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Office of the Secretary

FILE

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

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

MM Docket No. 87-268

To: Chief, Mass Media Bureau

REQUEST OF WAIVER OF FILING DEADLINE
OF DEL REY GROUP, INC.

The Del Rey Group hereby requests that the Commission waive the filing deadline established for filing comments in the above-captioned proceeding, and that it accept as timely filed the pleadng titled *Comments of the Del Rey Group, Inc.* of which an information copy is attached. The writer of the Comments, Mr. Richard J. Iredale, was in Montreal last week witnessing the progress of the HD-NTSC computer simulations and wanted to update the Comments to accurately reflect the current situation.

Respectfully submitted,

Richard J. Iredale
(805) 379-3395

5 December 1988

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DEC - 7 1988

Federal Communications Commission
Office of the Secretary

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

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 Reevaluation of the UHF Television Channel and Distance Separation Requirements of Part 73 of the Commission's Rules	MM Docket No. 87-268

COMMENTS OF THE DEL REY GROUP, INC.

The Del Rey Group is honored to provide comments regarding the above-mentioned Further Notice (the Document). For the sake of brevity and accuracy, this response has been arranged in the following fashion per the request of the Document, ¶ 5:

I. Information regarding the Del Rey Group, Inc.

II. Comments regarding the FCC Tentative Decision

III. Comments regarding the Interim Report

IV. ATV within 6, 9, or 12 MHz

V. Additional information about the HD-NTSC protocol

VI. Relaxation or repeal of NTSC standard

VII. Compatibility with Alternative Media

VIII. Production format compatibility

In addition, the Document asked for advice regarding the allocation of additional spectrum and possible licensee service area adjustment negotiations. We do not offer any comment on those particular matters, and continue to be encouraged by the possibilites of a single-channel solution.

I. Information Regarding the Del Rey Group, Inc.

The Del Rey Group, Inc. is a California Corporation engaged in the development of an ATV transmission signal that is compatible to as great an extent as possible with existing consumer receivers, terrestrial and cable distribution systems, and studio equipment. At this time it appears likely that such a signal can be fit within the constraints of a single NTSC channel while still offering genuine HDTV performance[1]. Additional information about the protocol, called HD-NTSC™, can be found in section V.

In February 1988, the Del Rey Group, Cox Enterprises (Atlanta), and Tribune Broadcasting (Chicago) together formed the Compatible Video Consortium L.P., intended to be a funding mechanism for ATV research and development. They were joined in October by Westinghouse Broadcasting Company, Inc. (New York). The Del Rey Group is general partner of the Consortium, and the primary but not limiting focus of the Consortium's activities at present is to fully investigate the TriScan™ subsampling technique, a key ingredient of the HD-NTSC protocol.

It must be emphasized that the comments herein represent those of the Del Rey Group specifically. The other members of the Consortium may have similar or different points of view as expressed in their own filings.

II. Comments regarding the FCC Tentative Decision

The Del Rey Group believes the FCC Decision was logical and well-balanced. A few years ago, our own particular project was founded on several similar assumptions:

[1]HDTV performance is here defined to be four characteristics: (1) doubled spatial resolution, (2) wide aspect ratio, (3) elimination of conventional artifacts such as interlace and chroma/luma interation, and (4) digital audio quality comparable to Compact Disc.

First, the new transmission signal had to be compatible with existing receivers without any "black box" conversion required. To allow any other course of action would not only cause chaos but would also severely depreciate the value of existing consumer equipment. The FCC Decision supports this view.

Secondly, our project insists that HDTV can be delivered over a single channel. We do not expect the FCC and the rest of the industry to automatically accept this as an act of faith; only through demonstration will it be possible to confirm this assumption. It must be kept in mind, however, that NTSC is ripe for improvement, since practical technologies exist today that could only have remained concepts to engineers a few decades ago. By limiting the HDTV transmission spectrum to only the existing TV allocation, we believe the FCC tends so support the view that more can be accomplished within a given amount of spectrum than might have been previously assumed.

Finally, the FCC determined that it was not in everyone's best interest to attempt to retard ATV developments in other delivery media, such as videocassette. However, they were mindful of the benefits of compatibility between media. The Del Rey Group is in complete agreement. Once again, it is our belief that a single-channel, compatible HDTV transmission protocol such as HD-NTSC will not only offer quality comparable to multichannel and/or incompatible approaches, but will also be able to be delivered over alternative media such as VCR and Videodisc. If that is the case, then there would be very little incentive for anyone to introduce an incompatible alternative media format.

III. Comments regarding the Interim Report

In general, the Del Rey Group agrees with the findings of the Report. We have reservations about some of the conclusions that were drawn, however. For example, the report concluded that a 6 MHz (single-channel) compatible system would not be able to deliver HDTV quality. We would suggest that the jury is still very much out on that question, and would call their attention to similar statements made during the "color wars" of the late 1940's, when experts stated it was theoretically impossible to deliver a single-channel yet compatible *color* system. We certainly encourage spectrum needs analysis, just in case, but we still believe a one-channel system such as HD-NTSC will eventually prove to be the best route.

Our second concern with the Report stems from the conclusion in the press that additional spectrum *was* available. It seems to us that such a conclusion was based upon a very fragile foundation of assumptions, and it remains to be seen whether those assumptions are valid. Even in the theoretical

extreme where plenty of additional spectrum was available, it would be a thorny policy issue to decide whether to use that spectrum to create a few HDTV channels to be enjoyed by those with high disposable incomes, or twice that number of conventional channels presumably aimed at the special needs of segments of society. Our conclusion, then, is that research into single-channel delivery possibilities should be taking precedence over multichannel allocation strategies, not the other way around.

