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15 High Definition Television (HDTV)

Douglas A. Ferguson

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15.1 INTRODUCTION

For many years, the television industry has awaited the arrival of high-definition television (HDTV). An updated format is long overdue: regular-definition television picture has been in service in the U.S. since the late 1930s, based on technology from pre-World War II era.

The original screen in the U.S. (with 525 lines of vertical resolution) was designed to mimic the screen format (aspect ratio) of the motion pictures shown in movie theaters. But television became so successful that Hollywood widened its screen format in the fifties and later developed surround-sound and digital effect technologies.

Conventional television set makers and broadcasters were able to copy the stereo sound but yearned to duplicate the high-quality projected image. The

Japanese succeeded in perfecting HDTV, but the amount of video information filled the space (spectrum) of six television channels, making the system impractical in the U.S. where spectrum is scarce. HDTV seemed like an impractical dream only a few years ago.

Video compression of a digitized HDTV signal in the nineties was the key development that made feasible high-definition video transmission. But, unlike color television, the new system was incompatible with existing TV sets. Congress and the Federal Communications Commission (FCC) devised a plan to allow broadcast stations and their viewers to make a slow transition from standard-definition video to HDTV.

The benefits of HDTV are clear. First, it fosters interference-free transmission. Second, it has the capacity to send additional data transmissions during transitory still images. Of interest to advertisers, the HDTV viewing audience can attain greater involvement because the shorter relative viewing distance makes a substantial difference in the qualitative feel of watching TV. Instead of the stereotypic passive experience, HDTV is like looking at reality out the window.

15.1.1 Some Definitions

HDTV is not the same as DTV (digital TV). The high-definition was initially achieved by an analog signal, but now is standardized as a digital format. DTV, on the other hand, is always digital but not necessarily high-definition. Initially HDTV was IDTV (the I was for *improved*), but the 1000-line threshold of vertical resolution, as high as 1280 lines, produced twice the resolution.

Even today, many so-called HDTV monitors are not true HDTV because they operate around 800 lines. HDTV standards put the screen width at 16:9 ratio to emulate the wider motion picture screens adopted by Hollywood in the fifties. Compressed digital HDTV requires the full bandwidth of a television channel (6 MHz) to deliver a maximum pixel (picture element) count of 2,073,600.

Compressed DTV (MPEG-2) is also the format used on DVD (digital versatile disk), digitized video files (MPEG) on computers and web pages, and tape storage formats such as D1, D2, etc. DTV is typically a compressed format, also allowing satellite distribution of high-quality images to small receiving dishes.

DTV can also refer to the video receiver itself. There is little to differentiate a digital TV from a computer. An antenna substitutes for the modem, and the hard drive is unnecessary, but otherwise the microprocessor, memory chips, and binary data function as in a computer. Just as with a computer, the bit stream flows in megabits-per-second (Mbps), usually at very high speeds, depending on circuitry and operating systems. Microsoft and Thomson are developing an operating system for DTV receivers that will likely surpass another system being created by Sony, if Bill Gates gets his way. The distinction between using a home computer and watching TV will likely continue to blur.

15.1.2 SDTV versus HDTV

SDTV (standard definition TV) is roughly the digital equivalent of old-style (analog) video screens in the 4:3 aspect ratio. Because of its lower resolution (480 lines) it occupies much less bandwidth than HDTV, one-fourth to one-sixth, allowing the delivery of four to six separate SDTV signals on a single 6-MHz bandwidth. SDTV channels for DVD movies and DSS satellite channels typically operate at 2.5 Mbps, depending on the amount of rapid movement in the picture.

HDTV is the maximum resolution and the highest quality of video and sound. The huge bit rate (at least 108 Mbps) prevents HDTV transmission unless signals are squeezed into a smaller space. In the nineties, advances in digital compression allowed the huge bit stream necessary for HDTV to fit into the 19 Mbps range possible within the confines of a 6-MHz channel.

15.1.3 Why Bother?

Although there are huge conversion costs involved, HDTV and its underlying DTV technology offer more channel capacity, significantly better picture quality, larger screens, more programming, interactivity, new digital services (e.g., high-speed Internet access, pay-per-view, one-to-one marketing). In his book *Defining Vision*, Joel Brinkley speculates that viewers will eventually have the ability to turn sex or violence up and down in a manner similar to volume control.

