channel transmission format compatible with existing television equipment.

The founding limited partners of the CVC are Cox Enterprises, of Atlanta, Georgia, and Tribune Broadcasting Company of New York. Their respective capital contributions to the newly-formed partnership are reported to be "in the six figures", according to Mr. Iredale.

For additional information about the Compatible Video Consortium and/or the Del Rey Group's HD-NTSC technology please contact the Del Rey Group at (805) 379-3395.

Second Milestone Passed With Compatible HDTV System

Wednesday, 9 December 1987

--Marina del Rey, California--

A television technology offering movie-like quality over a single broadcast or cable channel is another step closer to reality this month, according to Richard J. Iredale, founder of The Del Rey Group and a leading advocate of single-channel high definition television (HDTV). According to Mr. Iredale, researchers performing a simulation of the Del Rey Group's encoding system known as HD-NTSC™ have succeeded in applying the technology for the first time to color images.

Mr. Iredale explains: "The heart of our HD-NTSC transmission system is a subsampling technique called TriScan™ which takes a high definition monochrome (black and white) signal and compresses it down to the NTSC format. This compressed HD-NTSC signal behaves just like regular NTSC--it can be stored on an NTSC recorder, edited in an NTSC studio, and transmitted over a single NTSC channel. The great part is that this new signal can be received by conventional television sets to give a conventional picture, while at the same time a new receiver using the HD-NTSC decoding process will be able to build an image with nearly twice the vertical and horizontal resolution of regular NTSC. Plus, the new sets will deliver a wide-screen artifact-free picture and digital stereo--taken together, a tremendous improvement over conventional television."

Mr. Iredale continues, "This whole concept was first introduced in a paper we delivered at a SMPTE Conference about a year ago. Shortly afterward we had discussions with the Canadian Broadcasting Corporation (CBC) and with the INRS, a prestigious research center located in Montreal, about running simulations of the HD-NTSC protocol on the center's VAX 8600 system.

"Those first tests were performed last summer, using monochrome images. The results of those tests showed great promise, as reported in a press release issued at the time, and the decision was made to begin working with color images. I am delighted to report that several weeks ago the Montreal researchers succeeded in encoding a high definition color image into composite HD-NTSC and back again."

When asked about alternative systems under development both in this country and in Japan, Mr. Iredale smiled and responded, "There are many intelligent people working on a variety of systems, but to us the situation is quite clear. First, we believe a single 6MHz channel could be all we're going to get to play with--it's likely there's just too much demand for spectrum from a half-dozen directions to consider adoption of 1 1/2 or 2 channel systems. Secondly, many industry voices are emphatic that the signal coming down that single 6MHz channel had better be directly watchable on the 150 million receivers already in use. Thirdly, the transmission system needs to produce a really terrific picture,

because it has to compete against wideband videocassettes someday. Add it all up and we think it says HD-NTSC.

"The recent FCC Notice of Inquiry listed our proposal as only one of several under development. One organization has recently announced a subsampling system that is also single-channel and compatible, but they themselves state that picture quality is not much better than regular NTSC. Another team has shown simulations of a single-channel system quite different from our approach, and while offering promise, it is felt by some to fall short of the benchmark established by 1,125 line HDTV."

According to Mr. Iredale, the Montreal simulations exposed an unexpected feature--the ability of HD-NTSC to allow broadcasters to gradually increase resolution to very high levels over time while remaining within the bounds of a single NTSC channel. "HD-NTSC is capable of delivering outstanding resolution, but it would make sense to operate at somewhat reduced levels for a while as older receivers are gradually retired from service. It's like buying a new car with a powerful turbo engine and taking it on the highway. In order to be fully compatible with older sedans, you drive at their speed, but as more and more drivers trade up to turbocharged cars, your speed can be safely increased." He claims the simulations demonstrate both vertical and horizontal resolutions about equal to HDTV, or about 700 lines per picture height (l/ph), far superior to conventional NTSC resolution of 330 l/ph. Patents have been applied for on various aspects of the HD-NTSC signal.

Recently, several members of the American television industry flew to Montreal to join Mr. Iredale in viewing the latest simulation results. When asked what he needed most from industry at this point in time, Mr. Iredale immediately responded: "Funding. Funding is critical for us to get this program into high gear. If broadcasters and cablecasters don't get involved and vote with their pocketbooks, then it's quite possible that a technology hostile to their environment could be chosen instead. To borrow from an old joke, these first simulation results are like seeing light at the end of the tunnel, and at this point we're fairly certain that the light we're seeing is not the headlamp of an oncoming train. But much work remains to be done, and everything revolves around money. We don't need funding next year. We need it now."

Mr. Iredale was recently invited to testify before the House Subcommittee on Telecommunications and Finance in Washington regarding High Definition Television. His papers on the HD-NTSC proposal have appeared in the *IEEE Transactions on Consumer Electronics* , the *SMPTE Journal*, and most recently in the *IEEE Transactions on Broadcast Technology*. He graduated from the Massachusetts Institute of Technology with a BSEE degree in 1977, holds an MBA degree from the University of Southern California, and is a member of both The Society of Motion Picture and Television Engineers and the National Association of Broadcasters.

For further information, contact The Del Rey Group at (805) 379-3395.

Questions and Answers

9 April 1988

What exactly is High Definition Television?