IV. ATV within 6, 9, or 12 MHz

There are theoretically as many ways of delivering an improved television picture as there are engineers. This section will take a brief look at the pros and cons of the above-mentional categories, but will first make some general observations about resolution, bandwidth, and subsampling.

Some of the respondents to the previous Notice of Inquiry mentioned the equivalence of bandwidth and resolution. This is true in the general sense, in the same way, for example, that one might make the statement "More Cubic Inches" equals "Greater Horsepower" if refering to automobile engines. But cubic inches aren't the only way to increase horsepower; we might redesign the cylinder heads to incorporate four valves per cylinder, and perhaps add a turbocharger. In such fashion we can double our horsepower without the penalties associated with increased cubic inches (greater weight and poor fuel economy). In other words, increasing the signal bandwidth is not the only way to improve picture quality, and furthermore is perhaps not the preferred means, since doing so costs us dearly in terms of spectrum capacity.

Actually, bandwidth has little to do with static spatial resolution (the sharpness of still pictures) in a subsampled system like HD-NTSC, but has a great effect on dynamic spatial resolution (the sharpness of objects in motion). The reason is because the frame store in an ATV receiver will be able to use the subsampled signal to gradually build a still image of increasing sharpness over succeeding frames. As long as the integration time of the frame store is not too long, the process will appear transparent to the viewer.

Subsampling does, however, cause an artifact when viewed on a conventional set, but it really doesn't look like the 10 or 15 Hz flicker one might expect. Based upon early computer simulations, one of our TriScan variations had the general appearance similar to the sort of dot crawl one sees on a conventional set today. Furthermore, the artifact could be decreased by reducing the sharpness of the HDTV image feeding the encoder. Again, based on the TriScan simulations, it was discovered that full performance resulted in about twice NTSC resolution performance, but with noticeable

subsampling artifact on conventional sets; reduced ATV set performance (about 500 lines per picture height) resulted in little subsampling artifact.

In effect, we have a "resolution screw" that we can adjust at the encoder. We have two different systems, depending on the extreme settings of that screw. If we want full compatibility with NTSC sets, we can choose a lower setting, but over time, as ATV sets become a dominant part of the receiver population, the resolution can be increased without yet another receiver population changeover and without the need for additional spectrum. At the maximum screw setting the signal behaves more like an incompatible simulcast signal, except that the signal could still be picked up on NTSC sets, which at this point would primarily be of the inexpensive portable variety. From a viewing distance of perhaps 10 picture-heights, it is believed the image would still remain quite acceptable.

The Del Rey Group believes this unique transitional approach offers the benefit of continued single channel operation when compared to the approaches mentioned in the Document at ¶19, while still remaining compatible with small-screen sets. An incompatible signal, on the other hand, would be unusable by conventional sets at *any* viewing distance.

It is therefore our opinion that a 6 MHz channel is quite capable of carrying a compatible signal of high performance. In theory, an additional 3 MHz could provide additional performance, but when coupled with the additional overhead that non-contiguous location would entail, the additional half-channel might not provide a picture clearly superior. Furthermore, the use of an augmentation channel permanently transforms NTSC into a 9 MHz system, making it less efficient in the process, as mentioned in ¶13 of the Document.

A 6 MHz augmentation channel offers additional promise, but it is still not clear whether the improved picture would be markedly superior to a subsampled single-channel system like HD-NTSC; instead, the primary benefit would most likely come in the form of reduced artifact on conventional sets. Since our assumption is that the population of NTSC sets will eventually diminish as the new ATV circuitry declines in cost, this appears to us to be a minor benefit with a correspondingly heavy penalty: our ATV signal has now been permanently enlarged to 12 MHz.

Another option is to design a single-channel, but incompatible, signal. The thinking here is that by eliminating the need for compatibility with existing NTSC sets we could really pull out the stops and create a signal that delivered a markedly improved picture. Once again, however, we are not convinced such a picture would be substantially superior to an approach like HD-NTSC. What we

are sacrificing with HD-NTSC is primarily high dynamic spatial resolution, and we believe consumer surveys will show this to be a very innocuous tradeoff to make. Some argue that NTSC has "warts" which hinder performance. We agree, but believe those warts, such as interlace, cross-luminance, cross color, incorrect color matrixing, marginal static spatial resolution, squarish aspect ratio, and limited audio performance, can be fixed. Others state that incompatibility is needed to make the new service successful, since new TV sets would be required to watch the special programming delivered in this fashion. We would argue that without compatibility, a new service will have a very tough road; wouldn't it be far more practical for the consumer (and the broadcaster, for that matter) to be able to ease into the cold waters of HDTV a little at a time? HD-NTSC could provide that friendly transition; an incompatible signal couldn't.

Another possible difficulty with an incompatible signal is that it must be simulcast, at least for the near term. It appears at this time that the only means available to broadcasters would be to use the taboo channels. A proposal by Zenith asserts that it is possible to deliver a very low power signal over those taboo channels without interference to NTSC service. We see several potential problems. First, it remains to be seen whether such a parallel service could be truly interference-free. Secondly, our understanding is that such a service would require the elimination of nearly all LPTV licensees, and the possible legal difficulties of doing so could be substantial. Thirdly, a simulcast approach is efficient only if it is assumed that the old service will eventually be completely phased out, and it is not at all clear whether this could ever happen to NTSC. Additionally, those proposals that rely on taboo channels will most likely be rejected by the cable industry, since cable doesn't have any taboo channels. Finally, many taboo channels exist only because of UHF tuner limitations. As tuners improve and additional channels become available, would it not be more in the public interest to deliver two single-channel ATV programs to the home rather than one?

Another benefit claimed by the low-power simulcast proponents is the reduction in transmitter power costs. Our own informal discussions with major broadcasters indicates to us that such power savings are trivial compared to the total net operating costs.

