HIGH-DEFINITION TELEVISION:

AN OPPORTUNITY FOR CABLE

HOME BOX OFFICE, INC.
JUNE 10, 1987

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1. EXECUTIVE SUMMARY:

THE CHALLENGE OF HIGH-DEFINITION TELEVISION

High Definition Television (HDTV) has the potential to be the most significant development in the home-entertainment arena since the introduction of color television. A wide-screen video medium, HDTV will be able to deliver a TV picture vastly superior to any picture on the air today, with multi-channel, digital-quality sound to match. The introduction of this advanced video technology into the consumer marketplace will undoubtedly lead to other important developments, including the manufacture of the next generation of TV sets, a new standard of quality in videocassettes, as well as new technical standards of quality in broadcast and cable.

The emergence of HDTV technology is already evident. Successful transmissions have occurred over two UHF channels in Washington, D.C.; Japanese broadcaster NHK is testing satellite transmissions of HDTV for an hour each day with the goal of providing full-time transmissions within the next two to three years. Most recently, the market introduction of HDTV technology, from production aspects to consumer trends, was discussed at the International Symposium on High-Definition Television in Tokyo, June 2-3.

Perhaps the best indication of the scope of HDTV's recent development can be measured by tracking the 35 equipment manufacturers currently selling second-generation HDTV production and studio display equipment. And if we track the evolution of the VCR and CD player, it appears likely that an HDTV system, composed of an HDTV television and VCR/optical disk player, will be introduced into the consumer marketplace within three years. Similarly, some form of HDTV programming will be in consumer homes within four to five years, with software delivered via a VCR/disk built into the television set.

CABLE'S OPPORTUNITY

The potential impact -- positve or negative -- of this new medium on the cable industry is largely in the hands of the industry itself. Clearly, the choice for the cable industry is not one of either participating in HDTV or letting it go by. It's a choice of growing with the new medium or losing customers to it. Out proactive involvement in the initial stages of this developing technology can ensure optimal application of HDTV for cable delivery. But without the cable industry's involvement in these early developmental stages, HDTV technology will be defined by manufacturers or agencies not sensitive to cable's needs, which ultimately will result in the same kind of incompatibility

problems we as an industry experienced with "cable-ready TVs," connection of VCRs to the cable drop, and delivery of BTSC-MTS stereo.

Even if broadcasters and the cable industry are slow to deliver HDTV service, there's no doubt that HDTV will be a business. The technology already exists to provide HDTV delivery to television on compact disk or tape. The growth of VCRs and video stores have been exponential, and these same stores -- as well as their product suppliers -- can readily serve consumer demand for this new entertainment form. Furthermore, consumer research has consistently shown that cable subscribers are heavier users of television than any other consumer segment, and are more likely to purchase a new "top-of-the-line" television. Within the next few years, HDTV will re-define "top-of-the-line." If consumers cannot get HDTV quality programming via their cable hook-up, they will turn to alternative programming sources such as the VCR and compact disk that will provide it.

The broadcast industry faces challenges in adapting itself to become a major HDTV delivery medium. The television channel allocations assigned to broadcasters by the FCC technically may not be able to accommodate HDTV transmissions. Therefore, broadcasters are investigating the options of building a second, separate network to transmit HDTV on UHF bands or some other frequency and developing a compatible HDTV system.

CONCLUSION

The time has come for the cable industry to proactively get involved in influencing the direction of HDTV to ensure that in the future cable is a major source of HDTV programming for the consumer. And we need to get involved soon, before HDTV disk players or other in-home delivery systems entrench themselves as an alternative to cable delivery. Cable industry programmers and operators need to reach a consensus on an appropriate HDTV transmission format -- and begin communicating that information to the HDTV community. The fundamental question for the cable industry it, "How do we get HDTV transmissions over a satellite and down the cable wire?" Moreover, the cable industry needs to work out the availability dates of HDTV equipment with HDTV developers. Finally, we need to ensure that HDTV/cable compatibility comes with a minimum capital outlay and the least amount of disruption for operators. To that end, there are a host of questions the cable industry needs to consider, some of which are addressed in this document, others to be arrived at in future discussions:

- How can we improve on today's television technology?
- How can we use the current television spectrum allocation and continue to serve the public interest?
- How can we ensure "backward compatible" equipment for the consumer?
- How do we ensure HDTV will be cable-compatible?
- How do we ensure that HDTV technology is made available to consumers at reasonable prices?

The purpose of this briefing paper is not to endorse any particular HDTV standard, but to provide cable industry leaders with background information on HDTV to stimulate further discussion, which Home Box Office will initiate on an individual affiliate basis and at appropriate industry meetings in the weeks and months ahead. As an industry, we need to work together to ensure that this new medium is developed to become a transmission medium that cable can use. It is in our mutual interest to take a proactive role in ensuring HDTV's compatibility so that the cable industry becomes a major source of HDTV programming for consumers.

2. A HISTORICAL PERSPECTIVE[1]

SIX DECADES OF DEVELOPMENT

The concept of "High-Definition Television" has been around since the late 1920s when television systems were first under development. However, "High Definition" of the 1920s cannot be compared to the "High Definition" concept of the 1980s. Then, "High Definition" referred to displaying an image that may have been a mere shadow of the original subject. Today, "High Definition" refers to the creation of a theater-like experience for the viewer, including large screen display, 35MM film-like picture quality, theater-like screen shape and high quality multi-channel sound. Despite these dramatic differences, the fundamental concept of HDTV remains unchanged.

In 1937, the Director of Britain's Science Museum wrote "there can be no doubt that high-definition television is one of the most remarkable technical achievements of our times." Television systems were proposed as early as the 1880s, but it wasn't until the 1920s that true development of television systems began. The 1920s saw two distinct approaches to television systems: the first relied on mechanical systems such as rotating disks or prisms to capture and display an image; the second approach relied on electronic devices.

1. Mechanical Approaches: In 1927 Bell Laboratories demonstrated a television/telephone system that created a 2-1/2' x 2' image using 50 scan lines and requiring 18 seconds to create one image. Two years later, Bell Labs doubled the number of scan lines and experimented with color. During this same period, John Baird developed a 30-line system in Britain. By 1932 he was offering regular programming and sold over 10,000 television sets. In 1934 Baird increased the resolution of his system to 240 lines. The mechanical television system seemed like the way of the future.

2. Electronic Approaches: Simultaneous with the growth of mechanical systems, electronic systems were being developed, primarily in the United States and most notably by RCA Laboratories.

By 1930 NBC in New York was transmitting 60-line television, increasing the resolution to 120 lines in 1931. Finally, in 1939 NBC and RCA were ready to start regular programming from the Empire State Building with 441 lines of resolution.

In 1937, the FCC essentially defined the maximum resolution of television systems by allocating 6 MHz of bandwidth to each television channel. Picture resolution is dependent upon bandwidth, with greater bandwidth allowing higher resolution to pass, and narrow bandwidth allowing less resolution to pass.

However, the 441-line system used by NBC fit well within the limits of the FCC channel allocation. These FCC requirements established 50 years ago are still in effect for broadcast television today.

Unfortunately, the 6 MHz channel allocation that accommodated the television systems of 1937 may not be able to support HDTV systems without significant quality compromises. Broadcasters are investigating channel compatible systems as well as examining the benefits of additional channel capacity. However, cable, satellites, and VCR/disk can provide the channels needed for HDTV.

