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The American Advanced Television Transition

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Master of Arts in Media Arts and Technology

by

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March 2007

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By

Kristoffer Fox Campanale

Dedicated to my parents

and

My aunt, Sonya Campanale
For without whom, I would not have been able to attend graduate school.
You will always be remembered.

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ABSTRACT

The American Advanced Television Transition

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As we pass the 50th anniversary of the American analog color-television standard, we find ourselves moving into the next generation of home entertainment technology. High-definition television is becoming an increasing reality, or that is what the electronics and entertainment industries would like the public to believe. The United States designated 2006 as the year to begin the early stages of switching off the analog broadcast spectrum. The reality is that in 2006 we see that less than a quarter of households are digital-ready and that the public is fully ill-prepared for the transition to digital broadcasting. This paper will address the future of American home entertainment, examining the driving forces behind the seemingly simple transition from analog to digital and high-definition broadcasting and why that shift is taking an inordinate amount of time. By looking at current and future high-definition technologies, as well as social and political issues I will address the American advanced television transition.

In order to give the reader a proper overview, I summarize how advanced television was developed in America. Next, I will present the technologies behind HDTV itself, as well as its content delivery systems. Once the technology has been summarized I will examine the political and social concerns surrounding its development, and identify stumbling blocks in the digital television transition. Lastly, after interpreting the data collected, I will explore potential solutions to transition difficulties, and predict the future of advanced television in the United States over the next decades.

The data for this paper has been collected from a variety of sources, including books, academic journals, trade publications, newspapers, and corporate web sites, as well as gathered from tradeshows and private industry. This research expands the current body of knowledge surrounding HDTV by establishing a relationship among consumers, hardware manufacturers, and content providers, and also explains the way in which the technology itself affects the perceptions and political attitudes toward consumer technologies.

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INTRODUCTION

When the United States' 104th Congress passed the Telecommunications Act of 1996, it initiated a series of events that started the country on the path toward advanced television. This new form of television would be revolutionary in many ways: it would require higher resolution, thereby yielding a better picture; it would utilize an all-digital transmission method for terrestrial broadcasting, and it would be based on a system that was completely incompatible with every existing television set in the country. Because of this incompatibility, a migration plan was needed. The government's solution was simple; it would be necessary to create a gradual timeline in which this new system's infrastructure could be put into place, allowing for public adoption of the new technologies. Ten years was chosen as an acceptable timeframe for a transition.

1.1 – Problem Statement

Unfortunately, as 2006 draws to a close, it is clear that only a fraction of American households are prepared for digital broadcasting, and that the country is nowhere near a full transition. Economic problems, as well as a confusing plethora of

formats, competing products, and industry jargon all contribute to the slowdown. These elements, paired with the excessive costs of high-definition television (HDTV) equipment in the United States have resulted in a very small potential market for consumers and, in turn, little demand for high-definition content. Due to these high costs, a paradox has emerged. Content and hardware providers require a large consumer base in order to remain profitable with high-definition services. Until they have this base, these providers must keep prices high in order to recoup expenses. Alternatively, consumers need an array of affordable content and hardware in order to make the transition to digital television. Neither event has yet occurred. This paper examines the issues associated with this paradox to find possible solutions to the unsuccessful transition to advanced television.

1.2 – Relevance of the Research

This research is of utmost importance because it addresses not only the issues that the country is currently facing in its shift toward a next-generation television system, but also examines the issues of why these stumbling blocks have occurred. This paper contributes to the field of research by providing in-depth analyses from a technological perspective, as well as social, economic and content related positions. Consolidating this information provides a balanced evaluation of the problems associated with America's transition to advanced television.

1.3 – Literature Review

Currently, there are three main sources for the study of mass-media literature relating to this topic: 1) Technical write-ups from journals and corporate whitepapers; 2) Theory works, based on the effects and use of media; and 3) Social commentary on consumer technology, found in trade publications and mainstream periodicals. These literary sources, in addition to reports on government legislation and comments by experts in the field, make up the bulk of available research for this topic.