In summary, we believe that in consideration of the marginal improvement to be gained by 9 or 12 Mhz ATV delivery, coupled with the enormous complexity of such a move, it makes much more sense to concentrate on single-channel compatible transmission. It remains our belief that a protocol such as HD-NTSC can act as an excellent example in the implementation of a practical ATV protocol. Perhaps some of the reservations expressed by other organizations in ¶43,44 could in part stem from the desire of those organizations to continue in the direction they have already headed.

In short: we do not think the door should be completely closed on multichannel options, but we believe that most of the industry's efforts should be concentrated on delivering ATV in a single, compatible channel. Many ideas are possible in theory, but that does not make them practical in real terms.

V. Additional information about the HD-NTSC protocol

HD-NTSC is a transmission protocol that combines HDTV attributes into a signal that requires just a single 6 MHz channel and which can still be viewed on a conventional TV set. The Del Rey Group was among the first to propose an ATV transmission system, formally introducing the HD-NTSC protocol in October 1986. Since that time, numerous other proposals have been made by various organizations, but in our opinion none have matched HD-NTSC's combination of performance, economy of bandwidth, and "compatibility" with the existing environment.

Additional information is included in the attached paper (Appendix), which was delivered six weeks ago at a SMPTE Conference in New York City. Recent qualitative observations of a mockup signal in Montreal indicate that a random sampling of old and new consumer receivers and studio monitors had no difficulty with HD-NTSC's 55.3 microsecond active line time. Furthermore, the black bars resulting from the reduction of active lines from 483 down to 414 appear rather small and unobtrusive, and in one instance (a ten year old consumer set) are completely absent. This would tend to indicate that a mild form of letterboxing should be quite acceptable to consumers, in exchange for a 5:3 aspect ratio picture free of possible side panel seams.

VI. Relaxation or repeal of NTSC standard

As mentioned earlier, the Del Rey Group believes it will not be necessary to introduce an incompatible signal format in order to deliver high quality ATV to the consumer. The fact remains, however, that while the basic characteristics of HD-NTSC are identical to RS-170A, certain items are slightly different. For example, it is proposed that active line time be increased from about 52.6 microseconds to about 55.3 microseconds. In addition, it is proposed that the active image area be reduced from 483 lines down to 424 lines. Such changes are apparently received on conventional consumer equipment will no ill effects. Perhaps the FCC should be willing to permit modification of the NTSC signal as long as such modification does not signficantly degrade reception on the overwhelming majority of conventional sets.

VII. Compatibility with Alternative Media

The Del Rey Group believes that compatibility among the alternative delivery mechanisms is a very desirable characteristic for an ATV transmission protocol, for it is in this form that ATV could be rapidly integrated into the consumer environment. HD-NTSC offers an unusual advantage in that it is suitable not only for terrestrial and cable distribution but it also could be delivered via videocassette, videodisc, or DBS link. Due to the special chrominance/luminance prefiltering of HD-NTSC at the encoder, it would be highly desirable for the alternative media to either keep chroma and luminance signals separate through the record/playback cycle (perhaps through the use of a Y/C connection) or by use of a complementary decoder. Since HD-NTSC does not employ an augmentation channel or any additional quadrature signals, there should be no other limitations, although tests will need to be conducted to verify this conclusion.

The Del Rey Group has no comment on the concept of the Open Architecture Receiver at this time because none of the operational details have been described.

Regarding the question of consumer equipment interfaces, our preference is for a signal format based upon 525/59.94/2:1 component or Y/C.

VIII. Production format compatibility

Any transmission system can, in theory, be made to work with any production format, but the greater the differences the more complex the conversion process. We can think of HD-NTSC as starting from a 900 line (828 active) progressive scan running at 29.97 frames per second. Using other formats would involve transcoding, and the resulting performance would depend on both the inherent performance of the source format and also the degree of transcoding complexity. A summary of a number of possible production formats is included below. In each it is assumed that horizontal resolution (a function of system bandwidth) would be approximately equal to vertical resolution:

525/59.94/Interlace: Typical vertical spatial resolution would be limited to about 410 lines per picture height (l/ph) for static portions of the image, and 205 l/ph for dynamic (moving) portions, substantially below the inherent capabilities of HD-NTSC. Line upconversion would be required, further reducing image quality. Temporal resolution would be greater than is required.

525/59.94/Progressive: Typical vertical spatial resolution would be limited to about 410 l/ph for both static and dynamic portions of the image, substantially below the inherent capabilities of HD-

NTSC. Line upconversion would be required, further reducing image quality. Temporal resolution would be greater than is required.

1050/59.94/Interlace: Vertical spatial resolution would be limited to about 820 l/ph for static portions of the image, and 410 l/ph for dynamic portions of the image. A 7/6 downconversion to HD-NTSC would be required. Temporal resolution would be greater than is required.

1050/59.94/Progressive: Vertical spatial resolution would be limited to about 820 l/ph for both static and dynamic portions of the image, sufficient for HD-NTSC. A 7/6 downconversion to HD-NTSC would be required. Temporal resolution would be greater than is required. This would be a difficult format to implement with today's technology, and camera sensitivity would most likely be very poor.

1125/60.00/Interlace: Vertical spatial resolution would be limited to about 880 l/ph for static portions of the image, and 440 l/ph for dynamic portions of the image, somewhat below the inherent capabilities of HD-NTSC. A 5/4 downconversion to HD-NTSC would be required. Temporal resolution would be greater than is required, and the different frame rate would require a relatively sophisticated temporal interpolation process at the HD-NTSC encoder.