HDTV is generally defined to be any television system having the following characteristics:

(1) approximately double the vertical and horizontal resolution when compared to conventional television standards,

(2) elimination of conventional artifacts, such as interlace (line flicker) and cross luminance/cross color (dot crawl),

(3) widened aspect ratio of 5:3 or 16:9, and

(4) digital audio comparable to Compact Disc.

The Del Rey Group is promoting a transmission format, known as HD-NTSC™, that promises to meet each of these points while remaining within the bounds of a single NTSC broadcast or cable channel and while remaining compatible with conventional station equipment and consumer receivers.

Why have you chosen to have an exhibit here in the ATV Exhibition Room?

The general partner of the CVC, the Del Rey Group, felt it was important to let the American broadcaster know that work was progressing on the development of an HDTV transmission system that was evolutionary in nature and which promised to dovetail neatly into the existing NTSC broadcast environment. This new HD-NTSC transmission protocol is not a watered-down or compromised version of other transmission schemes but a robust format based from the ground up on the NTSC signal and NTSC compatibility. Although this project is still in an early phase the preliminary work to date shows great promise.

What is the CVC?

CVC stands for the Compatible Video Consortium, L.P., which is a limited partnership dedicated to the development of an HDTV transmission format that requires just a single 6Mhz broadcast or cable channel and which is compatible with existing studio equipment and consumer receivers. The CVC was formed in February 1988 as a Delaware Limited Partnership. There are currently two limited partners in the CVC, Cox Enterprises (Atlanta) and Tribune Broadcasting (New York). A prospectus on the Compatible Video Consortium will be available to qualified organizations from the Del Rey Group. Please note that the materials you are now reading do not constitute an offering. Such offering can only be made by the Prospectus.

What makes you think a single-channel HDTV system is possible when others insist it requires multiple channels and additional spectrum?

There is only so much information that can be transmitted through a given spectrum window. It is therefore clear that the more spectrum that one has to work with, the more information that can be sent. However, while we believe multi-channel formats can be made to work, there are several reasons for our selection of a single-channel technology:

First, there is a great deal of redundancy from frame to frame of a typical television image. Since NTSC is capable of transmitting 30 completely separate and unrelated images per second, researchers have felt for years that a sort of "overkill" existed. The new HD-NTSC protocol basically slows down the frame rate to 10 per second for stationary objects but keeps the usual 30 per second for objects in motion. The trick is that HD-NTSC does it in a way that eliminates the large-area flicker that one would expect to see at such a low rate.

Secondly, we believe a multi-channel approach could turn out to be sensitive to such commonplace problems as noise and multipath distortion, particularly if the two channels are not immediately adjacent on the spectrum.

Finally, from a practical point of view, a single-channel approach will be by far the simplest to implement in an industry as large and complex as ours, *providing* the image quality is comparable to non-broadcast delivery systems.

How will HD-NTSC compare with ACTV?

ACTV (Advanced Compatible TeleVision) is a development of the David Sarnoff Research Center (DSRC) and sponsored by NBC. DSRC recommends a two-phase approach to high definition television. The first phase involves a signal (ACTV-I) that is carried in compatible fashion over a single NTSC channel and which delivers an enhanced resolution wide-screen image. Phase II builds upon that signal by using an augmentation channel to carry additional detail information and digital audio. As such, full implementation (HDTV quality) requires the use of additional spectrum. In addition, the ACTV approach would probably require additional investment in the studio for dual channel video tape recorders and editing systems, since the Helper Signal is not placed in quadrature on the Main Signal until transmission.

There are similarities between ACTV and HD-NTSC. Both systems are based on a philosophy of receiver compatibility--in other words, a conventional NTSC receiver will be able to display an image when fed the new signal without the need for any black box converter. Both HD-NTSC and ACTV-I

can be delivered over a single broadcast or cable channel. Both systems incorporate a display memory in the new receiver design in order to provide a progressive display scan and eliminate interlace artifacts. Both systems employ luminance-chrominance prefiltering to remove cross-luminance and cross-color artifacts. Both systems deliver a 5:3 aspect ratio to the new receivers.

In other ways the two proposals are significantly different:

• HD-NTSC offers significantly higher spatial resolution, while ACTV delivers high temporal resolution.

• Though both systems deliver a 5:3 aspect ratio, the method of carrying the new shape is very different.

• HD-NTSC offers digital audio in addition to conventional MTS stereo; ACTV will rely on the ACTV-II augmentation channel to deliver digital audio.

• HD-NTSC offers the possibility of delivering, over a single channel, even higher spatial resolution in the future with just a simple adjustment at the encoder, while ACTV will rely on the ACTV-II augmentation channel for HDTV-quality resolution performance.

How will HD-NTSC compare with Muse?

Muse is a transmission protocol, first announced by NHK in 1984, that compresses a studio HDTV signal down to about 8Mhz. The original intent of Muse was to provide a mechanism for HDTV images to be sent to a totally new generation of consumer receivers via direct broadcast satellite. NTSC compatibility was never intended or even desired; the broadcast environment in Japan is substantially different from North America, and Muse was designed with the Japanese environment in mind. NHK has recently introduced a family of Muse protocols in response to the concerns of North American broadcasters: in addition to regular maximum-strength Muse there is now a 9 Mhz version called Muse 9, a 6Mhz version called Narrow Muse, and an NTSC compatible version called Muse-6.