The primary goal in switching to HDTV is enhanced video quality. Just as digital formats have enhanced audio, digital formats such as D1 (component) and D2 (composite) have been used in video studios for years because there is no loss in quality from original to successive copies (generations) and because special effects/editing are possible.

The benefits of interactivity and offering several SDTV signals over one channel are less clear. Wireless cable operators (also called MMDS) failed to get multichannel service off the ground. Broadcasters may have the same trouble emulating the kind of distribution offered by cable and direct satellite.

Benefits of HDTV are offset by some mighty drawbacks, primarily the cost of conversion but also video artifacts (picture glitches), which are also associated with digital satellite delivery. Additionally, many critics have expressed doubt that the public will want to buy the more expensive digital receivers.

The plan, however, is to force the new standard, just as the recording industry did when it discontinued vinyl records. Every non-DTV analog receiver is expected to be effectively obsolete by 2007, requiring some kind of converter box to down-convert the new digital standard to the old analog signal. This plan means the new HDTV standard will take effect less than a decade after its introduction.

It is a monumental undertaking to switch standards in less than 10 years. The situation is analogous to the introduction of color, according to research by Mark Schubin. Color TV in 1954 cost $1295, while a 1954 Ford cost $1695. The high cost of HDTV is not unprecedented.

The projected length of time for HDTV to be widely adopted, however, is remarkably short. It took 15 years for color television to catch on, and another 10 years for it to dominate black-and-white (B&W) receivers. However, color was compatible with B&W; DTV is not compatible with NTSC. Another favorable aspect for color TV was its backing by RCA, which made the sets, and its programming subsidiary, NBC, which made the shows. It is not likely (with the possible exception of Sony) that HDTV set-makers will influence the spread of HDTV programming.

15.2 HISTORY

To understand where we are it might be useful to look at how we got here. Television in the U.S. began with the 525-line system delivered on 6-MHz channels, first available shortly before World War II but delayed until after the war. The format came to be known as NTSC (National Television Standards Committee) as it evolved a color standard in 1952. NTSC requires that RGB (red/green/blue) signals from the color camera, in order to be compatible with black-and-white receivers, be transformed, by linear combination, into three equivalent component signals: luminance (Y), where Y=0.587 G + 0.299 R + 0.114 B); blue chrominance (C_b), where C_b= 0.564 (B-Y); and red chrominance (C_r), where C_r= 0.713 (R-Y).

DTV kept the component signals (Y, B-Y, R-Y) but used digital sampling to reduce the information on an analog wave to discrete (binary) numbers. For example, the 4:2:2 component standard takes 4 digital samples of the Y signal and 2 samples of both the C_b and C_r signals. Videotape systems such as D1 and D2 offered the first DTV to video professionals who needed the quality or editing capabilities. DTV transmission began mid-1994 with DirecTV satellite delivery.

But HDTV was originally an analog system like NTSC, not because digital TV was impossible, but because the compression necessary to make it practical was (or seemed to be) impossible. In the eighties, the Japanese (MUSE standard) and then the Europeans developed analog HDTV standards. IDTV (Improved Definition) had 750 lines and HDTV ranged between 1125 and 1250 lines.

Being first, however, as Sony had discovered with its Betamax VCRs, is not always best. The analog standard that looked a clear winner in 1987 was not so 10 years later. Indeed, the MUSE-only TV sets in Japan will become obsolete in 2003.

The following timeline, inspired by Sara Brown in 1998, sets forth the two-decade progress of HDTV.