1250/50.00/Progressive: This format, the likely production signal of the Eureka-95 consortium, is especially suited to the 625/50 worlds of PAL and SECAM. It would be a relatively poor source for NTSC countries. Vertical spatial resolution would be limited to about 980 l/ph for static and dynamic portions of the image, more than adequate for HD-NTSC. A 25/18 downconversion to HD-NTSC would be required. Temporal resolution would be greater than is required, and the different frame rate would require a relatively sophisticated temporal interpolation process at the HD-NTSC encoder. This would be a difficult format to implement with today's technology, and camera sensitivity would most likely be very poor.

900/29.97/Progressive: These parameters represent the actual HD-NTSC pre-encoded signal format, and thus could be seen as the ideal or most efficient standard if HD-NTSC were the only transmission format being fed. In other words, this format could serve as an excellent local studio format, but would not be a worldwide format, in the same context that NTSC cameras today can be regarded as local studio formats, but not ideally suited for feeding PAL or SECAM networks. Vertical spatial resolution would be limited to about 704 l/ph for static and dynamic portions of the image. Cameras designed to this format will employ a shuttering mechanism.

HD-PRO™: Intended as a global production format, HD-PRO is the Del Rey Group's proposal in the production format derby. It employs a very high line count of 1,500 in order to capture the highest possible spatial resolution. It affords easy line conversion to all known transmission formats, including 525 NTSC, 625 PAL/SECAM, 900 HD-NTSC, 1050 ACTV, 1125 Muse, and 1250 HDMAC. Vertical spatial resolution would be limited to about 1,175 l/ph for both static and dynamic portions of the image, more than adequate for HD-NTSC. In its suggested first implementation, HD-PRO's temporal resolution would be slightly less than ideal, but identical to that afforded by conventional 35mm film practice. Cameras designed to this format would have characteristics very similar to the SMPTE 240M format (1125/60) but would be equipped with a variable shutter and would be capable of increased sensitivity, a welcome attribute. Equipment already designed to the 240M format could be modified with little difficulty.

Conclusion

The Del Rey Group hopes these comments are useful to the FCC and other interested parties. We have long maintained that a collaborative effort will be needed in order to create the best possible ATV transmission format, and we stand ready and willing to work with others in the industry to accomplish this worthy objective.

Respectfully submitted,

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Appendix

A Status Report on HD-NTSC™: Compatible HDTV in a Single Channel

SMPTE

PREPRINT NO. 13-38

A STATUS REPORT ON HD-NTSC[tm]: COMPATIBLE HDTV IN A SINGLE CHANNEL

Richard J. Iredale
The Del Rey Group
Marina Del Rey, CA

PRESENTED AT THE

130th SMPTE TECHNICAL CONFERENCE

OCTOBER 15-19, 1988

JACOB K. JAVITS CONVENTION CENTER, NEW YORK CITY

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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A Status Report on HD-NTSC™: Compatible HDTV in a Single Channel

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Abstract

Two years ago, at the fall SMPTE Conference of 1986, the writer introduced a means of delivering a high definition image over a single NTSC channel. This paper serves to outline that protocol and to describe the events that have shaped the industry in the past two years, finally comparing the design philosophies of the current transmission proposals.

HDTV development around the world continues to accelerate, and the HD-NTSC protocol has become a popular topic for discussion because it appears to offer the most practical solution to the dilemma facing the broadcast and cable industries in North America. This paper will follow a question-and-answer format in order to quickly address the major topics while offering the reader what is hoped a refreshing break from the conventional paper structure.

What is HD-NTSC?

HD-NTSC is basically a collection of technologies. Some, such the concepts of progressive scanning and chrominance/luminance prefiltering, have been known in the industry for years, while a couple of technologies are unique. What we are basically doing is "tuning up" the established NTSC signal in order to provide strikingly improved picture and sound on a new generation of TV sets. It is believed that such a picture will compare very favorably with pictures delivered by other incompatible or wider bandwidth protocols. The following is a brief introduction to HD-NTSC; for more information, please refer to the original SMPTE paper (#128-108) which also appears in the October 1987 *SMPTE Journal.*

Several fundamental statements have guided this project from the very beginning. They are:

1. An ATV transmission standard must deliver a truly high definition product to ATV receivers.
2. The ATV transmission signal must also be capable of delivering a satisfactory image to existing NTSC receivers.
3. The ATV transmission signal must fit within a single 6Mhz broadcast or cable channel.

4. The ATV transmission signal will ideally also be compatible with alternative video delivery systems, such as VCR, Videodisc, and Direct Broadcast Satellite.
5. Finally, the ATV transmission format will be as friendly to the studio environment as possible, ideally requiring no replacement of existing facilities and equipment.

TriScan Subsampling

HD-NTSC employs a form of subsampling known as TriScan, which is a 3x2 pattern similar to the one illustrated in Figure 1. TriScan represents the concept of subsampling as applied to the NTSC environment. Muse is also a subsampled system, but optimized for a different set of parameters, without NTSC compatibility in mind. The subsampling pattern is one which provides little degradation when the signal is viewed via a conventional NTSC receiver.

Motion Adaptive Processing

Any ATV receiver design employing a frame store memory must also employ some sort of additonal processing that determines those times the processing circuitry should switch from the spatial integration mode. One simple example of this can be found in the new Improved Definition Television (IDTV) products about to be introduced by several companies. A primary feature of such receivers is a progressive display scan. This scan can be derived from the interlaced NTSC signal by storing or delaying the lines of one field temporarily such that they can be inserted between the current field lines. For still images, this produces a correct progressive scan, but the technique fails for moving objects, since adjacent fields represent different points in time. A motion adaptive circuit in IDTV receivers switches the operating mode under those circumstances to one which offers lower vertical resolution but which is otherwise artifact-free.