1.4 – Methods

I address the problems posed in the paper by providing, in Chapter 2, a historical perspective on key points in the annals of television. This allows us to view parallels between previous television technology transitions and the problem of digital television adoption that the public is experiencing today. I also discuss the progression of in-home entertainment, as its rise over the past thirty years has been one of the leading components in the push for high-definition television. In Chapter 3, I consider the technical choices put forth by the FCC's Working Group on Advanced Television, followed by a detailed technical summary of those formats chosen to become the American digital television standard. Examining the details involved with digital terrestrial broadcasting, I evaluate compression techniques and the new dynamics associated with transmitting a digital signal. I then look at associated costs of the transition to digital television for both consumers and

broadcasters, finishing up with an examination of the elements that have contributed to the slow transition. Chapter 4 illustrates HDTV's key role in the realm of in-home entertainment. I summarize the current electronic and physical premium content delivery sources, then analyze the benefits and drawbacks of each system by comparing and contrasting the competing systems. This section also includes an examination of next-generation systems that are still in developmental stages, in order to see how they compare to current offerings and to judge the potential success rates they may enjoy. Chapter 5 examines the key factors of why the transition has progressed so unsuccessfully. Historical trends, as well as the general public's perceptions are examined in an effort to explain the apparent consumer apathy amongst average Americans. By analyzing consumer demands, copyright law, government policy, and corporate decisions over the past ten years I further refine the problematical matters discussed. One of the key issues this paper examines is the changes affecting home entertainment's user-experience stemming from provider invoked controls and regulations on content in an all-digital media environment. In Chapter 6, I begin to look at the progress we can expect to see in the immediate future, examining the barriers associated with upgrades to infrastructure and end-user devices. I discuss how format wars within the high-definition media offerings have confused consumers, and how, if not resolved, they will further slow the transition. This chapter also views the costs to the consumer and how they can be adjusted by affecting market demand for hardware and content. Lastly, we consider solutions for facilitating the transition, as well as assessing the potential longevity of

this new digital television format. Chapter 7 concludes the perusal of the advanced television transition issue, by looking at possible ways to solve the paradox, and by weighing potential solutions. I then offer several predictions as to what progress the advanced television system and associated components will make in the coming years. Lastly, I offer suggestions for future research topics based on information found while researching this paper.

1.5 – Terminology

In this paper I make several references to the importance of the general public as a key demographic, necessary for the success of advanced television formats and peripherals. This comes from the understanding that while early adoption of a technology tends to come from the wealthy, that new technology is not proven a success until it has been embraced by a majority of the population. For the purposes of this discussion, I define a member of the general public to be of average education; to be in the country's median salary range; and to be a user of consumer technology, although not an enthusiast of any specific or particular technologies. For this average member of the public the price of an item would carry greater weight in the real world than raw performance and wow-factor. This is not to say that items that excel in raw performance and wow-factor would not appeal to members of the general public, but the purchases of such products would require an excess in disposable income. Overall, the general public model reflects what I feel is an accurate cross-section of the majority of consumer electronics users.

2

BACKGROUND

Societal transitions from one technology to another are nothing new. American consumers have experienced many over the better part of the last century. These transitions usually take decades to complete, having to allow for gradual adoption throughout the population until they are completed. 1996 marked the beginning of the latest technology transition for the American public with an upgraded form of television. While this new, advanced form of television was incompatible with the existing analog television systems, a concession was made to accelerate the adoption: a pre-approved government mandated format. Nothing on this magnitude had ever been attempted before. Unfortunately, even with government involvement, the transition has proven to be all but a complete failure. This chapter examines the historical factors that have led to a cultural demand for advanced television.