February 1981	first American demonstration of analog HDTV
February 1982	first demonstration to FCC
March 1985	ATSC adopts analog HDTV standard (1125 lines, 16:9)
October 1985	CCIR adopts same as international standard
Spring 1986	CBC shoots 13-hour miniseries in HDTV
January 1987	HDTV is first broadcast over standard TV channels
January 1988	ATSC unanimously adopts analog standard
September 1988	FCC adopts compatibility standard for HDTV
January 1989	Defense Department issues $30M RFP
July 1989	$50M pledged to fund Defense research for HDTV
June 1990	General Instruments develops digital HDTV
March 1992	GI and MIT demonstrate digital HDTV
September 1992	FCC gives broadcasters six years to begin HDTV
February 1993	NHK’s analog standard withdraws from competition

May 1993	Grand Alliance formed by GI, Zenith, AT&T, and ATRC
October 1993	Grand Alliance adopts MPEG-2 compression
February 1994	Zenith wins the race to design the transmission standard
April 1995	First broadcast of digital TV
July 1996	WRAL-HD Raleigh begins HDTV transmission on Ch. 32
August 1997	ABC and Sinclair plan to multicast DTV channels
January 1998	First HDTV receivers shown at CES; KTLA covers Rose Bowl parade in HDTV
February 1998	FCC releases final allotment table
November 1998	Digital broadcasting begins
November 1998	FCC sets 5% fee for multicast pay-per-view
January 2007	End of NTSC broadcasts

15.3 THE HDTV TECHNOLOGY

The electronic HDTV camera transduces the real image with a lens and pick-up devices, generating an analog HDTV signal (video and audio). Bits are the ones and zeros that digitize the analog video and audio signals.

As described earlier, the component signals of the video source are sampled and reduced to a bitstream. Subsequent devices (e.g., editors, special-effects processors, recorders, and display screens) process the data or translate the bitstream into a viewable wide-screen image.

The Serial Digital Interface (SDI, also known as SMPTE 259M) is the standard used for the transmission of uncompressed digital video (with embedded audio) through a video facility, assuming a device separation no greater than 300 meters. Originally an 8-bit signal, the CCIR-601 specification on which SDI is based had been upgraded to a 10-bit component or composite format. There are two incompatible variations: Sony's SDDI (Serial Digital Data Interface) and Panasonic's CSDI (Compressed Serial Digital Interface). A possible open-standard resolution to incompatibility, called SDTI (Serial Digital Transport Interface), is being studied at this writing. Such a standard would greatly reduce the costs of building a digital video facility.

15.3.1 Transmission

A band of frequencies (measured in cycles per second, called hertz) is designated for each television channel assigned by the FCC. Each channel is the same width but its exact location is different for each channel number. Until the projected eventual switchover at the beginning of 2007, each television broadcaster has two channels: the original analog channel plus an additional digital channel. Digital TV broadcasts have a 6-MHz pipeline (bandwidth) through which only 19.4 million bits per second (Mbps) can be transmitted.

True HDTV signals have around 200 Mbps, which is beyond the capability of the 6-MHz pipeline. MPEG-2 data compression allows redundant information (from frame to frame) to be eliminated from the bitstream. Compression, also known as Bit Rate Reduction (BRR), was originally intended for digital transmission, but also applies to digital video in computers and digital video recorders. Depending on the desired picture quality, compression can be at either a set rate or a variable rate.

Two kinds of video compression schemes (algorithms) have been developed: lossless, which reduces the size of digital data files by eliminating redundant information, and lossy, which eliminates noncritical data. In lossless schemes, pictures are analyzed for redundancy and repetition and unnecessary data is discarded. Lossy compression systems digitize the picture quality according different criteria: what the human eye will notice (perceptual coding), which picture elements remain the same from frame to frame (predictive coding), and what movement can be inferred from inertia (motion compensation).

The device used by local stations to compress their digital signal into the 19.3 Mbps bit stream is called an encoder. Encoding for HDTV was first available via a $500,000 device from Mitsubishi. SDTV encoding was first available with Divicom's $65,000 MPEG-2 encoder.

15.3.2 Recording

SDTV signals are recorded on digital tape recorders. D1 recorders use a component digital video recording format that uses data conforming to the ITU-R BT.601-2 (CCIR-601) standard. D2 recorders use a composite digital video recording format that uses data conforming to SMPTE 244M. Both D1 and D2 record onto 19 mm magnetic tape. Other corresponding formats (D5 and D3) record onto half-inch tape. There are two other component formats for straight DTV: D9 (Digital-S) uses half-inch tape at 50 Mbps and D7 (DVCPRO) uses quarter-inch tape at 25 Mbps.