In a similar fashion, the function of the HD-NTSC decoder's Dual Resolution Processor (DRP) is to convert those parts of the HD-NTSC image that are in motion into a lower spatial resolution (but high temporal resolution) format. Currently under study are conventional mechanisms such as the transmission of motion vectors (as used by Muse) and auxiliary data (as employed by DATV adherents), as well as a specific approach especially designed with HD-NTSC in mind. The DRP circuit determines, on a real-time basis, the amount of movement present in a scene and adjusts between the High Spatial Resolution / High Temporal Resolution modes accordingly.

Aspect Ratio Modification

The new HD-NTSC protocol provides for a 5:3 (15:9) aspect ratio, attained primarily by keeping the full width of the conventional 4:3 presentation format and reducing the vertical dimension from 483 active horizontal lines down to 414. The active NTSC image area is widened by slightly reducing the size of both the Front and Back Porch regions of the horizontal blanking interval, as shown in Figure 2(b). These changes combined with a modest horizontal compression of 2% result in a full 5:3 format.

This new aspect ratio is different enough from conventional NTSC that one will immediately recognize a receiver built to the HD-NTSC specification, even when turned off. This distinction is actually very important for marketing considerations; though the digital hardware that is part of the new process will rapidly drop in cost over time, a purchaser will still be paying a premium price, and it is important to provide ample justification for the differential price. In other words, not only does the HD-NTSC receiver provide a far superior picture with a more pleasing aspect ratio, but it also looks newer.

A typical home receiver does not even show a full 483 scan lines, due to overscan (to allow for adjustment drift and undervoltage). If a 10% overscan is present, the viewer sees about 435 lines, so the HD-NTSC image represents a vertical shrinkage of only about 4.8%, with 2.4% above and an equal gap below. With the recent trend towards less "rounding" of the receiver image, a clean cutoff top and bottom might even be preceived by the public as an improvement in its own right, even though the image is very slightly smaller in the vertical direction. An additional benefit is that nearly the entire widescreen image is visible on conventional sets, eliminating the need for pan-and-scan.

HD-NTSC Auxiliary Data Window

The HD-NTSC format creates 69 horizontal lines per frame (34.5 lines per field) that are no longer employed for the transmission of image information. This Auxiliary Data Window, defined in Figure 2(b), is available for the delivery of additional information to HD-NTSC receivers. The Window is capable of carrying a data rate of at least 600 Kbits per second, using, for example, conventional encoding developed for the Teletext environment.

Conventional NTSC receivers will display such modulation on the very top and bottom portions of the screen. Due to the robustness of digital encoding, only transitions from reference black to dark grey will be

required. With the plummeting costs of digital hardware it is conceivable that automatic adaptive filters in the receiver can be used to not only maximize Data Window security but also provide for a ghost-free video image.

The primary use of the Auxiliary Data Window will be for the delivery of multiple channels of digital audio. Miscellaneous control information from the HD-NTSC encoder will also be present, and a small portion may be set aside for future purposes.

Chrominance Information

Throughout this discussion we have been referring to just the Y (luminance) signal, not the chrominance components. To ignore color completely would be incorrect, for our final image would have high luminance resolution but somewhat vague color placement, akin to the effect one gets by colorizing an old black and white film. We expect substantial improvement in chrominance performance due to several changes:

••Up until recently the I bandwidth in modern NTSC receivers was arbitrarily limited to .5 MHz even though the broadcast signal contained information out to 1.3 MHz; by expanding the I channel in our HD-NTSC receiver out to the full width we will have achieved a substantial sharpness increase for much of the color spectrum.

••Luminance and chrominance prefiltering has been shown to be capable of eliminating virtually all cross-luminance and cross-color artifacts.

••The same philosophy of subsampling employed for the luminance channel can also be adapted to increase the bandwidth of the chroma channels.

••Chrominance performance can be even further improved by adopting modern thought regarding linear matrixing and proper gamma correction.

Compatibility

"Compatibility" is a complex issue. We will briefly explore HD-NTSC compatibility as it applies to four parts of the chain that stretches from the original source image to the home receiver.

Production format Compatability: HD-NTSC can, in theory, be made to work with any production format. However, each format will offer particular strengths and limitations, and the more the format differs from HD-NTSC's basic timings the more complex the conversion process.

Studio Compatibility: The issue here is the degree of modification required by a current NTSC studio environment in order to handle HD-NTSC. In theory, at least, a high definition video image encoded into HD-NTSC will behave almost exactly like conentional NTSC as defined by RS-170A. There are several ways that the two signals differ. First, HD-NTSC represents a six field sequence, rather than two. Secondly, subsampling creates a folded spectrum, resulting in a more even distribution of energy at all frequencies up to the 4.2 Mhz cutoff. Thirdly, the Front and Back Porch times have been slightly reduced. Any equipment (such as a time base corrector) that assumes a specific back porch time will need to be modified.

Transmission Path Compatiblity: There is nothing different about the HD-NTSC signal that would suggest a different behavior than that already well documented with NTSC, simply because the two signals are nearly identical. In the absence of corrective measures, however, HD-NTSC will exhibit a slightly increased sensitivity to noise, due to the six field periodicity.

Home Environment Compatibility: The HD-NTSC receiver will deliver an image that offers up to twice the static spatial resolution of conventional NTSC, a 5:3 aspect ratio, a progressively scanned (no interlace twitter) flat field (no visible lines) display, greatly improved color characteristics, and digital multichannel audio, as well as conventional NTSC services such as teletext, closed caption, and SAP. Dynamic spatial resolution will be no worse than that available with conventional NTSC.

The HD-NTSC signal can be delivered to the home via conventional Videodisc or even VCR. The degree of impairment will be directly related to the degree of impairment of conventional NTSC signals exhibited by those media. In theory, a terrestrially broadcast HD-NTSC signal can be recorded and replayed with a conventional SVHS VCR.