NTSC STANDARDS

During the developmental years of television until 1941, there were no technical standards. Various systems - some mechanical, some electrical, but all incompatible - co-existed, which confounded equipment manufacturers attempting to service the public. To develop standards, the first National Television System Committee (NTSC) was formed in 1940, and by mid-1941, the committee recommended to the FCC the basic black-and-white television format in use today:

525 lines per frame
60 fields per second
2:1 line interlace
4:3 aspect ratio

World War II put a hold on television development, but afterwards demand skyrocketed. By 1950, 6 million black-and-white television sets were sold, and the issue of color-television standards came to the forefront. CBS Laboratories won initial acceptance by the FCC for a color-television system, which was incompatible with the existing base of standardized black-and-white television sets. In 1953, the FCC reversed its acceptance of the CBS system on the recommendations of the second National Television System Committee (NTSC) formed in 1950 to address the issues of color-television standards. Subsequently, in 1953 the NTSC proposed to the FCC a color-television system that was compatible with the existing black-and-white television transmission standards and the existing base of 25 million black-and-white television sets. To achieve compatibility, black-and-white television sets experienced a loss in resolution and additional picture degradation. The FCC approved this compatible standard, commonly called NTSC, and 34 years later it continues to be the standard.

Today the implications for HDTV are clear. Over-the-air television channels serving the existing base of NTSC televisions cannot be used for HDTV transmissions, which are incompatible. Another HDTV delivery system must be found (such as cable,

satellite, VCR/disk); at the same time, consumers' HDTV television sets must also be capable of receiving standard NTSC channels.

3. HDTV: WHAT IS IT?

High-Definition Television (HDTV) refers to any television system that enhances or heightens viewers' television experience relative to existing television systems. The term "definition" is used instead of "resolution" because HDTV provides more than just improved image detail. HDTV gives the viewer an illusion of "being there" by: increasing the amount of detail visible both horizontally and vertically; displaying a screen- aspect ratio like that of a theater (about 5:3); increasing image size; improving sound quality; and reducing or eliminating many of the artifacts we have learned to accept within our existing NTSC television system.

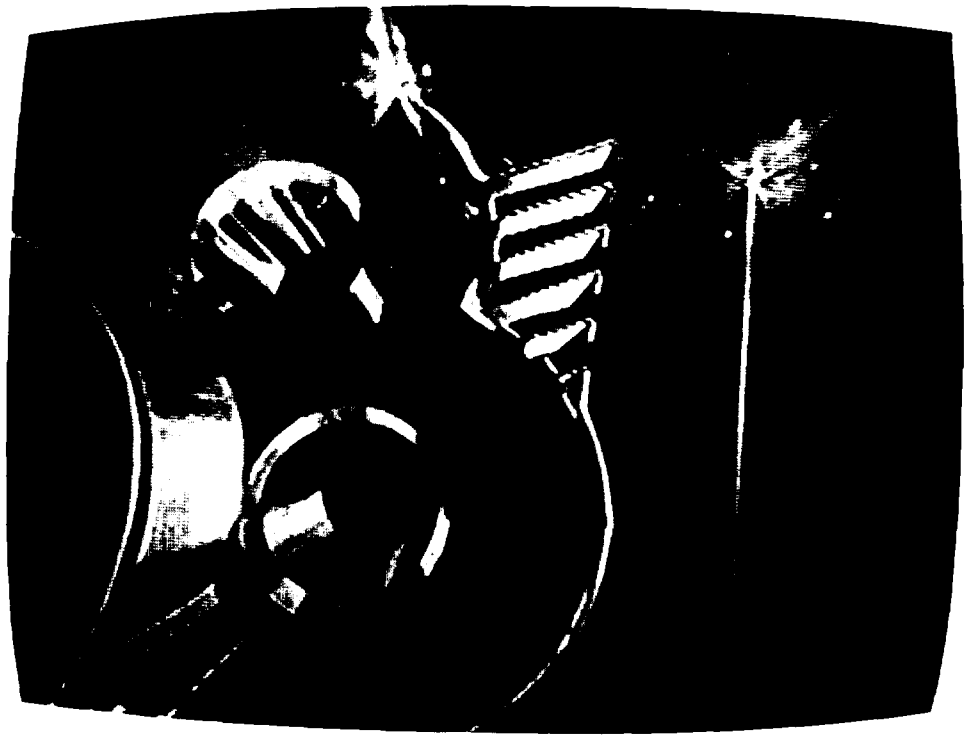
The HDTV viewing experience can be compared to watching live action through a clean window. The detail, color and lighting appear "real". Film detail and clarity are like that experienced in a movie theater.

Despite the general view that HDTV is a system to enhance television viewing by creating a "theatrical experience" for the home viewer, it also has many applications for industrial and commercial fields. The print and movie production industries have found increasing use for HDTV, and film distributors may some day use HDTV to replace film and mechanical projectors in theaters. (See Exhibit 1). It is also technically suited for the medical field because of its capabilities for displaying images of very high detail. In the retail field, department stores are even looking to use HDTV as a vehicle for point-of-purchase displays.

The original HDTV system was developed by NHK (Japan Broadcasting Corporation) in the 1970s and demonstrated in 1981 at the Winter Society of Motion Picture and Television Engineers (SMPTE) Conference in San Francisco. This system, developed with contributions from several Japanese companies, is capable of recording and displaying an image quality comparable to 35MM film. The NHK-HDTV is not a transmission system. Its sole purpose is for use in television and film production, origination and display. NHK-HDTV as a transmission system has only recently been discussed.

Figure 1 illustrates the difference in screen size between our NTSC television and HDTV systems. The top image has an aspect ratio of 4:3, the same as our current TV system. The bottom image has an aspect ratio of 5:3, similar to proposed HDTV systems. Figure 1 also shows the improvement in detail and picture quality achieved by HDTV. The top picture shows standard NTSC quality and the bottom image is a realistic simulation of the HDTV picture quality. A comparison of the NHK system and the current NTSC system is shown in Exhibits 2 and 3.

FIGURE 1



ATTRIBUTES OF AN HDTV SYSTEM

To justify the expense of HDTV to programmers, consumers, and equipment manufacturers, HDTV must offer substantive and highly visible improvements over the 34-year-old NTSC color system in use today. This distinction must be at least as dramatic as the difference between black-and-white television and color-television in 1953. These differences can be categorized as follows:

1) Increased horizontal and vertical detail or resolution.
2) Theater-like screen shape (Aspect Ratio).
3) Large television screens.
4) High quality multi-channel sound.
5) Reduction of artifacts found in the current television system.

1. Increased horizontal and vertical detail and resolution: Increased horizontal and vertical resolution allow better image reproduction by displaying more detail and truer color rendition. The viewer experiences a sense of reality as if watching the live scene through a clean window. The visual experience can be roughly compared to the difference between a picture in a newspaper and a picture in Time magazine. Picture detail is also important when the image is displayed on a large screen such as a home-projection television system or in a movie theater. Imagine doubling the size of a newspaper picture. The picture would suffer from a loss of quality and detail. The quality could be restored only by adding more detail, which is precisely the reason the detail that HDTV provides is needed as television pictures are made larger. High definition is equally important in commercial applications used by the medical profession and in print production. Image resolution goals have been set so that over time they approach or equal 35MM film.