The digital HDTV format is D6, which uses D1 tape to record HDTV at 1200 Mbps, or 1.2 gigabits per second (Gbps). There is no D4 or D8 format, nor will there be.

The digital-video interface standard for HDTV is IEEE 1394 (FireWire). The standard (not specifically intended for video, but widely adopted for that purpose) handles digital information in both small and large packets. FireWire supports up to 63 devices on a single bus, with bridged buses allowing thousands of devices. It can handle at least 20 Mbps of continuous data, with speeds of 100 Mbps expected in the new millennium (allowing the transfer of fully uncompressed video). Even at slower speeds modest compression can yield outstanding quality.

The clear advantage to recording digital video is that multiple generations (layers) do not result in any loss of quality, allowing much more complex effects. Eventually consumer-grade video recorders (priced near $1,000) will permit up to 49 hours per cassette at extended-play mode, or 7 hours for standard mode, once equipment manufacturers and copyright holders hammer out a workable protection scheme.

15.4 HDTV AND SDTV FORMATS

Silent film was shot and projected at rates of 18 frames per second (fps) to take advantage of the human eye's persistence of vision; sometimes such slow rates produced a flicker which gave early films the nickname *flicks*. The coming of sound in the late twenties required faster speeds for adequate audio fidelity, so the film standard was raised to 24 fps, where it remains today.

As mentioned earlier, television in the U.S. is a 525-line system with 60 interlaced fields per second generating 30 fps (interlace scanning). Why 30 fps, and not 24 fps? Because the electric current in the U.S. is 60 cycles per second (60 Hz), so synchronization is easier with 60 cycles than with 24. Alternating electric current in Europe is 50 Hz, which explains why 25 fps video is in use on that side of the ocean.

The interlaced fields were an elegant solution to early technological shortcomings. The NTSC system scans the odd-numbered lines in a picture first, then scans the even-numbered lines to create two fields that comprise a single frame every 30th of a second. Because of the vertical blanking interval between frames, NTSC has only 480 visible lines of vertical resolution (330 lines horizontal).

By the time computer monitors were designed, television signals were capable of being created from lines scanned in sequential order (progressive scanning). Different types of video look better (or worse) in progressive scanning. For example, interlaced looks better with large-screen projection, but progressive is better for flat-TV screens. As for content, programs shot on film look better on progressive, but true video (especially live-action sports) looks better on interlaced.

With the advent of digital television, the old NTSC standard will be replaced by ATSC, which has 18 formats. Only four of these formats, perhaps five, will be used in the U.S.:

SDTV	480P	4:3	640x480	(307,200 pixels)	148Mbps	@30fps	b.c.
SDTV	480P	16:9	704x480	(337,920 pixels)	162Mbps	@30fps	b.c.
HDTV	720P	16:9	1280x720	(921,600 pixels)	884Mbps	@60fps	b.c.
HDTV	1080I	16:9	1920x1080	(2,073,600 pix)	995Mbps	@30fps	b.c.

The fifth format would be 1080P with the same resolution.

The true pixel difference between 720P and 1080I is deceptive because a true comparison counts pixels per 60th of a second. 1080I/30 displays 1,036,800 pixels versus the 720P/60 which displays 921,600 pixels. Those who want the 1080I standard argue that true HDTV is at least one million pixels.

By 1998, CBS and NBC had adopted 1080I and ABC had chosen 720P. As of this writing, Fox is predicted also to go with 720P, although it would prefer 480P for multicasting. PBS will likely adopt a new version of 1080 to complement its datacasting plans.

DirecTV and DSS satellite transmissions were expected to begin in 1999, with variants of the 1080I format delivered to double-sized dish receivers. There is no shortage of program content, because Hollywood movies from the last 40 years are already high-resolution wide-screen format. Unfortunately, most programs filmed (or taped) for TV were shot with the narrow format.

The new standards specify digital surround-sound (Dolby 5.1). HDTV receivers in the home, especially with very large screens, will thus rival the projection of movies in theaters with regard to video and audio quality (leading one to wonder whether theater owners will change their in-theater experience yet again to compete with the in-home experience).