NTSC receiver compatibility issues can be summarized into several specific areas, namely the *subsampling artifact* and *aspect ratio modification*:

Subsampling Artifact: One effect of viewing an HD-NTSC signal via a conventional receiver will be the appearance of a sort of flicker located at sharp luminance transitions; for example a black object surrounded by a bright background. This effect is caused by the three subpixels making up a pixel located right at the box edge having significantly different luminance values. Research to date indicates that this artifact has the appearance very similar to conventional dot crawl. Qualitative tests have shown that even at this stage of the research the artifact only becomes significant at very high levels of static spatial resolution (approaching 700 lines per picture height). One plausible scenario is to eliminate most of the artifact by holding spatial

resolution to some intermediate value (perhaps 450 l/ph) during the transition to HD-NTSC. The spatial resolution is controlled at the encoder, and future increases will not require new versions of HD-NTSC receivers or any increase in spectrum requirements.

Aspect Ratio Modification: As described earlier, conventional sets will show a narrow black bar at the extreme top and bottom portions of the screen. We believe this will be an entirely acceptable compromise to the public, especially when compared to the alternative method of using side panels, which suffer from other significant shortcomings.

What then do you sacrifice by working within the constraints of compatibility and single-channel operation?

We make sacrifices in several areas. First, the encoder and decoder designs are complex, but we all know how rapidly VLSI technology is advancing. Secondly, as mentioned before, the old receivers will show narrow black bars top and bottom, and will have a sort of microscopic "dot crawl" in parts of the image. But we don't think anyone will really care, since we accept those effects now on many programs. Finally, the only constraint of the picture on the high definition set is that objects in motion will be slightly softer than when they are stationary.

Why had this approach never been tried before?

Primarily because of the cost of performing such pixel manipulations in the past. This process depends heavily upon the remarkable advances in VLSI digital signal processing chip performance, and will really only be cost-effective a few years down the road. The Del Rey Group is convinced the further price reductions that will be necessary to make this technology practical will occur. It is inevitable.

What has been the reaction of the industry?

When the original HD-NTSC paper was given, the reaction was mixed. Some were openly skeptical, while others were fired with enthusiasm. The major problem then was that the protocol existed only as a concept on paper. One of the organizations curious about this approach was the Canadian Broadcasting Corporation. Since they had access to a video simulation facility in Montreal, it was decided to take a look at

the notion of TriScan subsampling to determine, first, the nature of artifacts that would occur on conventional TV sets, and secondly, the degree of spatial resolution improvement as displayed by an ATV set.

Those first tests proved promising, and in February 1988 the Del Rey Group entered into an agreement with two interested broadcasters and the Compatible Video Consortium was established.

What is the Compatible Video Consortium?

The Compatible Video Consortium (CVC) is a limited partnership dedicated to the development of a compatible HDTV transmission system. The first two limited partners are Cox Enterprises (Atlanta) and Tribune Broadcasting (Chicago). The Del Rey Group is the general partner. It needs to be emphasized that the objective of the CVC is to develop a compatible system, preferably single channel. The CVC is investigating TriScan subsampling because that technology appears to offer the most promise for the accomplishment of the objective.

What about the other systems that are under development? How do they compare?

To best explain the current state of the industry, it is perhaps helpful to turn back the clock to 1986 and recount the developments since then:

In the fall of 1986, there was growing concern by broadcasters that Muse, a bandwidth reduction system championed by NHK, would turn out to be a problem for them. Many were still skeptical that Muse could work at all outside of the laboratory, but if it did, it would require two channels to deliver, and spectrum was extremely tight to begin with. Whatever extra spectrum existed was in imminent danger of being turned over to the land mobile industry by the FCC, and the NAB and others immediately launched a campaign to save that spectrum for future HDTV delivery. It was assumed by all that HDTV would require additional bandwidth, because everyone assumed the relationship between picture sharpness and bandwidth was simply a law of nature.

Not only did Muse require more than 6 MHz of spectrum but the signal was also incompatible with receivers unless some sort of set-top decoder was used, a major stumbling block for rapid acceptance by consumers. Others were addressing this incompatibility problem. Some time earlier, CBS had created a two channel system where one of the channels was directly viewable by NTSC TV sets. Dr. William Glenn of the New York Institute of Technology in his Florida research facility was developing a two channel protocol also,

employing different principles. Meanwhile, research at MIT was being directed at more basic fundamentals of video imaging, including for example the notion of interframe interpolation and motion compensation techniques. Out in Northern California Faroudja Laboratories was demonstrating actual hardware that was able to clear up what had originally been thought to be a fatal flaw of NTSC--the mixing of luminance and chrominance information in the composite signal, resulting in the familiar dot crawl and cross-color effects. Mr. Faroudja was able to demonstrate that with careful prefiltering of luminance and chrominance before encoding, one could deliver a picture without those defects.

It was into this environment that the HD-NTSC paper was delivered. Shortly thereafter, the CBC began its investigation of TriScan subsampling on a video simulation facility in Montreal.

While work progressed in Canada in the spring of 1987, North American Philips introduced a two-channel system fed by a special MAC signal. This system, first named ENTSC, consisted of an NTSC compatible signal and a second "augmentation" channel.

The fall of 1987 was marked by two announcements. At the Ottawa Conference NBC demonstrated publicly for the first time a single channel protocol called ACTV, and at about the same time NHK announced they were developing a compatible version of Muse, known as Muse-6. Now suddenly the spotlight returned to the possibilities of single-channel HDTV, which of course is what the Del Rey Group had already been preaching, largely to deaf ears, for over a year.