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

*Pan and scan: the process of selecting the relevant 4:3 portion of the wide aspect ratio image for display on NTSC televisions.

serious note, in a point-of-purchase environment, a new screen shape is immediately visible to the consumer - even when the set is off. (See Figure 1.)

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

4. High-quality multi-channel sound: High quality multi-channel sound enhances the viewing experience. Since television was first introduced in the '50s, television sound was secondary because of limitations of network audio distribution to affiliates. For decades we all listened to television through a 3-inch speaker built into the set. Five years ago, televisions appeared that allowed the audio to be played through external speakers. And just two years ago, stereo television became available. The HDTV system will include very high quality, (probably digital) multi-channel sound to complement the picture quality.

It is interesting to note that HBO was the first satellite-delivered premium service to deliver digital stereo sound to cable headends and TVRO consumers.

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

COMPONENTS OF AN HDTV SYSTEM

There are three main components to any HDTV system:

1) Production/Program origination
2) Transmission or delivery medium
3) Display

Each component can stand alone, but to insure that the entire system is technologically and economically desirable, effective co-ordination is needed between, as well as within, each segment.

1. Production/Programming Origination Format

The NHK/HDTV system is intended as a production standard, providing the best possible image detail. It is used in conjunction with film, and may even replace film in the future as the original recording medium. In addition, the NHK/HDTV system is intended to be used when attempting to get maximum detail when recording directly in the video format. (See Exhibit 1.)

HDTV playback facilities can originate standard NTSC signals and HDTV signals simultaneously by using HDTV-to-NTSC standards converters. Therefore, duplication of plant is not required to originate HDTV and NTSC versions of the same material.

Requirements for production and playback equipment have stimulated the manufacture of HDTV video-tape machines, switchers, special- effects devices, studio displays, standard converters, film-to- tape and tape-to-film transfer equipment. In fact, at the 1986 National Association of Broadcasters (NAB) Conference, 24 manufacturers displayed NHK/HDTV compatible equipment[2].

In May 1986, delegates to the 16th Plenary Session of the CCIR in Dubrovnik, Yugoslavia attempted to establish the NHK/HDTV system as the world production standard for high definition television production. However, the decision was postponed until 1988, to allow more research. The reasons for the rejection of the NHK system were well documented in the September 1986 issue of IEEE Spectrum (pp. 32-37):

> Socio-Economic: the EEC countries with large television production and manufacturing interests did not want to allow Japanese to enter into the market.
>
> Technical: European countries felt the NHK/HDTV, based on 1125-line, 60-Hz field rate, would result in degraded images when converted to the European standard of 625 lines, 50 Hz.
>
> Philosophical: By calling for immediate adoption of the NHK system, the U.S. reportedly antagonized many of the European conference delegates.

Today the NHK system continues to be the accepted applied standard in the U.S. and Canada, despite the lack of official recognition. Currently, at least 35 manufacturers[3] are building HDTV equipment to the NHK specification. Sony alone has sold about 60 HDTV-production systems worldwide and about 8 systems in the U.S., making the NHK system the defacto production standard, at least for North America.

In contrast, the European countries continue to reject the NHK system. Instead they are developing their own competing HDTV system using their technology and resources.[4] Therefore, it's likely that in 1988 the CCIR will recognize both the NHK and European systems as HDTV standards.

2. Transmission or Delivery Format

Once orginated, the HDTV signal may be delivered to the final user in one or more of the following ways:

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

It's conceivable that one HDTV-transmission format may be found that works in all of the above situations. However, it is more likely that a format developed for one delivery mechanism will not be suited for another. In addition, proponents of one system may not be willing to wait for another compatible system to be developed.

The transmission format is still to be defined. Various U.S. agencies, most notably the Advanced Television Systems Committee (ATSC), Center for Advanced Television Studies (CATS) and Society of Motion Picture and Television Engineers (SMPTE) are attempting to resolve the following issues:

- Should an HDTV format be compatible with the existing NTSC standard?
- To what extent should the format approach the absolute quality of the NHK/HDTV system?
- How much bandwidth is acceptable in the transmission of HDTV signals?
- Due to bandwidth compression techniques required, how much degradation (of motion, etc.) will the viewer accept?

- Compatibility: The issue of whether the HDTV transmission should be compatible with standard NTSC signals is a point of continuing debate. The supporters of compatibility argue that the use of HDTV will be limited if broadcasters are required to use a medium separate from the NTSC broadcasts currently used to reach the 87 million plus television households nation-wide.[1] Furthermore, supporters say, cable distribution and VCR/disk HDTV distribution will be economized if compatibility can be achieved. Another school of thought argues that compatibility is desirable provided it can be achieved in a manner that offers a truly improved HDTV system; but if this cannot be achieved, incompatibility and its inherent problems may be a fact of life.

- Bandwidth: Bandwidth requirements for an HDTV signal refer to the number of standard 6 MHz-television channels needed to transmit the signal. For example, the NHK/HDTV production system would require five contiguous television channels or 30 MHz to transmit one channel; the NHK MUSE system might require 1-1/3 television channels or 8 MHz;, and an HDTV system that is totally compatible with the current NTSC system would require 1 television channel or 6 MHz.

  As the bandwidth of the HDTV signal is reduced, some of the improvement is lost. A major area of study concerns the amount of improvement over NTSC that is necessary for the viewer to perceive a significant difference and thereby be induced to purchase the new system.

- Achievable Level of HDTV: The challenge to the television industry worldwide is to achieve the highest possible level of HDTV. Considerable research is being done on those factors that would lead viewers to believe they are seeing a television system improved to the extent that they will want to buy one. Industry opinions range from: 1) improve the existing NTSC system using today's technology; 2) increase the bandwidth slightly (1-1/2 television channels) and apply sophisticated signal processing techniques to squeeze the HDTV signal into that bandwidth and accept the resulting signal degradation; and 3) transmit the full NHK/HDTV format.

Today there are many competing proposals for an HDTV transmission format. The top format proposals are: MUSE, CBS, NYIT (Glenn System), Philips, Bell Laboratories and the Del Rey Group.

The first five formats use more than one channel of bandwidth. Four of the five, all but MUSE, contain one compatible NTSC channel and utilize additional bandwidth for the supplementary HDTV information. Only the MUSE system has actually been demonstrated (see Exhibit 4), and it is being strongly considered as the format for pre-recorded HDTV optical-disk players.

The sixth HDTV format proposal, submitted by the Del Rey Group, discusses a totally compatible one television channel system, but work on this approach is in the preliminary stages.

3. Display

The final element in the HDTV system is the display device or television set, either medium-size direct-view sets or large-screen projection systems. In the near future, these television displays will be "smart", i.e., able to recognize the format of the received signal and then convert into the appropriate receive mode. By necessity, these television sets will be capable of receiving and displaying both standard NTSC programming as well as HDTV programming.

Display manufacturers must wait until the transmission formats are chosen before these sets can be designed and built. The transmission format selected will determine the necessary signal receiving and processing circuitry as well as the display format (i.e., number of lines, size, etc).