15.4.1 Transmission

Once the signal is encoded and ready for broadcast, local stations need an 8-VSB (eight-level digital vestigial-sideband scheme) transmitter. In many cases, broadcasters seek to improve existing NTSC programming, by using upconverters or line-doublers, available in 1998 from Snell & Wilcox or Faroudja Labs.

The STL (studio transmitter link) is how the signal gets from the station to the transmitting antenna. One method uses 7-GHz digital microwave. Fiber-optic cable is another means, using the DS-3 standard (45 Mbps).

PSIP (Program and System Information Protocol) provides analog and digital channel information merely by entering the original channel assignment (e.g., Ch. 2 analog might be Ch. 51 digital, but PSIP shows the analog signal as 2-0, while 2-1 and 2-2 are the same station's digital channels for HDTV and SDTV); another scheme lets analog Ch. 2 keep that designation with the high-definition digital version a Ch. 2D and SDTV channels as 2D.1, 2D.2, etc.

Transmitted data is not limited to video and audio. Asynchronous Transfer Mode (ATM) is a very high bandwidth transmission, switching, and multiplexing technology that can move very large streams of data very quickly. ATM utilizes cells to move data from one point to another. It does not care which bits are which: audio, video, graphics, data, or voice. Everything is sent down a single pipeline.

ATM takes different types of data and converts them into fixed length cells that are 53 bytes long. Within the cell, five bytes contain control information and the other 48 bytes contain data. The cells are moved through very large data pipes at a high rate of speed and are then reassembled into their original form at the receiving end of the connection. Since the information is sent in small packages, ATM offers a highly reliable way of transmitting data from one point to another. If a cell does not get through, it can easily be resent (see Silbergleid).

On November 1, 1998, 42 stations began broadcasting digital television signals. DirecTV and DSS were scheduled to begin in 1999 and cable television delivery was slated for 2002 when converter box issues were likely to be resolved.

15.4.2 Display

Receivers made by CEMA (Consumer Electronics Manufacturers Association) have been designed to receive any of the 18 formats in the A/53 DTV standard but in 1998 only displayed some of the standards by converting them to 1080I, 960I, or 480P. For most first-generation sets, 1080I was the native format.

Even old TV displays (NTSC standard) were expected to look better with the new digital signal converted by a digital-TV tuner/decoder because signal defects are automatically corrected. At best, most conventional TV sets (as of this writing) offered S-video inputs which yielded DVD (digital video disk) quality.

Smaller-screen displays using a CRT (cathode ray tube) require masks or grilles with tiny holes that permit the phosphor dots to glow when struck by the electron beam; higher-resolution means higher cost of manufacturing very tiny perforations in the mask. Sony's small-screen set cost as much or more than rear-projection sets with much larger screens.

A possible advantage of DTV is the cliff effect of antenna reception: viewers see a perfect picture, regardless of distance from the source, or nothing at all. Indoor antennas are much more susceptible to multipath interference. One unanswered question is whether consumers will put up with adjusting an indoor antenna, if each adjustment requires that they have to back away from the antenna.

Certainly, directionality and antenna height are key variables in considering multipath interference. Rotating rooftop mounts and/or co-location of DTV transmitting antennas in a TV market were expected to hold the answer. In 1999, it remained to be seen if devices in the receivers that compensate for multipath interference, adaptive equalizers, would overcome the kind of problems uncovered in early test transmissions before the official U.S. launch of digital HDTV in November 1998.

15.5 MULTICASTING

Packet-switched statistical multiplexing (stat-mux) allows unused bits to be assigned to other tasks, such as computer data. Broadcasters can transmit up to six SDTV channels (fewer with high-action sports), as long as one channel is free. Pay TV is more difficult to establish because, as of this writing, no standard for conditional access has been decided.

Different types of programming require varying bit stream rates. The contrasting speeds needed to transmit video data are shown below:

Entertainment and news	3.8 Mbps
Sports	8.0 Mbps
Data	1.2 Mbps

15.6 IMPLICATIONS AND ISSUES

Standardization has been a very bumpy road for HDTV since at least the analog designs of the 1980s. Adoption of open-architecture technology, with which digital video equipment manufacturers can create compatible systems, was seen in 1998 as critical to the future of HDTV.