2.1 - History

2.1.1 – Classical High-Definition

The concept of high-definition television is not a new one. The term's usage today is no different than its use in the 1930s when it was used to define the "higher

definition" images of electronically scanned television when compared to the lesser quality ones produced by the mechanically scanned systems of the day (Winston, 103). These "high-definition" images were created in an attempt to match the quality of the 16mm film that was commonplace in the cinemas. Ironically, while today's high-definition television may be comprised of more advanced technology than the engineers in the 1930s could ever have imagined, modern high-definition television systems were also modeled off the film industry. The current high-definition standards were designed to yield an image that resembles the quality of 35mm film, the current standard in modern cinema (Winston, 141). While the term "high-definition" can historically be used to describe television's attempts to match the quality of film, it is commonly used to simply characterize television that looks aesthetically better than that of which we currently use.

2.1.2 – Rival Color Television Formats

Although black and white television was popular, color television marked the beginning of the modern in-home entertainment movement. It had been experimented with as far back as far as the late 1930s, but it was not until after the Second World War that a surplus of newly developed technology and the engineers to use it allowed the country to fully develop a color television system. Even after the system was available, color television's birth was a rough one. This was in part due to industry competition. CBS had experimented with color prototypes in 1940 and had working systems in place by the mid-to-late 1940s. RCA, the corporation

behind the black and white television system, had created an all-electronic color system by 1951 (Britannica Online, Television). Understandably, these two television systems were not compatible with one another because the two companies were archrivals. RCA owned NBC, CBS' primary competitor. In addition, the fundamental technologies behind each system were inherently different. The CBS system used a mechanically controlled color wheel similar to those found in today's single-chip DLP projectors for the creation of its image. The RCA system, on the other hand used an electronically scanned system that modulated the color information within the original black and white signal (RCA, Color Television) This worked by adding a color value at 3.58MHz to the original black and white signal that could be read and converted into the color TV's image information (Extron Electronics, Signal Transmission). Black and white systems did not have the ability to read this color information, would simply discard it and the image would remain unaffected. This served not only to maintain backwards compatibility but also to keep costs down. While the CBS system eventually offered backwards compatibility with the existing black and white system, it could only do so on screens no larger than 12 inches in size.

2.1.3 – NTSC Color Standard

Although both systems generated color images, the government wanted a single standard so that both broadcasters and hardware manufacturers could focus on a single technology. In 1950, the Federal Communications Commission (FCC) turned

to the National Television Systems Committee (NTSC), the group that in 1941 finalized the broadcast specifications for black & white television. The NTSC found benefit and drawbacks in both the CBS and RCA formats, but after a long battle, the committee decided on the RCA system in 1953 (Winston, 122). The NTSC color standard was introduced to the public on January 1, 1954 with a coast to coast broadcast of the Tournament of Roses Parade (Bankston, 6). Due to costs and limited content only a few of the wealthiest Americans were able to watch the broadcast in their homes, as most color televisions at the time were in storefronts for public viewing. It would be another fifteen years before color television would begin to be commonplace in American homes.

The role television played in the everyday life in the 1950s compared to today was relatively limited. While there was ample entertainment, programming was meant to be more informational. Television programs were shot on tube video cameras or converted from 16mm film. These images of the time may seem crude to us now, but they were well within the inherent quality limitations of NTSC broadcasting. If people wanted to enjoy higher quality visuals, they still had to go to the cinema.

2.2 – Rise of In-Home Entertainment

2.2.1 – Birth of Cable TV

The television climate began to change in the 1970s when Community Antenna Television providers introduced specialized programming with a better quality

picture to consumers, who only had access to network affiliates before. Now named Cable Television, this service offered increased content that was fed directly from the broadcasters or via satellite, providing a cleaner picture than the over-air competition (NCTA, History). In 1972 the Home Box Office (HBO) channel made its first broadcast of what would eventually become a new revolution in home entertainment: Pay Television (MBC, Home Box-Office). For a modest fee, a viewer could watch movies and sporting events without the interruption of commercials. By 1980, HBO had over 12 million subscribers and the American public was one step closer to modern day to in-home entertainment.