It is clear from NHK documentation that, due to performance limitations, Muse-6 is not intended to be the final transmission mechanism for North American broadcasters, but only an interim step on the path to full Muse, which will require additional spectrum and which is incompatible with the approximately 250 million NTSC receivers in North America and Japan. By contrast, HD-NTSC promises receiver, channel, and studio compatibility, and in addition appears capable of increased performance in the future without the need for additional spectrum.

Muse is an intelligent design with first-rate engineering. The only shortcoming from a broadcaster's point of view is that it was designed for a DBS environment and was never meant to be compatible with NTSC.

What changes to broadcasting facilities would be required in order to carry HD-NTSC?

In theory, at least, there is little that needs to be changed. The signal coming out of the HD-NTSC encoder has exactly the same characteristics as conventional NTSC. If a studio currently delivers an excellent-quality NTSC signal, it should have no problem with HD-NTSC.

The HDTV signal that feeds the HD-NTSC encoder could come directly from an HDTV telecine unit or from HDTV cameras. The HDTV cameras could be designed specifically for the HD-NTSC format, or could use other production formats, such as 1125 line, 1050 line, or the new HD-PRO™ format that will be introduced by the Del Rey Group later this year.

Could cable handle HD-NTSC?

Early indications are that there should be no problem whatsoever with cable delivery, as long as the cable system is able to deliver an excellent-quality NTSC image currently.

How long will it take for HD-NTSC to be implemented?

The implementation schedule is strictly up to the industry. Additional funding will be needed to accelerate the development process. A 1995 window is a reasonable target if sufficient funding is obtained.

One of the key strengths of HD-NTSC is that actual implementation can proceed quickly once the hardware becomes available, because it is an evolutionary or "implementation-friendly" technology.

How does the CVC hope to have a chance of competing against other much larger and well-financed organizations?

The Del Rey Group believes that *every* organization is relatively small compared to the enormous total size of the television industry. Therefore, the only way that *any* system will be adopted will be if the industry as a whole agrees that the approach makes sense.

What will the HD-NTSC signal look like on a new HD-NTSC receiver?

Preliminary results indicate that an HD-NTSC signal properly decoded by an HD-NTSC receiver will offer a substantially improved static spatial resolution nearly double that of conventional NTSC, and will be free of interlace effects and dot crawl. The image will have a wide 5:3 aspect ratio, and digital audio of at least 2 channels will offer impressive dynamic range and clarity. Finally, the new receiver will deliver substantially improved chroma performance from the standpoint of extended bandwidth and linear I/Q matrixing.

What will the HD-NTSC signal look like on a conventional NTSC set?

The new signal as displayed by a conventional receiver will be slightly degraded in several ways. First, although cross luminance (color dot crawl) will be eliminated, a new artifact looking somewhat like it will be introduced. This new artifact is due to the TriScan encoding process and is of roughly the same magnitude as conventional cross luminance. What we are doing, in effect, is substituting one artifact for another. Neither artifact will appear on the HD-NTSC receivers, of course.

Finally, NTSC receivers will display a narrow black bar at the extreme top and bottom portions of the picture. These bars will amount to only a few percent of the total picture height.

Is the CVC seeking additional partners?

On an individual basis, the CVC will be discussing the partnership with qualified organizations. Please note that the materials you are now reading do not constitute an offering. Such offering can only be made by the Prospectus.

Can HD-NTSC work with the NHK 1,125 line production format?

Yes, the HD-NTSC transmission protocol can use an 1,125 line format as the source signal, but performance will suffer if the production format employs interlace. HD-NTSC could also work well with a 1,050 line format or a new production format known as HD-PRO that will be introduced by the Del Rey Group later this year.

How many "lines" does HD-NTSC use?

The question is difficult to answer because it is too vague. Since HD-NTSC is very similar to NTSC as defined by RS-170A, it could be said to be a 525 line system. Of those 525 lines, however, only 414 are "active" in the context of carrying picture information, and those 414 lines are derived from 828 active lines, which in turn are derived from a production format such as 1,125 line HDTV.

What perhaps makes more sense is to categorize systems by their performance as measured in lines per picture height (l/ph) for both vertical and horizontal axes. Conventional NTSC is capable of resolving about 330 l/ph vertical and horizontal, and the Muse system is able to show about 700 l/ph. HD-NTSC appears capable of static spatial resolution performance from about 450 to just over 700 l/ph for both vertical and horizontal measurements, well inside HDTV territory.

Can HD-NTSC accommodate digital audio?

Yes. A number of scan lines that are no longer needed to transmit image can be redeployed for other uses, including digital audio.

What will happen if North American broadcasters don't unite in supporting a single-channel HDTV system?

The handwriting is on the wall: if broadcasters do not take an active role in determining the evolution of television, then others will be perfectly willing to do it for them. The danger is that the resulting formats may be hostile or incompatible with the status quo.

I've heard the Del Rey Group will be proposing a new HDTV production format called HD-PRO. What is it, and why are you proposing it if the NHK 1,125 format has already been accepted?

HD-PRO and HD-NTSC are only related in that HD-PRO is a production format capable of feeding all proposed and existing transmission formats, including HD-NTSC. The charter of the Compatible Video Consortium is to develop a transmission format, and therefore HD-PRO is outside the scope of this discussion.

The NHK 1,125/60 production format has been approved by the SMPTE and ATSC organizations as *a* production format, not *the only* production format. Every format will offer particular strengths and shortcomings.

The NAB itself is seeking broadcaster's support for an "Advanced Television Test Center (ATVTC). How does the focus of that center compare with the work of the Compatible Video Consortium (CVC)?