An initial lack of encryption standards also slowed the development of consumer-level digital video recorders. Motion picture and television program copyright holders feared piracy of their products, not unlike the problem faced by computer software distributors and the recorded music industry. Digital reproduction makes a perfect copy.

At the station level, choosing an equipment standard has presented a critical challenge. Chief engineers at broadcast facilities had to decide among options that included 4:2:2 digital component, 480P, 720P, and 1080I.

Nevertheless, the deployment of HDTV in the early years of the new century is expected to present manifold influences on media economies and media audiences. Beyond the crystal-clear images and sound and the general lack of signal interference, all sorts of digital information (web pages and e-mail) and data could coexist with video and audio signals.

Broadcast networks have not fared well in the multichannel environment. Advertising has provided an important but solitary revenue stream to over-the-air commercial television. Old-line companies in the late nineties embraced the opportunity to attract new audiences and revenue streams but feared the threat of new costs with uncertain rewards. Broadcast networks own and operate many of their largest affiliated stations. Costs to those stations included a new transmitter, more power consumption, and a DTV encoder. Because not all antenna towers can withstand the weight of an additional sidemounted DTV antenna, some stations needed a new tower and transmission line, assuming that FAA regulations and local objections could be surmounted. On average, the cost was $4–5 million per station to upgrade completely to HDTV.

Multicasting SDTV channels added to the expense of digital conversion. Broadcasters realized that they might need to subsidize the cost of converter boxes, similar to satellite multichannel television providers such as DirecTV and Echostar (DISH).

15.7 FCC POLICY

In addition to technical and economic concerns, important policy considerations have played an influential role in the transition to digital television. The old analog channels in the U.S. are slated to go off the air at the end of 2006 (provided that at least 85 percent of the viewers in a city own digital television receivers). The old NTSC 6-MHz frequencies, a huge portion of usable spectrum space, is scheduled to be auctioned to other wireless services (e.g., land mobile telephones). Auction proceeds for the U.S. government were expected to reach $6 billion. Budget-balancing plans and revenue projections in the mid-nineties were predicated on this revenue for the Federal Treasury.

The transition to HDTV receivers assumed that television audiences would want to replace their receivers to get better quality pictures and sound, which in turn presumed sufficient HDTV programming. But many broadcasters wanted to offer limited HDTV service until the critical mass of receivers were in place. By multicasting SDTV channels, they hoped to recoup their huge investment in digital conversion. By 1997, however, it became clear that Congress wanted HDTV, not SDTV. House Telecommunications Subcommittee Chairman Billy Tauzin (R-La.) and Senate Commerce Committee Chairman John McCain (R-Ariz.) pressed hard to hold broadcasters to their promise of HDTV instead of SDTV multicasting. This chicken-or-the-egg dilemma was an important policy matter at the FCC in the time leading up to digital deployment.

On another front, the White House also wanted free political time in exchange for additional spectrum set aside for digital broadcasting. Vice President Al Gore led the effort to extract additional public-interest commitments from digital broadcasters.

The FCC announced plans in 1998 requiring broadcasters to pay the government five percent of any pay-subscription revenue via DTV channels. Despite objections from public interest groups, stations would not have to share revenue from home shopping, infomercials, and other direct marketing enhanced by additional SDTV capability.

15.8 CABLE

In the nineties, multiple system operators (MSOs) for cable television spent huge sums to upgrade their set-top converter boxes, hoping to depreciate the cost over a period of years. Waiting for HDTV to decide on standards was not an option for many of them, and, once committed, these cable operators were reluctant to reinvest in new converters that cost hundreds of dollars apiece.

More important was the issue of shelf space. Cable operators had no vacant channels on which to locate the new digital channels for local signals. The FCC *must-carry* rules required cable operators to provide local channels on their systems, but cable systems announced that they were unable to find space for *two* channels for each local signal.

Two-thirds of all television homes received video reception via cable service in 1998. The alternative was rooftop antenna, which was a major inconvenience for some and an impossibility for others. Cable providers at the turn of this century find themselves in the unenviable position of not being able to provide, for technical and economic reasons, the HDTV signals readily available over-the-air and via direct satellite.