Since that time both North American Philips and Dr. Glenn have announced that the augmentation channel of their systems has been reduced to a half-channel. Curiously, the NBC/DSRC team has gone the other way, announcing a two-channel version of ACTV, appropriately named ACTV II. Very recently, Zenith tossed its hat into the HDTV ring by announcing a system of their own design.

Other worthy systems have been announced but for the sake of brevity they will not be listed here.

So how do all these different systems compare?

Although each system is unique in certain respects, it is helpful to categorize them under the headings of (a) incompatible, (b) compatible but greater than one channel, and (c) single channel. While the writer is, of course, an advocate of HD-NTSC, it is believed that each system has reasonably well-known characterictics that can be fairly summarized here:

(a) **Incompatible**--In this category we find Narrow Muse, MIT-CC, and the Zenith systems. These systems offer the tantilizing prospect of high performance for little bandwidth, but suffer the problem of requiring either a set-top converter for reception by conventional sets or the need for an additional channel to carry the conventional NTSC signal. If the FCC were to adopt a philosophy of phasing out the old sets over a fixed interval, then these protocols offer great promise, but we find such a course of action highly unlikely since NTSC is so solidly entrenced and is so ripe for compatible improvement. The Zenith system is the only one so far that proposes to use the taboo channels, neatly solving the spectrum space problem for terrestrial broadcasters but unfortunately doing nothing for cablecasters (there are no taboo channels on a cable system).

(b) **Compatible but greater than one channel**--here we find the Glenn, North American Philips, and ACTV II systems. These systems do a great job of compatibility with existing sets but suffer the drawback of permanently tying up 9 MHz or more for each HDTV program. There is also a question about the practicality of transmitting two separate signals that need to be precisely mated back together again in the ATV receiver.

(c) **Single channel**--the most commonly-discussed single-channel systems today are HD-NTSC from Del Rey, ACTV I from NBC/DSRC, and SuperNTSC™ from Faroudja. SuperNTSC cleans up the cross-luminance, cross-color, and interlace defects, and uses a line doubling mechanism to remove the appearance of scanning lines (static raster), but does not offer HDTV resolution performance. ACTV I offers a wide screen picture of improved resolution, but some believe the signal will be very fragile in the presence of noise and multipath. Perhaps the greatest shortcoming of ACTV I is that it offers spatial resolution performance that falls substantially short of HDTV levels, and broadcasters are greatly concerned about adopting a system that puts them at a disadvantage compared to alternative delivery methods such as Muse or HD-NTSC videocassette and videodisc.

What changes do the broadcasters and cablecasters need to make in order to offer HDTV? That, of course, depends on which system is adopted. In general, we believe that some systems, such as Muse-E, would require an entirely new station, which some industry experts estimate will cost about 30 million dollars *per station*, a very large burden. At the other extreme are signals like HD-NTSC, which will require little modification.

But how do you expect the Del Rey Group to compete for attention and resources in an industry dominated by giants?

Well, first of all, it's not just the Del Rey Group anymore, but the Compatible Video Consortium, and we expect Cox and Tribune to be joined by other major organizations in the near term.

Regardless of the size of the CVC, we believe the *every* company 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 a particular approach makes sense, and we think our HD-NTSC system will be shown to make the most sense.

Since more and more homes are wired for cable these days, doesn't that negate the problem of spectrum scarcity and make the two-channel HDTV systems practical?

The cable situation is actually quite similar to that faced by broadcasters. Although a cable system is in effect it's own "spectrum", it appears that consumers always want more and more program choice, not necessarily fewer programs with wider channels (*Broadcasting*, May 30, 1988). Rebuilding a cable system to deliver more bandwidth would be very expensive. In any event, much or most of our viewing in cable households is of signals from the local broadcasters, putting cable in the same boat as broadcasters. Furthermore, although cable's penetration rate is gradually increasing (slightly over half of all households now receive some form of cable TV), the new crop of "Personal Video" portable TV sets could become very popular with consumers, and of course those sets will never be connected to a cable. Finally, the heady days of rapid cable expansion are for the most part over: at this point, cable has been strung pretty much everywhere it makes economic sense to do so. Further increases in the percentage of homes served by cable will come slowly.

What about Optical Fiber? When that arrives, won't our HDTV compression efforts be unnecessary?

Fiber is finding great acceptance with the telephone companies, since they are now able to replace the thick trunk lines linking cities with just a single fiber cable, saving installation and maintenance expense. Surely one day fiber will reach homes also, but that still does not mean spectrum will be free, just less expensive than before. We believe that since the typical consumer would be hard pressed to tell a single-channel HDTV

protocol from one using several channels, the carrier's preference will be to use the additional spectrum for more services, many of which at present are probably just a gleam in some entrepreneur's eye.

So, in all, what can we conclude about HD-NTSC?

A couple of things. First, HDTV is definitely coming. Secondly, the HDTV technology furthest along will probably not be the one that wins the race. Finally, there is a strong possibility that clever engineering can create a different HDTV system that fits neatly into the existing environment, and the writer believes the Del Rey Group's HD-NTSC format will be found to be the one that does the job best.

The Del Rey Group hopes that these thoughts, arranged in this slightly unorthodox manner, have been helpful, and looks forward to working with the industry in bringing the excitement of high definition television to the American public.