It is our understanding that the ATVTC will serve in a testing capacity. In contrast, the CVC's purpose is to develop a single-channel transmission protocol. The two charters are quite different, and we believe each is worthy of support.

Won't people object to the narrow black bars at the top and bottom of the picture as displayed on a conventional NTSC receiver?

Recent evidence suggests not. There are two ways of showing a wide-screen image on a narrow display. The first is to show only a portion of the wide-screen picture, and manually shift the field of view back and forth in order to capture the essential information. This is known as Pan and Scan, and has been practiced in this country for many years. The second option is to reduce the wide-screen picture slightly so that it fits within the narrow-screen window. This introduces black bars at the very top and bottom of the screen. This format has been employed in European television for many years, and recently has become a common practice with many music videos on MTV™. Some recent MIT studies have found that viewers object to the black bars at first, but upon being told that they have a choice between black bars or missing the sides of a wide-screen movie (pan and scan), they strongly prefer seeing the whole picture, even with the bars.

HD-NTSC reduces the vertical dimension from 483 down to 414 lines, or about 14%, which is less than other proposals, which call for a 25% reduction. The overscan on conventional sets will mask most of that, leaving only narrow strips at the extreme top and bottom. Given the trend towards square CRT bezels these days, many will probably find the new shape to be an impovement to the old "rounded" format.

Finally, it should be mentioned that HD-NTSC receivers will employ a 5:3 aspect ratio screen, and of course no bars will be evident at the top and bottom.

One organization claims that the technology for HDTV displays is not even available yet, so there is no urgent need for an HDTV broadcast system.

One look around the room you're in right now should convince you that very high quality CRT displays are readily available for HDTV viewing. Certainly the computer graphics industry is full of monitors and projection systems having 1,024 or even 2,048 line capability and 60Hz frame rates. It is true that such technology is not inexpensive, but costs will drop as production volume increases.

Do you think additional spectrum space can be found for HDTV transmission?

Such a question is better asked of those organizations that regulate the spectrum.

What will happen to the MTS audio format?

MTS will continue to be a part of HD-NTSC, in order to maintain compatibility with MTS-equipped receivers.

Why try to improve NTSC when new technologies and new formats are reportedly just around the corner?

We think all the drumbeating about new and improved signal formats, such as DBS/MAC, are partly solutions in search of a problem. NTSC was designed around sound principles back in 1941, and decades of use have uncovered additional ways of adding utility and signal robustness. One of the most significant limitations to NTSC in the past has been the unintentional mixing of luminance and chrominance information that results in cross-luminance and cross-color artifacts. Research performed by a number of organizations has indicated, however, that with special inexpensive filtering techniques even these artifacts can be eliminated. We think the situation regarding radically new transmission formats is similar to the reports of "Flat-Screen" TV: such technology always seems to be "just a few years away".

Some other HDTV systems advocate a "two step" approach. Is HD-NTSC a two-step system?

Not exactly. The idea behind a two-step philosophy is valid, but perhaps not practical. Basically, the concept is this: rather than make a giant leap from NTSC to HDTV, maybe it makes more sense to make two smaller leaps. The first jump gets you to an interim solution that provides improved picture quality (EDTV) but not true HDTV. Then, at some point in the future when additional spectrum is found, the industry can implement a full-blown HDTV system. Another variation is that once virtually all receivers are EDTV sets, we can go directly to an HDTV format that can be viewed with the EDTV sets but which is incompatible with NTSC sets.

There are several problems with these approaches. First, it is not clear that additional spectrum will ever be found, since there are bound to be ever-increasing demands on spectrum in the future. Secondly, a typical consumer might not be willing to purchase an interim receiver, knowing that it is doomed to obsolescence. Finally, a two-step approach implies that the industry will be going through not just one but two wrenching upheavals in the future, the first in going from NTSC to EDTV, and the second from EDTV to HDTV.

HD-NTSC represents a subtle variation of the two-step philosophy. With HD-NTSC, system performance can be adjusted at the encoder from modest improvement (about 450 lines per picture height) to full HDTV quality (700 l/ph both vertical and horizontal). In effect, a continuous transition can be accomplished, assuring that HD-NTSC can remain competitive with other non-broadcast delivery systems for many years to come.

HD-NTSC is a trademark used by the Del Rey Group to identify its single-channel receiver-compatible high definition television transmission protocol.

Point of View

Advanced Television Systems for the United States:

Getting There from Here

William F. Schreiber

Summary

In this paper, the origin of the present controversy about improved television systems is discussed. The intense concerns shown in this matter are explained in terms of the economic interests of those involved. The characteristics of the principal contending systems are quantified, and principles are proposed that might form the basis for federal decision making in this area. The probable results of adopting each of a number of possible scenarios for development are predicted. The very different economic effects of these scenarios is stressed, together with the importance of protecting current and future investment in equipment by industry and viewers. A series of recommendations is made, including abandoning US support for adoption of the NHK system as an international standard, setting goals for a final system, establishing a period of experimentation with alternatives, phasing in new systems by a staged process, and considering the guidance of development by legislating certain receiver standards.

Background of the Controversy

The recent petition to the FCC for an Inquiry was occasioned by two considerations. One is the supposedly imminent introduction into the US of high-definition VCR's and receivers, which might compete with terrestrial broadcasters and cable distributors for audience share. The other is the possibility that some of the unused portions of the UHF spectrum, which might be allocated for HDTV transmissions, may be reassigned to land-mobile radio. A lot of money is at stake.