2.2.2 – Home Video

The advent of the VCR in the late 1970s led to the categorization of the television as a solid entertainment device. Within a few years the home video market exploded, rendering the VCR an essential item in nearly every American home. Just as there were two competing manufacturers of early color television systems, two companies emerged as rivals in the VCR industry, each making their own proprietary home video formats. For these two companies, Sony and JVC, the rising public interest of home videos meant that the only thing standing between them and the windfall of the VCR market was each other. While the quality that the videocassette provided was unable to rival that found in the cinema, it succeeded greatly in attracting consumer support. Between the two companies, the factor of determining victory rested not with the product that offered the greater quality, but with the product that

offered the most flexibility and lowest price (Noll, 95). Sony decided early on to keep the Beta format proprietary. Figuring that since its product offered the better performance of the two formats, Sony not only assumed that the product would be purchased solely on merit, but also refused to license the Beta technology to rival companies early on. Conversely JVC, knew it could not win the format war on quality alone and decided to license their technology to any manufacturer who wished. The plan succeeded and eventually JVC won the format war, relegating Sony's Beta format to the history books and launching VHS into immense success that lasted decades.

2.2.3 – Early High-End Home Video

Throughout the 1980s and early 1990s the home video industry soared into a billion dollar per year industry (Walley, 78). This combined with Cable's ever-growing selection of programming and pay movie channels meant that television was becoming more and more an essential part of the entertainment industry in general. Between the two, television was providing a more viable alternative to the cinema. With more and more households opting for home viewing rather than cinema, the demand for increased visual quality was beginning to grow. The late 1980's introduced consumers to premium technologies such as Super VHS and Laserdisc. Though these two technologies were not without their share of problems, not least of which was their high cost, they did help bridge the quality gap for the videophiles and the wealthy. These new technologies also made the need for better quality TV

sets apparent, because they were required to exemplify the improvements the new technologies provided. By the early 1990s, forty years after its inception, the television equipment that was available had all but reached the full capacity of the NTSC video system.

2.3 – Developing Modern HDTV

2.3.1 – The Need For More Quality

In any given field, perhaps the best gauge by which to judge where the average consumer will be in the near future is where the enthusiasts of that field are now. In the case of the television industry, the demand for higher quality from these enthusiasts was a signal that a new video system would eventually be needed. In the late 1980s, the increased popularity of home entertainment and advancing television technologies led the FCC to begin looking for ways to improve the technology of broadcast television. The FCC's official research into the development of a next generation television technology began when they formed the 1987 Advisory Council on Advanced Television (ATSC, History). Consisting of twenty-five members of the television broadcast industry, it was the job of this committee to set the course of television for future generations. Proposals included improvements to the current NTSC broadcast standard as well as complete replacements altogether. After six years, the committee came to the conclusion that an all-digital high-definition system similar to the Japanese prototype high-definition systems available at the time would be the best solution for the country.

2.3.2 – The Japanese Approach

The Japanese system had made its technical debut in the lab in 1968. The prototype was made possible through a partnership between the Japanese state broadcaster, NHK, and the major Japanese electronics firms. The television system utilized a screen with 1125 interlaced lines of resolution and a wide 5:3 aspect ratio. Development of the Japanese system went on for nearly twenty years and eventually made its first public debut with the broadcast of the 1988 Olympic games in nearby Seoul, South Korea (NHK 2003). While some changes were deemed necessary, this system provided a solid starting point for the new American system.

2.3.3 – ATSC HDTV

Once the committee made its recommendations in 1993, manufacturers spent two years developing the new television standard. Because this process requires manufacturers to work with the government to create a new television standard, a third process is often required to mediate the process. In the case of digital television, the third party was the Advanced Television Systems Committee (ATSC). The ATSC is the main organizing body that oversees the standards for the international digital television standard (ATSC, About the ATSC). Much like the Society of Motion Picture and Television Engineers (SMPTE) or the Motion Picture Experts Group (MPEG) the ATSC is a privately owned voluntary industry standards

organization. ATSC members are drawn from professionals and members of almost two hundred organizations representing all aspects of the television industry.