4. COMPETITIVE ANALYSIS

Today, much of the American public is aware of HDTV and its benefits. As this consumer awareness continues to grow, so will the demand for the successful development of HDTV. By the early 1990s, one may expect it to be a viable consumer product. HDTV's introductory phases will likely track the growth curve of the VCR and compact disk player. At first there will be few, if any, over-the-air broadcasts. However, cable programmers and, in particular, pay services whose source material is predominantly high-definition 35MM film will be able to provide HDTV programming. Sports programmers and VCR/disk players will also bring HDTV to the consumer.

The first sign of HDTV equipment's introduction will be its use in commercial applications such as the medical and publishing fields, video theaters, point-of-purchase kiosks, and other non-consumer television applications. These commercial applications will be among the first to bring HDTV in front of the consumer. At the same time, we can expect a high-end consumer HDTV television system, including an HDTV VCR/disk player, to be introduced along with a growing amount of HDTV software. Commercial users of HDTV hardware will give manufacturers the ability to start production for HDTV television sets, VCRs and video-disk players, and thus drive hardware prices downward.

Because most existing software (film) is HDTV in its original film format, consumers will be able to have access to a large amount of HDTV product on VCR tape or optical disk. All that is required is to retransfer the software to tape or disk in the HDTV format, and make it available to the consumer at a reasonable price.

As consumers begin to experience the improved quality available from their HDTV-VCRs or disk players, they will expect the same quality from broadcasters, cable systems and satellite program distributors. If that quality is not there, the HDTV-VCR/disk market will draw viewers away from the standard NTSC programs.

The competition for viewers' time is strongest when the competing media are offering similar products. Today, over 60% of cable viewers own VCRs. The VCR complements cable by allowing the viewer to adjust his viewing by time shifting. However, if we add to the VCR equation the additional benefit of HDTV to give the viewer even more of a "theater experience" in his home with picture and sound quality clearly superior to that of the services he gets via his cable connection, his choice of programming source becomes clear.

Cable operators must keep pace with this emerging consumer trend, which is similar to the need to carry BTSC-MTS stereo that transpired only a few years ago. Consumers will simply expect cable systems to be capable of delivering those programs

identified as HDTV whether they are off-air HDTV channels, satellite-delivered HDTV basic channels or HDTV premium channels. The over-the-air broadcasters face the challenge of finding a way to deliver HDTV while continuing to serve the existing base of television households.

The broadcasters have two options:

1. Use a compatible HDTV format - this clearly allows broadcasters to continue to serve viewers in the VHF band and provide some type of HDTV service.

2. Find additional spectrum that can accommodate additional HDTV channels - The NAB and a group of 55 broadcasters have petitioned the FCC to consider allocation of the UHF television channels to HDTV. Their petition addresses the issue of the FCC's consideration of allocating some of this spectrum to land-mobile radio. Broadcasters argue that by not allocating this spectrum to HDTV, the FCC is forever denying the public access to over- the-air HDTV by making it impossible for the broadcaster to transmit HDTV. In support of this, CBS has petitioned the FCC to consider allocating to HDTV transmissions 250 MHz of the spectrum assigned to DBS satellites.

Satellite distribution, with its wide available bandwidth and U.S. coverage, is an optimal method of HDTV delivery. In order not to disturb the transmissions to cable headends, another satellite transponder can be used to deliver an HDTV signal nationwide to participating cable systems.

The degree of success of satellite-delivered HDTV largely depends on the quality of the received signal at the TVRO. This signal quality is directly related to the satellite power and TVRO antenna size. An analysis of the transmission requirement shows Ku-band provides a significant advantage over C-band for HDTV. Because cable distribution is, in effect, a closed circuit system, the cable operator is in the position to allocate the needed bandwidth for HDTV signals to accommodate consumer demand. Technical and distribution problems related to the HDTV signal can be avoided if the cable industry particpates in HDTV development now.

HDTV source material will be supplied by satellite programmers, local origination and off air. It is assumed that one display format will be used for all HDTV formats. The various transmission systems will need interfaces either in the television set or external to it, in much the same way a cable converter descrambler or a consumer satellite descrambler is external to the television set today.

In all cases, HDTV television sets will need to be NTSC compatible so that existing VCRs, disks, and standard television programming may be viewed.

COMPATIBILITY WITH HBO'S DISTRIBUTION CHANNELS

Home Box Office, Inc. can select an optimal HDTV transmission medium, place it on a separate transponder and receive it and decode it as appropriate in the cable headend. Furthermore, Home Box Office, Inc. is capable of distributing HDTV by Ku-band satellite - the optimal satellite band to use for HDTV distribution to cable systems. Cable-headend reception would include reformatting the channel to be compatible with the cable system. The cable operator may then have to reformat at the subscriber's location to be compatible with the consumer's television.

HBO's programming portfolio, largely made up of film product, is tailor-made for an HDTV service, necessitating only that the product be transferred to tape in the appropriate HDTV format.

The drive to HDTV is a worldwide effort involving broadcasters, programmers, equipment manufacturers and standards-setting organizations. The selection of a system by Home Box Office, Inc. and the cable industry in general is not sufficient by itself to cause general acceptance by the HDTV community. The industry needs to work closely with the HDTV community to influence, where possible, the development and selection of appropriate transmission formats and to monitor the development and introduction of the consumer HDTV TV-VCR/disk player system. In addition, HBO plans to develop facilities requirements for film-to-tape HDTV transfer, playback, uplinking and satellite capacity, with a series of tests planned in early 1988 using the most probable HDTV transmission system.

5. SUMMARY

HDTV comes as a response to five questions:

1. How can we improve on today's television technology?
2. How can we use the current television spectrum allocation and continue to serve the public interest?
3. How can we ensure "backward compatible" equipment for the consumer?
4. How do we ensure HDTV will be cable-compatible?
5. How do we ensure that HDTV technology is made available to consumers at reasonable prices?

As a production and display medium, HDTV is here now. In the near future HDTV will offer consumers the wide-screen picture that present big-screen TVs cannot. It will do so with a picture quality better than that on any TV of any size purchasable today. It will accompany that picture with the highest-quality multi-channel sound available. In a market place that has seen the consecutive booms of VCRs and CDs, it is being reasonable to assume that consumers will not ignore such an offering.

The cable industry needs to ensure that this new medium is developed as a transmission medium that cable can use. It is in our obvious interest to see that cable television takes an active role in ensuring HDTV's compatibility and becomes a major source of HDTV programming for the consumer.

For that to be the case, HDTV equipment and transmission specifications need to be developed jointly between the HDTV community and the cable industry.

The choice for the cable industry is not one of either participating in HDTV, or letting it go by. It's a choice of growing with the new medium, or losing customers to it.

FOOTNOTES

1. John P. Freeman "The Evolution of High Definition Television," SMPTE J May 1984, pp. 492-501

2. Joseph Roizen, "Dubrovnik Impasse Puts High-Definition Television On Hold," IEEE Spectrum, September 1986, pp. 32-37

3. HDTV Newsletter, January 10, 1987, p. 8

4. HDTV Newsletter, December 10, 1987, pp. 12-13

A Reprint

EXHIBIT 1

This article first appeared in the September 1986 issue of Image Technology. Reprinted by permission of the British Kinematograph, Sound and Television Society, London, England.

A Film Studio Looks at HDTV

By Richard J. Stumpf

This article looks at HDTV from the viewpoint of a major motion-picture studio involved with the production and distribution of feature films and drama for prime-time network television. Examples of past efforts to introduce video into the filmmaking process are cited and related to the ways in which HDTV can make the most significant initial contribution. Its greatest impact is expected to be in the area of post-production, where it will simplify image manipulation and compositing. The role of HDTV standards is also examined, and the importance of establishing a single worldwide distribution format is emphasized.