The NHK system. Originally intended specifically for DBS use, it became apparent that its 30-MHz bandwidth was excessive even in that application. In 1984, a reduced-bandwidth version called MUSE was announced, requiring only one-fourth the channel capacity. This was achieved by reducing the spatial resolution by half (discarding half the picture elements in each frame in a diagonal fashion) and by reducing the transmission rate of detail information to 15 frames/sec. This produces some loss of sharpness of moving objects, but a clever interpolation method results in surprisingly little loss of static resolution as compared with the wideband NHK system. However, the sophisticated signal structure is not robust under analog transmission degradations, so that MUSE cannot be used in cable or terrestrial transmission without excessive quality loss. It can successfully be recorded on tape or disk or transmitted in a single satellite transponder channel, although a somewhat higher carrier-to-noise ratio (CNR) is required at the receiver than with NTSC.

Production standards, transmission standards, and transcoding. When HDTV development started at NHK in 1970, there was no concept of production standards as distinct from

transmission standards. Film is the *de facto* production and program-interchange standard at present, to the extent that there is one. Since NTSC, PAL, SECAM, and film are mutually incompatible, transcoding is required when programs are interchanged between systems. Although there is some quality loss, especially when frame rates must be changed, this is quite acceptable to viewers and does not affect the salability of programs.

The NHK system as a production and program-interchange standard. The use of the NHK system for this purpose is supported by Japan, the US, and a few small countries, but strongly opposed by all the principal 50-Hz PAL countries. Many Americans backed this proposal in the vain hope that Europe would accept it and we would then have a worldwide standard, as least for these limited purposes. The Europeans are now developing a 50-Hz system under the well funded Project Eureka; the proposal for a worldwide 60-Hz standard is dead, although not yet buried.

Since the NHK system was originally intended for transmission and display, it is interlaced. As a result, it is very inconvenient, although possible, to transcode to or from film or to PAL or NTSC. Transcoding is much simpler from a progressive source. A source for NTSC would be 59.94 fps and one for film-making would certainly be 24 fps. Actually, the latter, especially if operable at 25 Hz as well, would be a good candidate for a source for all systems, since 24/25 fps film provides such a large portion of program material in all countries. The motion-compensation principle that made NHK HDTV-to-PAL conversion acceptable to meticulous European TV interests, if used for film-to-NTSC conversion, would give much better motion rendition on TV than seen in the theatre from the original film.

In view of all this, a natural question is why there is so much passion behind the adoption of the NHK system for production. My opinion is that such a production system gives a great advantage to MUSE, with which it is directly compatible, for transmission and recording. The latter functions are where the profit lies. There is, potentially, a great deal of money to be made in HDTV, and the distribution system is the key to controlling it.

The intimate relationship between the NHK wideband production system and the MUSE distribution system comes from the fact that they use the same scanning standards, cameras, and receivers. MUSE is *intended* as the NHK transmission system, and the NHK system is *intended* as the source and sink (destination) of MUSE signals. If it really did not make much difference which production standard was adopted, I doubt that we would see one particular standard so vigorously pressed on us.

The Players

There are large profits being made in delivering TV services, and more in store when "the benefits of Advanced Television Systems" are eventually brought to the public. Whatever government decisions are made in this field, there will be winners and losers. This is to be expected, of course - it represents the ordinary working of our economic system - but it is well to keep in mind that it is primarily money that lies at the heart of this controversy.

Among the groups involved are TV professional equipment manufacturers, the consumer electronics industry, theatrical program producers, nontheatrical program producers, wholesale distributors, local distributors, alternative distributors, theatre owners, the recorded material

rental industry, and, finally, viewers and the public at large. It is fairly easy to see where the interests of each group must lie.

In view of the large number of parties involved, and the overwhelmingly economic nature of their interests, it is clear that decisions about Advanced TV Systems (ATV) are mainly about jobs and money, and only marginally about beautiful pictures. Some players see ATV as a threat and some as an opportunity, and to some, it doesn't make any difference. To some, which ATV system is used is important, but to others, one is as good as the other. In the long run, very few domestic players would be harmed more by an American ATV than by a foreign one, even if the former came along later. Most, especially domestic manufacturers and the public, would be adversely affected by a foreign ATV and would benefit from an American system, mainly manufactured in the US.

Performance of Various Proposed ATV Systems

It is remarkably difficult to make quantitative comparisons among the various proposed ATV schemes. This is partly due to the fact that none is completely described in the literature. In spite of this, it is important to attempt the comparison to show what the possibilities are and that there are many of them.

In order to make a compact comparison among the various proposed systems, I have listed certain performance parameters in the following table. Spatial resolution in fixed and moving areas is calculated on a uniform basis from the available data, as is the bandwidth requirement. It is assumed that the resolution is limited by the scanning standards and the bandwidth only, and that the camera and picture tube are perfect. This does not affect the relative performance of the various systems. Actual resolution reached will be smaller in all cases. As equipment improves, the resolution will rise. The other characteristics listed are judgments, no doubt subject to error.