Figure 1: TriScan Subsampling Pattern

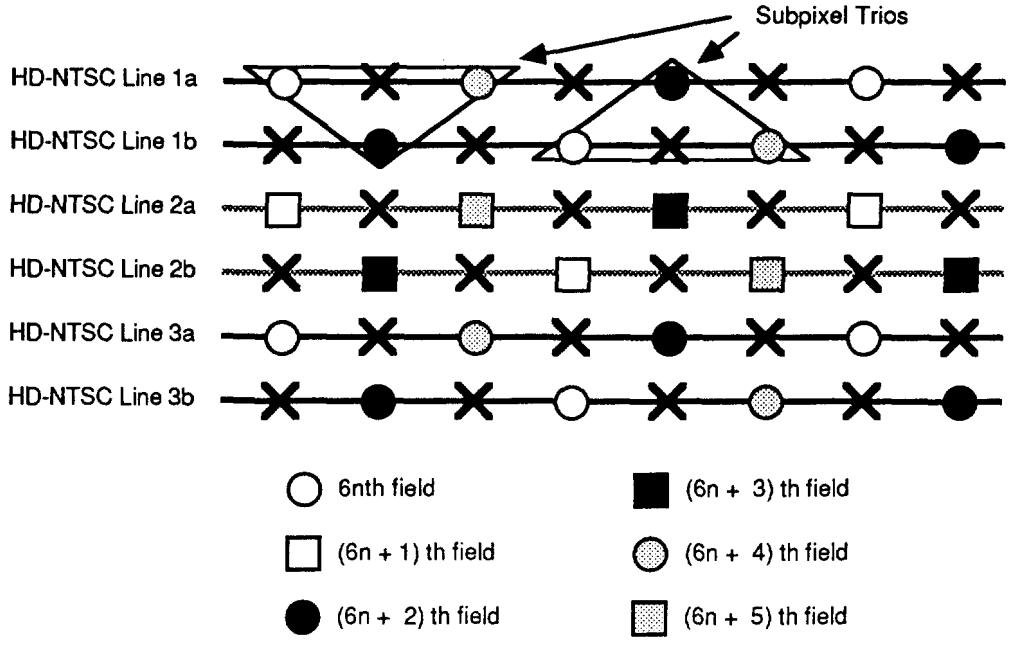
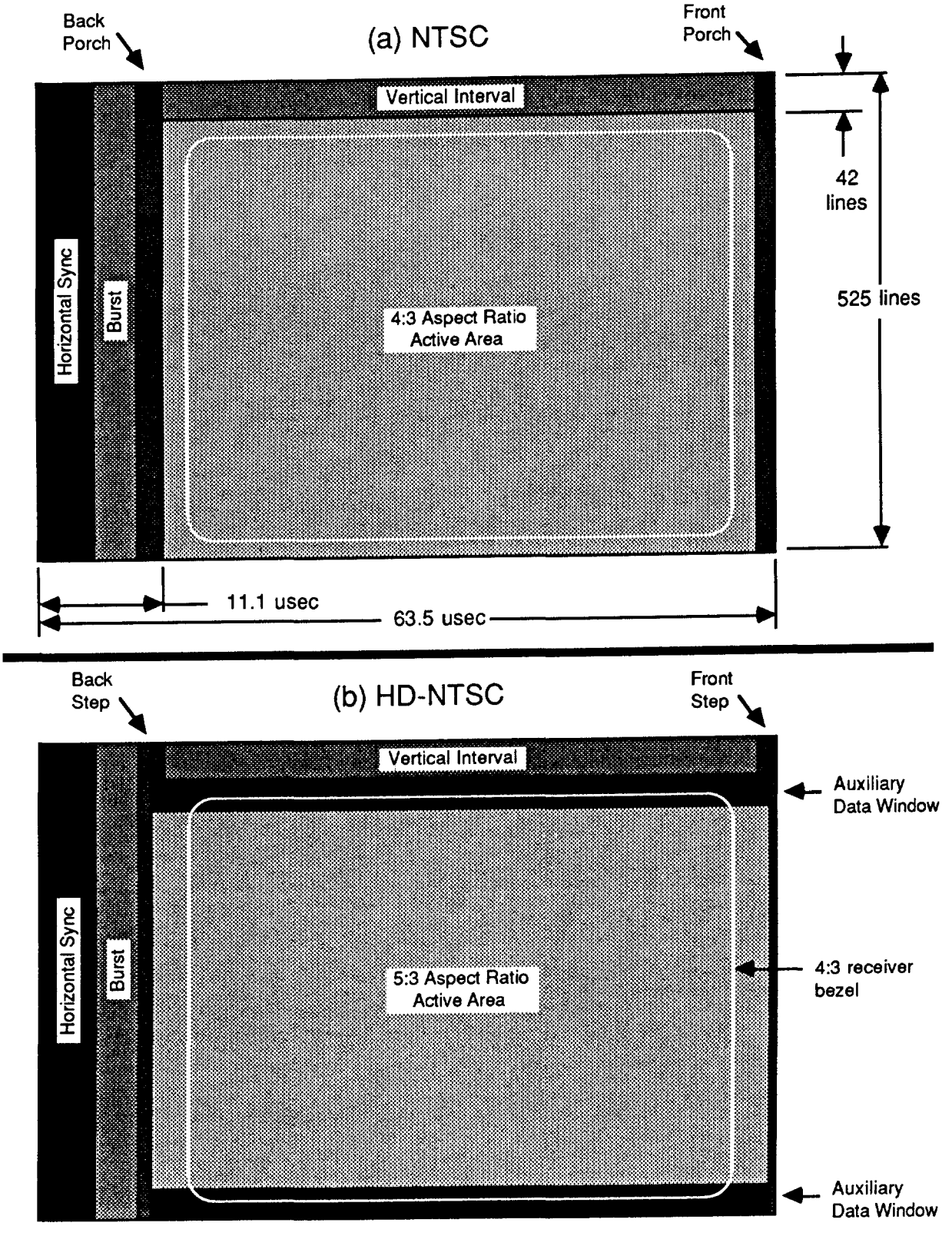
Figure 2: HD-NTSC Presentation