At this writing, it is unclear how this issue will be resolved. The FCC will, of course, play a major but reluctant role. Members of Congress are influenced by competing industries: broadcast (through the NAB) and cable (through the NCTA).

15.9 COSTS TO CONSUMERS

Buying a new, expensive television receiver is an important issue to consumers. The consumer electronics industry welcomed the opportunity to sell new receivers to 100 million television homes. But the decision was not simple for the average person. Some observers predict that consumers will not spend huge sums for television sets. Joel Brinkley in 1998, however, reports that tens of thousands of consumers had already bought high-end NTSC receivers that sold for $5000 to $50,000, so it is reasonable to predict that many viewers would continue their intense attraction to the video medium.

The set manufacturers decided to offer two formats: integrated and HDTV-ready. The latter requires a separate decoder, analogous to the way computer monitors are sold separate from the computer itself.

Panasonic offered the first DTV receiver, capable of reproducing only 800 lines (enhanced definition) because true 1080I resolution monitors cost $40,000 in 1998. Initial enhanced definition receivers, first sold to consumers in August 1998 and widely available by early 1999, were overbuilt and cost $6000 to $10,000. A retailer in San Diego sold 30 display units the first day, discount-priced at $5500 each, and took orders for another 18 the second day.

Except for the early adopters who would pay almost anything for the latest technology, ordinary consumers will decide how long to wait for the prices to drop. Analog equipment, such as VCRs, took a decade to drop to half of the original cost, but digital components are expected to get less expensive much more quickly, according to Moore's Law. After all, digital receivers are more like computers than television sets. In late 1998, HDTV was projected to cost $3500 by Christmas 2000 and $3000 by 2002. The price was not expected to reach below $1000 until 2004.

15.10 ANALYSIS AND PREDICTIONS

First, we can be suspicious about exaggerated cost estimates for HDTV transmission and reception. When costs are phrased as being "as much as" and "up to" inflated amounts, we can assume the translation is "a lot less than." Second, we have learned that competition is sufficient to foment an innovation like HDTV, but that cooperation (e.g., the Grand Alliance) is necessary to crystalize it, especially when government agencies are reluctant to set a standard.

My own view is the transition will take three to four years longer than the 2007 target year. But the transition will happen, as surely as telephones, radio, recorded music, and nearly everything else gone digital. As I write this, the digital signal already reaches 37 percent of the nation in its first month. It is inevitable, but how it will all unfold is not at all clear. What is clear is that HDTV is long overdue.

REFERENCES

Blake, Jonathan D., "The Origins of DTV Revisited," *Broadcasting & Cable*, October 26, 1998, 39.

Booth, Stephen A., "Digital TV Turns On," *Popular Science*, November 1998, 76–82.

Brinkley, Joel, *Defining Vision: The Battle for the Future of Television*, New York: Harcourt Brace, 1997.

Brinkley, Joel, "HDTV: High in Definition, High in Price," *The New York Times*, August 20, 1998, D1, D8.

Brown, Sara, "HDTV Highlights," *Broadcasting & Cable*, March 9, 1998, 38–46.

Dickson, Glen, "Counting Down to DTV," *Broadcasting & Cable*, July 20, 1998, 22–40.

Ferguson, Douglas and Klopfenstein, Bruce, "How Media Managers Deal with Change: The Case of HDTV." Panel paper at Assoc. for Ed. in Journalism and Mass Commun. (AEJMC), Baltimore, August 1998.

Higgins, John M., “Making Sense of Multicasting,” *Broadcasting & Cable*, September 8, 1997, 14–17.

McClellan, Steve, “Ready and Not, Here Comes DTV,” *Broadcasting & Cable*, March 9, 1998, 28–46.

McGann, Mike, “HDTV is Here (Finally),” *Home Theater*, November 1998, 42–53.

Schubin, Mark, “Metamorphosis,” *Videography*, October 1998, 38–44.

Silbergleid, Michael, *The Guide to Digital Television*, New York: Miller Freeman, 1998.

West, Don, “The Dawn of Digital Television,” supplement to *Broadcasting & Cable*, November 16, 1998, S1–S56.