Proposed Principles for Guiding Federal Involvement

The prevailing contemporary view is that federal regulation should be minimal, consistent with the goals of national policy. Market forces should be relied upon to the extent possible. Since no transmissions are permitted under existing law free of FCC regulation, doing "nothing" means that ATV will develop solely through nonbroadcasting channels, a result that today's broadcasters believe would be extremely detrimental to their interests. Doing "everything" means deciding, in the near future, what the shape of ATV will be for many years to come, and prescribing transmission standards and spectrum allocations to support those standards. While some of the more enthusiastic supporters of one system or the other may endorse this approach, most would say that such action is premature, particularly in view of the extraordinary creativity being shown in the field at present. I suggest that reasonable considerations for federal action in this field must include the long-range effect on the economy, the impact on consumers as well as industry, and spectrum conservation.

Performance of Various Advanced Television Systems

System	1	2	3	4	5	6	7	8	9	10	11	12	13
Stationary-area luminance resolution													
Vertical	480	336	480	728	728	480	408	717	408	480	480	600	720
Horizontal	440	316	440	1007	1007	550	874	1300	650	650	750	660	1275
Diagonal	F	F	R	F	R	F	F	R	R	R	F	R	R
Stationary-area chrominance resolution													
Vertical	480	336	120	728	520	120	240	?	120	120	480	360	240
Horizontal	158*	62	62	352*	352	62	247	?	62	62	200	124	425
Diagonal	F	F	F	F	R	F	F	?	F	F	F	F	F
Moving-area luminance resolution													
Vertical	480	336	480	728	520	440	408	408	408	480	480	360	240
Horizontal	440	316	440	1007	629	316	494	441	316	316	750	316	425
Diagonal	F	F	R	F	R	R	F	F	R	R	F	F	F
Moving-area Chrominance resolution													
Vertical	480	336	120	728	260	60	240	?	120	120	480	360	240
Horizontal	158*	62	62	352*	352	62	124	?	62	62	200	62	425
Diagonal	F	F	F	F	R	F	F	?	F	F	F	F	F
Channel (rf) bandwidth, MHz	6	6	6	50	10	6	12	9	6	6	12	6	6
Compatibility (1-10)	NA	5	5	1	1	4	5	5	4	3	5	4	1
Receiver complexity (1-10)	NA	5	4	2	1	3	3	3	3	2	3	1	1
Multipath performance (1-10)	NA	3	3	5	1	3	?	3	?	?	3	3	5
Low SNR performance (1-10)	NA	4	5	5	3	4	4	4	?	?	4	4	5
Cross Effects (1-10)	1	2	4	5	5	4	4	4	5	5	4	4	5

Systems:

1. NTSC theoretical
2. NTSC notch filter 525/30/60
3. NTSC 2-d comb filter 1050/60/60
4. NHK wideband 1125/30/60
5. MUSE 1125/30/60
6. Fukinuki, Matsushita 1050/60/60
7. NA Philips 525/60/60
8. Glenn 1050/60/60
9. ACTV 525/60/60
10. ACTV 1050/60/60
11. Rzeszewski 1050/60/60
12. MIT-RC 1050/60/60
13. MIT-BE 1200/60/60

Notes:

A/B/C means A lines, B frames/s, C fields/s
Starred items have different resolution for the two color components
F = full, R = reduced diagonal resolution
Last five lines are qualitative judgments
All calculations subject to correction

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The economy. The current trade imbalance, which reflects the demise of American manufacturing, would be worsened by expansion of demand for products that must be imported. Since this also affects employment, we would be better off without any ATV system unless much of the demand could be satisfied domestically.

Consumers and industry. The consumer ultimately pays for television, and in a field where government regulation is essential for any reason, these regulations should operate to advance consumer interests as much as feasible. Investment in existing receivers and VCR's, as well as new ones that are blessed with government action such as operating standards, must be protected for a reasonable period of time. Any departure from the principle of "free" basic television service must be made only with the consent of a very large proportion of users. In industry, winners and losers are inevitable no matter which course is chosen. A level playing field, service to the public, and the overall effect on the economy are the main considerations.

Spectrum conservation. Radio-frequency spectrum is a scarce commodity, which is the main reason why it is regulated. TV is, by far, the most voracious consumer. There are many other demands, such as land-mobile radio. One principle of regulation might well be to promote the most efficient use of spectrum. The image quality achieved per unit bandwidth is therefore the single most important parameter of any proposed new system. Since NTSC is inefficient, its ultimate phase-out is desirable, provided that can be accomplished with minimum adverse economic effects.

As a principle, replacing every piece of TV hardware in the country is a path to wealth, not poverty. This has occurred in many fields that ultimately have made important contributions to our economic well-being, such as the automobile industry. The problem is how to deal with the dislocations to individuals, companies, and industries in the process.

Possible Scenarios: Their Costs and Benefits

The NHK/MUSE route. If the NHK wideband system is adopted as an international production and program-interchange standard, MUSE will come to the fore as a distribution standard via cassettes, optical disks, and, in some cases, DBS. Dual-standard NTSC/MUSE receivers will be marketed. Profits will come first to manufacturers, renters, and sellers of receivers and other equipment as well as software. The losers will be terrestrial broadcasters and local cable companies. US manufacturers would be effectively shut out of the market.

Note that MUSE is not compatible with existing 6-MHz channels or with existing receivers. It is intended to provide a wholly new service. This would make NTSC a second-class service, the more desirable programs being reserved for the high-definition service. In his keynote speech at ISBT'87, "Future Prospect of Satellite Broadcasting and Hi-Vision," Dr. Yuko Nakamura, Director-General of Engineering of NHK, compared present day television and HDTV to AM and FM radio, respectively. This may well be a suitable solution for Japan, but it certainly is not for the US. The networks, for example, would have a hard time explaining to their stockholders their intention to go the way of AM radio.