Universal City Studios makes motion pictures for feature exhibition. It also produces dramatic-action series programs and movies for prime-time network showing. Figure 1 is an aerial view of the studio's lot of 420 acres in Universal City, Calif. Thirty-two sound stages, a large back lot, and complete post-production facilities for a heavy production schedule are housed here. The studio employs 5000 to 6000 people at the peak of the production season, including 325 editors and 2500 other craftsmen in set construction, property, and studio operation. The output from all of this activity this year will be seven feature films and 8 hours per week of prime-time network programming. In addition, Universal has 16,000 titles stored in its film vaults which are an extremely valuable source of future programming.

New Technology

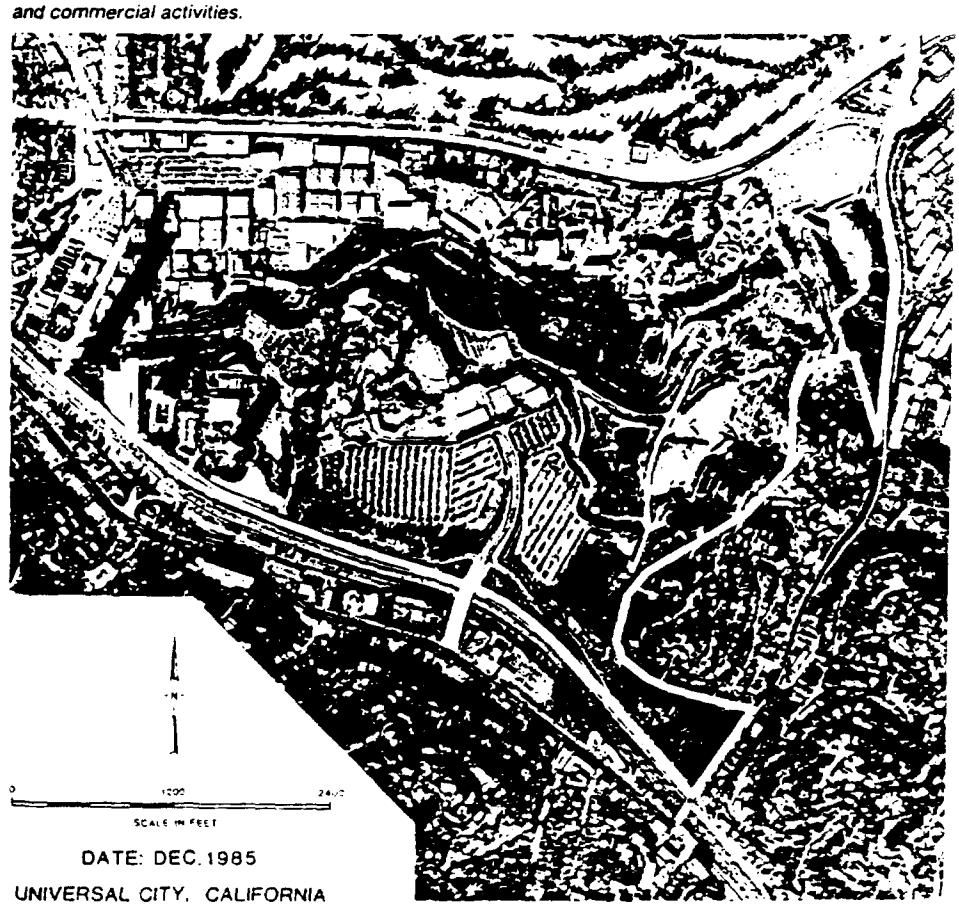
Because of the large stake Universal holds in filmmaking and distribution, studio management aggressively keeps abreast of emerging technology. When techniques appear which offer promise to extend a better way, we look them over. If appropriate, we try them out and evaluate the results. From the many new propositions received each year on subjects ranging from 3-D to digital sound for release prints, no proposal is overlooked. Thus, Universal was among the first studios to evaluate the CMX 600 for video-assisted film editing in 1970. That interest in electronic editing has been carried into the present, as detailed later.

In another television application, Universal was one of the first film studios to utilize an NTSC system modified for a 655-line 24 frame/sec system to eliminate the shutter bar seen on TV screens when photographed by motion-picture cameras. This was used in 1970 when *The Andromeda Strain* was filmed.

The WGHDEP

Realizing the importance of HDTV with its 35mm-like quality, I was encouraged to chair the SMPTE Working Group on High Definition Electronic Production (WGHDEP) when it was organized in 1984. Of all the groups studying proposals for HDTV standardization and CCIR

Figure 1. Aerial view of Universal City Studios, showing the program production complex, tour and commercial activities.



Presented at the 127th SMPTE Technical Conference in Los Angeles (paper No. 127-102) on October 31, 1985. Richard J. Stumpf is affiliated with Universal City Studios, Universal City, CA 91608. This revised article was received on July 7, 1986, and first appeared in the September 1986 issue of *Image Technology*. Reprinted by permission of the British Kinematograph, Sound and Television Society, London, England.

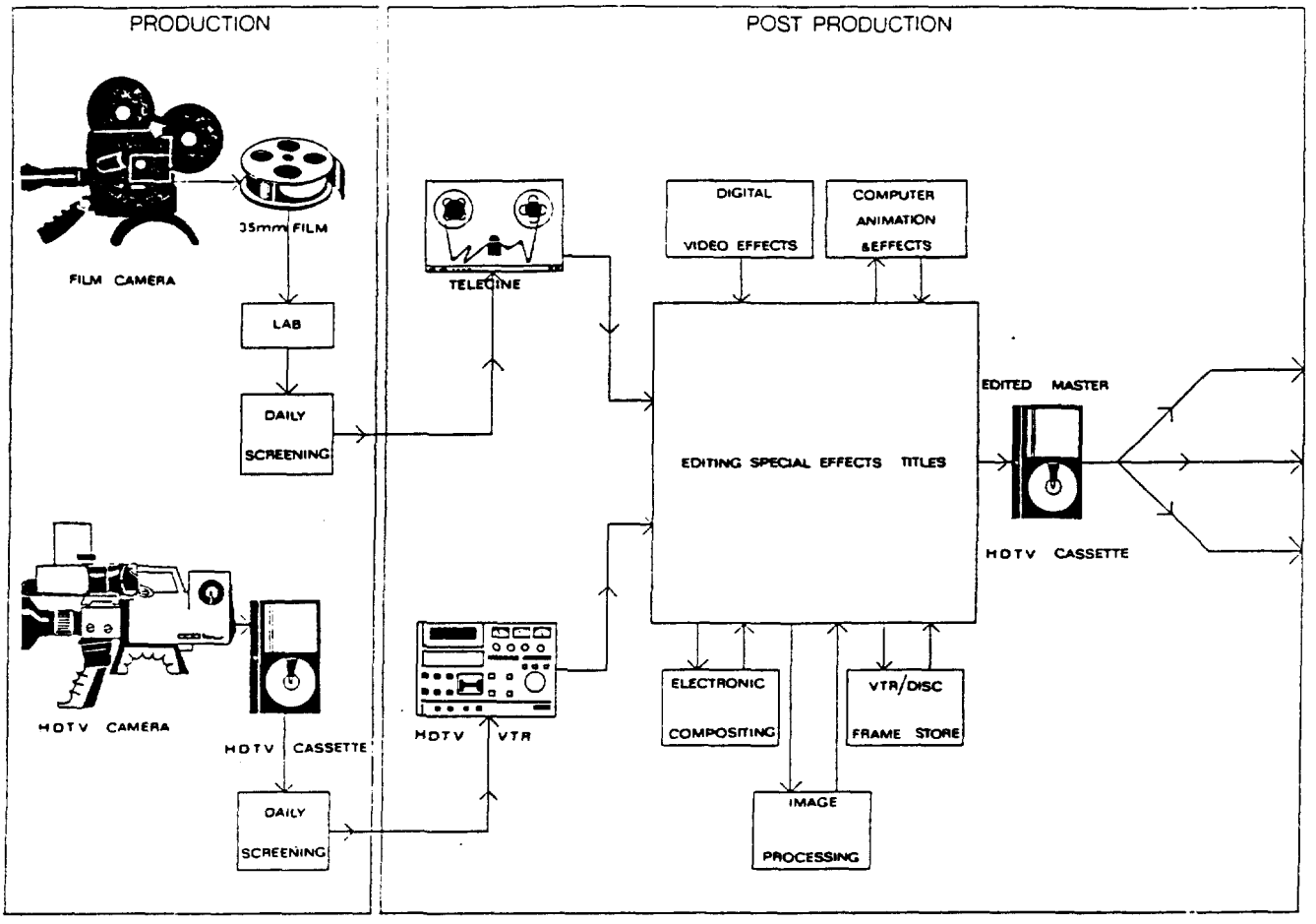


Figure 2. Model of a future HDTV production system in which action can be shot with comparable quality on either film or tape.

deliberation, the WGHDEP is unique. The other groups are made up primarily of broadcasters, which is appropriate since the CCIR presides over the broadcasters' world. The SMPTE Working Group is the only body which has included motion-picture applications in its agenda. For this reason, committee activity has been centered in the Hollywood area. Here it is able to draw upon the major pool of expertise in both film and television. The response from Hollywood has been gratifying and the Working Group has now achieved good representation of engineers from studios, labs, and suppliers, balanced with membership from TV broadcasters and manufacturers.

In the early stages of organizing the Working Group, a model was developed to focus attention upon HDTV to study the attributes, versatility, and flexibility necessary to yield a truly useful system. Figure 2 outlines the salient features of this production/post-production system and how it might fit into the distribution channels (Fig. 3) expected to evolve in the future. The objective of the Working Group coincided with the best interests of film studios in defining a future system in which the 35mm-like quality of HDTV would merge with film. Realization of this goal could make origination possible with equal quality on either film or tape, whichever is most appropriate to the needs of the director.

Production

In our vision, the images captured on film or tape in production would be equally acceptable to an advanced post-production system. Here the Working Group model envisions dailies in the form of tape or film being input to an all-electronic, computer-aided post-production system. Here, film and TV images flow in and out with equal ease and yield completely intercuttable quality. Some portions of this system are already beginning to be implemented in laboratories and at film studios to produce visual effects, compositing, computer graphics, generate titles and animation. It is in post-production operation that high-definition electronic technology probably has its greatest near-term applications in the film studio. It is also likely that system performance exceeding broadcast requirements will be demanded here if HDTV electronic post-production processes are to be transparent to our viewers.

The HDTV master tape made from the on-line assembly of the HDTV editing session could serve to meet the diverse requirements of distribution. It will be suitable for electronic cinema and most certainly, if the single world HDTV standard dream can be realized, program interchange will be greatly facilitated for home delivery systems. If the standardizing bodies and development laboratories do their work properly, the HDTV tape will have a high degree of convertibility into existing distribution media.

The main thrust of this activity is production and distribution of programs first to the cinema or network and then to the ancillary markets, both video and film. It is not generally realized that in making the dramatic-action shows for prime-time network viewing, the studio is in a deficit position when the programs are delivered to networks. These programs cost over $1 million an hour to produce, a prohibitive cost for an advertiser to

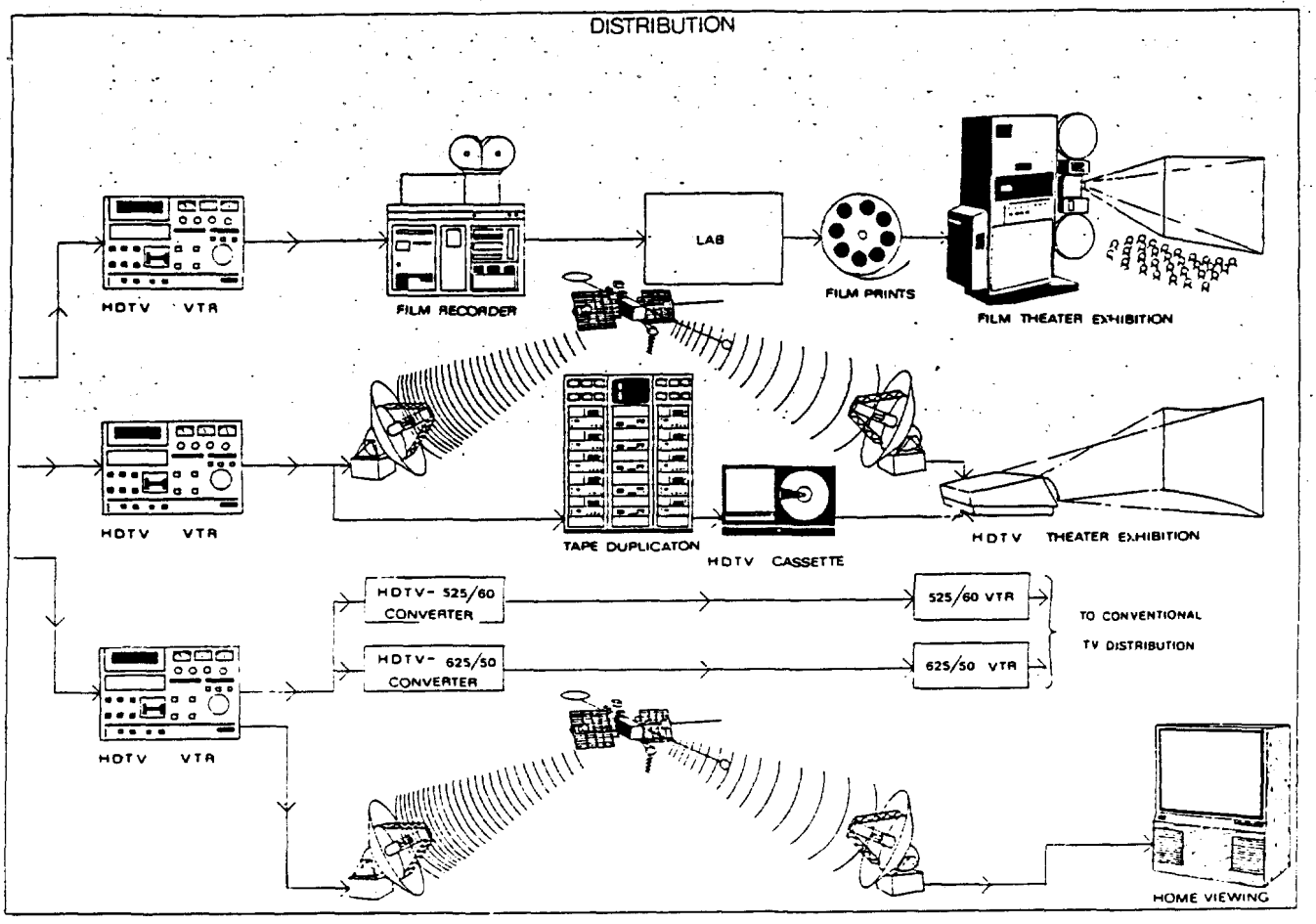


Figure 3. Future distribution channels served by the HDTV/film production system.

bear. The investment of film-for-TV producers then must be recovered in the so-called ancillary markets of syndication. A major portion of that market today and for the foreseeable future is film with 35mm or 16mm prints — the medium most desired by our clients. Thus a cardinal operating principle in planning for Universal City Studios operations is to provide film economically at the output.