This scenario describes the likely course of events in the absence of any action by the FCC. Since it is so injurious to American interests, it is astonishing that it has any support in this country, especially by the government itself. In my opinion, any kind of standardization,

other than by the concerned manufacturers, constitutes an endorsement, however unintended. The need for standardization at the present time, especially by government, seems questionable, particularly in the light of the statement by Joseph Flaherty, at the Markey hearings, that the worldwide total of production houses using the NHK system was just 20, only about half of which are in the US.

Receiver-compatible enhanced-definition (EDTV) route. American thinking about ATV is dominated by two interrelated problems. One is the danger of losing audience share to improved TV delivered by alternate means. The overwhelmingly preferred solution is to compete by means of ATV transmissions that are both receiver-compatible and channel-compatible, such as the recently announced Advanced Compatible TV (ACTV) from the Sarnoff Laboratories. This adds additional information to the normal signal with little degradation of reception on existing receivers. A sophisticated receiver constructs a substantially improved image. Other proposed systems use one standard NTSC channel, for compatibility, plus a second channel, usually 3 or 6 MHz wide, for enhancement information. The special receiver uses both signals, which may be in either adjacent or noncontiguous channels, to construct the enhanced image.

These systems enshrine the inefficiencies of NTSC, permanently eliminating the possibility of HDTV in 6 MHz, which I believe is a realistic goal. In addition, they depend on the wide-scale purchase of new sets solely for improved picture quality, a form of consumer behavior for which there is no evidence at all.

Another issue is the so-called "chicken-and-egg" problem. In a new service, there is little incentive to buy receivers if there are few programs and there is little incentive to produce programs if there are few receivers. Today's thinking is that receiver-compatible EDTV will stimulate viewers' appreciation of and desire for high-quality audio and images, and may therefore serve as a "bridge" to true HDTV, which will require a more radical break with the past. Clearly, the bridge system must lead to the final system technologically, as well as from the standpoint of image quality. Otherwise, we create another reverse compatibility problem.

The winners in this approach are traditional broadcasters and domestic manufacturers. Viewers would also benefit, provided that their investment in improved receivers were protected long enough. The losers are those who would benefit from the NHK/MUSE approach.

The bandwidth-efficient channel-compatible route. There are many advantages to ATV systems that conform to the existing channels. Of course, spectrum is conserved. Equally important, much less investment is required on the part of the broadcaster. To achieve MUSE quality or better within 6 MHz requires abandoning the inefficiencies of NTSC. Starting from a clean slate, and taking full advantage of new components and new knowledge, I have little doubt that fully satisfactory image and sound quality is attainable. Attractive as such systems may be in the long run, their use requires alternative service to existing receivers. Cable is in the better position, since customers are already paying for programs and universal access to every transmission is not needed. The cable audience, which includes half of all TV homes, is a large enough market to warrant the design of special receivers. Thus, there is no particular obstacle to establishing a bandwidth-efficient 6-MHz service in such a controlled medium.

Two-stage introduction of ATV for terrestrial broadcasting. It appears to be possible eventually to reach the highly desirable goal of channel-compatible HDTV if the right kind of bridge system is chosen. The key element in the system is a "smart," programmable, open-architecture receiver. A receiver of this kind is so arranged that it can easily and cheaply adapt itself to receive and decode any of a wide variety of TV signals, such as NTSC and various ATV systems. If, at the outset, both a bridge system and a final high-efficiency HDTV system are designed to be displayed on the same new receivers, consumers can buy them with confidence that they will not soon be made unusable by changes in transmission formats.

In this scenario, a channel-compatible bridge system is introduced and smart receivers are placed on sale at the same time. As the population of smart receivers rises, the public's taste for high quality rises, and people begin to prefer the EDTV programs.

This permits options to be kept open for some years. One possibility is that the bridge system becomes the final system. Another is that an overwhelming preference develops for high definition. In that case, a decision can be made that broadcasting will shift, on a certain schedule, to some high-efficiency system receivable on the smart receivers but not on old NTSC receivers. NTSC broadcasts can be maintained on a few channels for some additional number of years. When the system changeover is made, smart receivers will show an immediate substantial improvement in picture quality. As the years go by and more powerful processing capabilities become available, receivers can be upgraded and picture quality can continue to increase.

There are no losers in this scenario. With an evolutionary plan, manufacturers, broadcasters, and consumers all can invest with confidence. Market forces can operate freely and a system can evolve that will be acceptable to all concerned. Foreign manufacturers are not discriminated against, but enterprising American manufacturers can have a fair shot at the market.

Recommendations

Everybody likes beautiful pictures, but NTSC pictures, for all their limitations and defects, are good enough for the purposes for which they are used. The interest shown in ATV by the TV industry is almost entirely a commercial interest. If a large demand develops for ATV products, and almost all of that demand is satisfied by imports, the domestic economy will suffer. If a substantial portion of the demand can be filled from domestic sources, a welcome stimulus to the economy may be provided.

NHK and MUSE. The United States should withdraw its support for the adoption of the NHK wideband system as an international standard for program production and interchange. As explained above, MUSE and NHK are cousins - we are likely to get one with the other. There is no pressing need to adopt any standard at this time. There are very few domestic interests that would be advanced by using MUSE and there are many that would be injured. While we should not discriminate against these systems, we should not encourage them either.