Our studio is typical of several in Hollywood where film is the medium used for features and for high-value dramatic-action shows for network broadcasting. On the other hand, game shows, sports, situation comedy, and variety shows have long been the established fare for videotape. We have produced our share of these shows using multicamera videotape techniques.

Even though the cry "film is dead — long live videotape" has been heard in Hollywood over the past 15 years, film is still firmly entrenched. This presents a formidable challenge if HDTV is to penetrate the film bastion. I, myself, upon leaving a career primarily in video technology 17 years ago to come to the studio, expected videotape to replace what to my mind were archaic and cumbersome film processes. Who could expect, thought I, a very bright future for the labor-intensive upright Moviola, and blind cameras with no viewfinders for requiring three or more people to focus and dolly. Then there was the laboratory, which stood between shooting and viewing the day's work. How long could filmmakers ignore videotape with its then emerging editing capabilities, real-time special effects, title generation, and the ability for instant playback on the stage of each take? Film certainly must yield, to my mind, when held up to scrutiny against the superior properties of TV cameras and videotape. And indeed, during this time serious and concerted attempts were made to shape video technology to challenge film. A review of these endeavors to introduce video into a film world, which concentrated on cameras and editing systems, can reveal guidelines as to how HDTV can be applied to the filmmaker's task.

Cameras and Editing Systems

In 1980, after a detailed study of the unique requirements for editing dramatic, single-camera productions, CBS and Sony introduced an innovative computer-assisted system. This electronic editor accommodated the many layers of reediting encountered in feature-style, single-camera productions. It provided the post-production tool for a specialized television camera then being developed for use on the shooting stage.

Broadcaster-style video cameras have never been accepted for shooting in the single-camera style of major film studios. Mechanical configurations of these cameras, and the quality of the electronic image produced, did not meet the expectations of cinematographers and other creative people in the film world.

To overcome this drawback, the specifications for an electronic cinematography camera were developed by CBS. This work was described in the November 1981 *SMPTE Journal*. The objectives of these specifications were realized in the Ikegami EC-35, shown in Fig. 4, which was configured with the cinematographer in mind. Many optical, mechanical, and electronic features were included in its design to emulate the profession-

al film camera. Its purpose was to replace the 35mm film camera in single-camera "film-style production" for TV release.

The EC-35 camera was a major achievement. It amassed an outstanding record of performance, reliability, and video quality. It did more than any previous video camera to yield a "film look" and meet the expectations of creative filmmakers.

Shortly after the EC-35 appeared, Panavision introduced the Panacam, shown in Fig. 5 — another attempt to lure Hollywood away from film. It included an optical viewfinder, a separate camera control unit (CCU), and accepted standard Panavision lenses.

Both of these cameras were used by Universal in actual production of dramatic television programs. The "Portrait of an Invisible Woman" program, with its intensive special effects, could not have been shot except by using video techniques. The EC-35 was used throughout, to the satisfaction of all. The Panacam was used in another test of video production, undertaken when a complete episode of "Harper Valley PTA" was shot. Here again, the results were satisfactory, although the projected savings expected from changing to video did not fully materialize.

Other producers experimented with the new electronic cameras in the 1981-to-1982 season with generally good results, but the results were not good enough to commit to videotape production in the future. Cost savings never measured up to what was expected. Producers and directors who have experience in both film and tape origination state that for equal production value and quality there is small difference in originating on film or tape.

The result of all of this film and talented work has made little impact on the production of programs for prime-time television. Figure 6 depicts the proportion of film and videotape used in the past 20 years to originate prime-time programming on the three U.S. networks. There has been remarkably little change over the years, and the new video techniques just described have had no significant influence on how programs are shot. There are no major film producers currently utilizing the advanced electronic cameras, although they are used occasionally for commercials.

The majority of the filmmaking community is very happy with film as a creative medium. Its capabilities are well understood by a large number of craftsmen who are readily available to light, photograph, edit, and create special photographic effects. Large pools of equipment exist for rental as needed by the filmmakers. Film is convenient to use for production. Finally, in distribution today, 16- or 35mm film is the most desired and universally accepted release medium. Filmmakers are also aware that the 35mm negative and printing elements in their vaults are an existing high-definition medium which will not in any way limit the quality of HDTV when that marketplace is established and when proper HDTV telecines are available.

The challenge which must be met by HDTV before it is sought out and adopted by filmmakers for production, is to give the new system something not attainable by film. It must have attributes so valuable that it simply makes no sense to continue in the old ways. Perhaps it will be some time before HDTV will be applied to original photography of production, but then, electronic imaging has not come to full fruition. Perhaps one day CCD cameras, digital storage systems of massive capacity, and other technology yet to be defined will allow electronic systems not just to emulate, but to challenge film on the shooting stage. During this time, however, the film medium also will continue to evolve and improve. These improvements will be embodied in the film itself and will be available to the filmmaker without the need to invest in new equipment for each step of incremental advance.

Post-Production

Leaving the realm of origination on sound stage or on location to focus upon the post-production process, we find several areas of promise for advanced techniques. Here the long

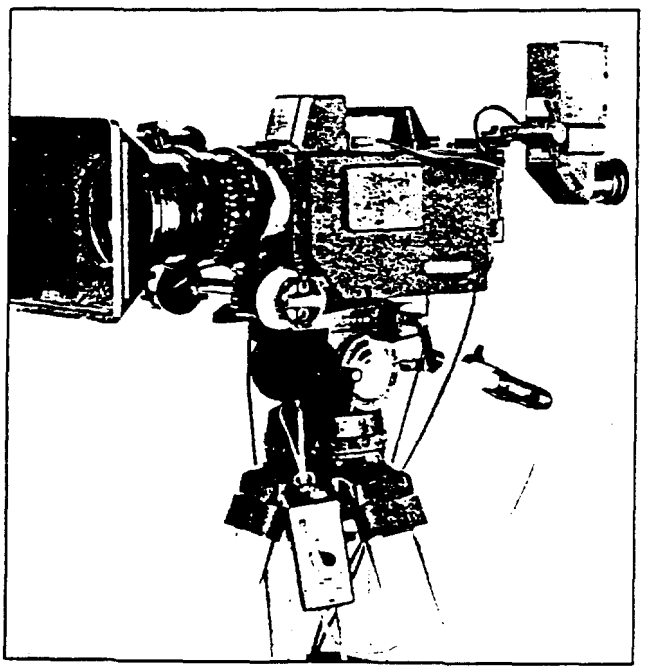


Figure 4. Ikegami EC-35 camera.

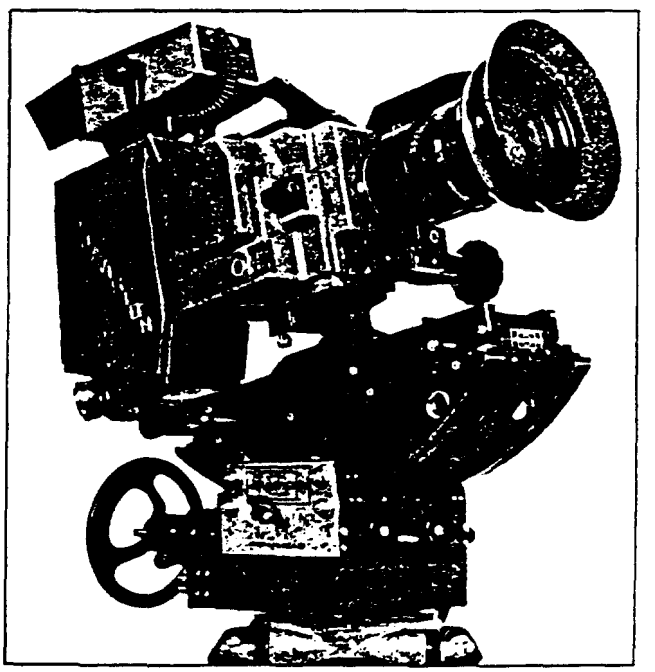


Figure 5. Panacam video camera.

struggle, which started with the CMX 600 to develop an electronic editing system to challenge the upright Moviola, is beginning to bear fruit. The pioneering work of CBS and associated manufacturers over the years has resulted in several video editing systems with advantages so outstanding that more and more film projects each season are being committed to them. This season a total of 21 episodic series film programs are being edited on electronic systems. These improved systems, coupled with business decisions by the networks to accept videotape, have contributed to this development. After network airing of the videotape, film is still needed to service the ancillary markets and future HDTV distribution channels. To fill this need, work is proceeding to improve methods of cutting negative and generating film optical effects from videotape "work prints" resulting from video-assisted film editing.

A project recently completed at Universal is representative of this approach. We have successfully used the Ediflex editing system to edit 20 episodes of "Still the Beaver," produced in 1984 and 1985 for the Disney Channel. This show was shot on 16mm film, the negative transferred to Betacam videotape as an intermediate, and also to ½-in. VHS cassettes to use on the Ediflex. Disney Channel received 1-in. C tapes assembled from Betacam videotape according to the Ediflex edit. The original negative is safely stored in vaults, although no immediate plans exist for distribution on film, because the after-market for cable shows has yet to be established. But this is not the situation for network prime-time production. As mentioned before, the producer is left in a deficit position after delivering the show to the network, and to recover the initial investment, the production must be played off in domestic and international syndication where 35 and 16mm prints are preferred because of their convertability to various TV standards.

For this reason, at Universal City Studios, all production for TV networks is planned to yield film as a final product. We also recognize the potential of video-assisted film editing. For this reason, and to better support the large volume of our work, we are actively pursuing development of hardware to utilize Eastman Kodak's Datakode® process for recording time code on film. By this means, unambiguous identification of film frames will survive 30 frame/sec video editing and, hopefully, will yield a simplified method for accurate negative cutting. The equipment and systems being developed are expected also to benefit traditional film-editing methods such as automated synching of sound and picture, as well as to streamline other post-production procedures. The Datakode® system is scheduled to be used on a full-scale production in the 1986 season.

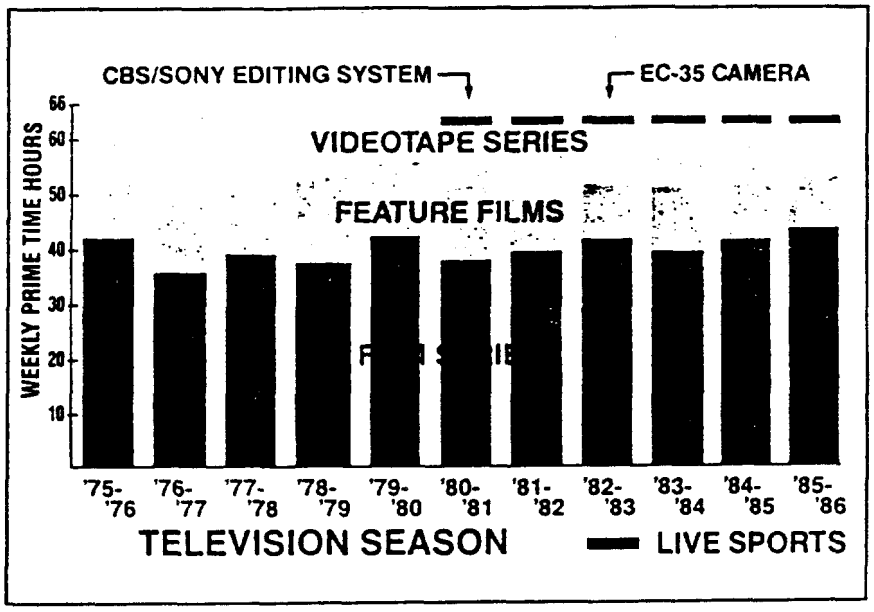


Figure 6. Sources of prime-time programming for networks in the U.S. over the past 20 years.

While these remarks on video-assisted film editing do not apply directly to HDTV, they are mentioned to show the movement toward new methods in post-production. They indicate that filmmakers are not so conservative and rigid that their attitude will not change when they are presented with alternate technology having inherent advantage. Five years ago one would have been hard pressed to find a single producer willing to trust his precious negative to a telecine. This season, however, that situation has changed, with at least 21 shows and 1 feature being edited on video editing systems such as Editdroid® and Editflex®. In this same frame of mind, producers will seek out HDTV to augment their work when presented with techniques which clearly do a better job.

The advanced video editing systems in use today are probably of sufficient quality to support HDTV on an off-line basis, but it is in other post-production areas where HDTV holds the great promise for early application.

One glimpse of how HDTV can augment film was recently demonstrated at Universal City Studios, when film was shown of blue-screen Ultimatte compositing of images originated on HDTV cameras at the NAB '85 exhibit. Videotapes of the Ultimatte output were transferred to 35mm film on the Sony EBR, with very promising results. When compared with the results of film compositing, with its five to nine intermediate elements, the HDTV-originated images were quite acceptable. With further refinement and improved equipment availability, this system will make possible production of more than one script which has been shunted aside, awaiting ways to economically execute the special effects involved.

In compositing use, HDTV needs continuing attention to widening its brightness dynamic range, to more closely approach the 7/*f*-stop range of film, to be able to gracefully handle specular reflections in outside photography and to eliminate lag and streaking. Furthermore, tighter control of image stability is required in telecines where film backgrounds are transformed for Ultimatte input. The outcome of this effort is almost certain to result in success for electronic compositing in film production.

Future HDTV Application

In considering the scale of future HDTV applications as a whole, it is obvious that filmmakers could account only for a small fraction of the

EXHIBIT 1 (con't)