Spectrum allocations. A date should be set, perhaps 2 or 3 years hence, to choose the bandwidth to be allocated for a final HDTV service. (If one were to guess today, 6 MHz would not be a bad choice; it would be better not to have to guess.) In the intervening period,

studies should be carried out as to how much bandwidth is available and how much is needed for some desired quality of service.

Economic impact. A study should be begun, as soon as possible, to assess the economic effect, on the whole country and not just the TV industry, of the shape of a new high-quality TV system. This study should enlist the support of a wide range of talent from government, industry, labor, academia, and the public.

Receiver compatibility. Consideration should be given to legislation setting forth compatibility requirements for ATV receivers sold in the US. No sales should be permitted in advance of promulgating such rules. The purpose would be to ensure that no *de facto* standard develops as a result of the sale of a relatively small number of special-purpose receivers, such as those to be used with MUSE recorded material. The import of MUSE and NHK equipment should not be otherwise regulated.

A period of experimentation. With the public protected by the receiver compatibility regulations, a period of time should be established during which experimental transmissions in a variety of systems would be encouraged. Within the 2-3 year period mentioned, the bandwidth could be agreed on, and within another 2 or 3 years, the actual system could be chosen. It would have two stages - a first, NTSC receiver-compatible EDTV stage and a second, high-efficiency HDTV stage. When the EDTV system has been in use long enough to determine its acceptance, a decision can be made if and when HDTV transmissions can be started and if and when NTSC transmissions are to be halted.

Conclusions

Some may argue that those who now stand to be injured directly, principally the traditional program distributors, had ample warning and did not do enough to protect themselves. However, the reasons for the present predicament are beside the point. It is too late to leave this subject entirely to the marketplace, and its potential effects are too far-reaching for it to be left entirely to the TV industry. Without some action on the part of the government, damage will be done not only to the distributors, but to most of the TV industry, to the consumer electronics industry, and to the country as a whole.

In my view, the actions to be taken by the United States should have the overall aim of creating a level playing field, within the country, for the development of Advanced TV systems appropriate to our needs. Some goals might be set such as the maintenance of a reasonable amount of free programming viewable on inexpensive receivers and the achievement of a certain minimum picture quality in the final system. I have proposed a scenario by which this might be done with minimum risk and with maximum flexibility. No doubt others can suggest different plans. But we need some kind of plan that provides at least a chance that we may move to this new medium without undue economic damage.

The opinions expressed here are those of the author and not of MIT or the members of the Center for Advanced Television Studies. This paper was excerpted from comments presented to the FCC relating to Notice of Inquiry, MM Docket 87-268. The complete paper is available from the author.

Advanced Television Systems for the United States:

Getting There from Here

William F. Schreiber

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and not of MIT or the sponsors of
the Advanced Television Research Program.

Background of the Controversy

1. HDTV recorded media may be introduced in the US in 1990.

2. Audience share of TV and cable broadcasters may fall.

3. More spectrum may be needed to compete.

4. Land-mobile radio also wants spectrum.

Wideband NHK System

1. Developed for separate DBS service

2. Not designed as a production standard
   Interlaced camera and display
   No frame stores

3. Facilitates use of MUSE for transmission

4. Very wide bandwidth

5. Requires transcoding for film as well as
   all existing TV transmission systems

MUSE

1. Developed for DBS
2. One standard transponder channel
3. Compatible with wideband NHK system
4. Multipath vulnerability
5. Primary application DBS or recorded media

Principles of Federal Involvement

1. Effect on the economy
2. Effect on consumers
3. Effect on industry
4. Spectrum conservation

The Main Players

1. Professional equipment manufacturers
2. Consumer electronics industry
3. Program producers
4. Wholesale program distributors
   Networks and cable companies
5. Local Program distributors
   TV stations and cable operators
6. Theatre owners
7. Recorded media rental industry
8. Viewers
9. The economy as a whole

Possible Scenarios

1. The NHK/MUSE route
2. Receiver-compatible EDTV route
3. Bandwidth-efficient channel-compatible route
4. Two-stage introduction of ATV for terrestrial broadcasting

The NHK/MUSE Route

1. Introduction via recorded media
2. Possible erosion of broadcasters' audience
3. Likely to be unprofitable for suppliers
4. Little role for domestic industry

Receiver-Compatible EDTV Route

1. Serves existing audience
2. Either complicates NTSC signal or requires augmentation channel
3. Little incentive to buy new receivers
4. Enshrines inefficiencies of NTSC

Bandwidth-Efficient Channel-Compatible Route

1. MUSE quality in one channel
2. Suitable for cable or other pay services
3. Incompatible with existing receivers
4. Requires simulcasting
5. "Chicken-and-egg" problem

Two-Stage Introduction of ATV for Terrestrial Broadcasting

1. Start with receiver-compatible EDTV

2. Later move to bandwidth-efficient HDTV

3. Use same "smart" receiver for both

4. Second step optional -
   Taken only when likely to be successful

5. Phase out NTSC after second step
   Final system is bandwidth-efficient

6. Low risk plan for all players

7. Level playing field for all suppliers

Recommendations

1. Withdraw US support for NHK production standard.

2. Set a date (2 or 3 years hence) for decision on bandwidth to be used for ATV.

3. Study economic impact of ATV.

4. Require ATV receivers to be compatible with a range of ATV systems.

5. Establish a period of experimentation with a variety of ATV systems.

6. Implement the 2-stage strategy.