Figure 2.1 – NHK vs. ATSC vs. NTSC Formats

	Max Resolution	Aspect Ratio	Transmission Mechanism
NHK	1920x1125	5:3	Analog
ATSC	1920x1080	16:9	Digital
NTSC	704x480	4:3	Analog

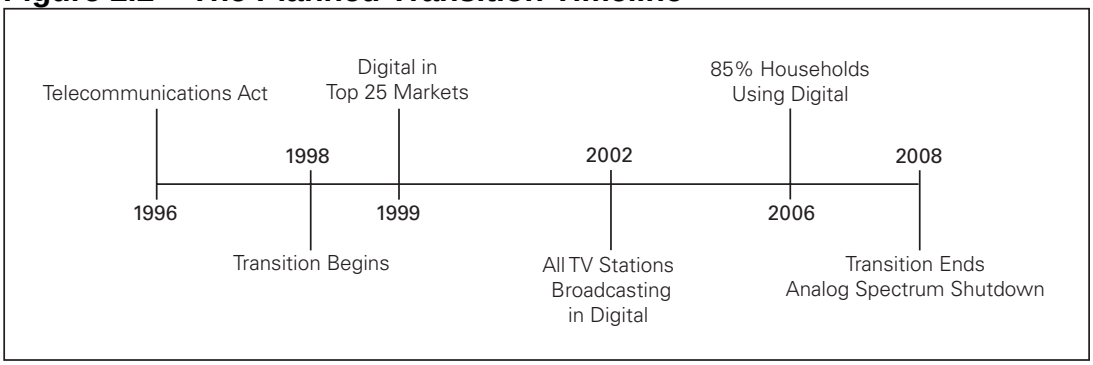
In September 1995, the ATSC presented the version of the digital television standard that the country knows today to the FCC Advisory Committee. A year later, the FCC declared that this standard for digital terrestrial broadcast television was going to become America's standard.

2.3.4 – The Planned Transition

With the passage of the 1996 Federal Telecommunications Act, a mandate for a ten-year transition to digital terrestrial television was set. Broadcasters would be given a new portion of the radio spectrum to be used solely for digital television. Television stations in the ten largest markets were required to begin transitioning to digital broadcasting service by November 1, 1998 (Hunold, 1998). This would be followed a year later by the stations in the remaining top 25 markets transitioning as well. This plan intended to make digital television accessible to half of America's population. A steady increase of stations broadcasting digital television was planned

for the following years. The overall goal for broadcasters was for every television station to be offering at least some form of digital television by 2002 (Stern, 226). It was estimated that ten years would be an adequate time for the public to purchase the equipment needed for this new technology.

Figure 2.2 – The Planned Transition Timeline



The purpose of this ten-year transition was to not only move the United States to a higher quality of television but to set a time at which the soon-to-be obsolete analog television spectrum could be sold off. On paper, the process seemed brilliant: switch to a new kind of television on a new section of radio spectrum and sell off the unused segment of the spectrum to the highest bidder. During the dot-com boom that occurred in the late 1990s, the plan looked to be on track, supported by all the new wealth and society's technical prowess. Then in the early 2000s the American economy began to tumble and since then, various national disasters and international conflicts have further weakened it so. During this unsettled time, new television technology has taken a back seat to the more important matters facing the American

public. This is the dilemma HDTV is presently experiencing. In such an uncertain era, can the American public make its complete transition to digital, and if so, how long will it take?

2.4 – America's Introduction to Digital Entertainment

When the ATSC finalized the initial specifications for digital television it was still too early for a consumer version to be made available, let alone for broadcasters to provide an infrastructure in which the equipment could be used. Therefore something would be needed in the meantime, a product that would yield an improved video image than existing media while at the same time begin to introduce consumers to the benefits of digital content. This led to the creation of the device known as the Digital Versatile Disc, or more commonly known as the DVD.

2.4.1 – DVD

The DVD was created by a partnership of hardware manufactures and content providers called the DVD consortium. Some of these companies initially included Toshiba, Pioneer, Panasonic, Warner Brothers and Sony. When it first came out in spring of 1997, the DVD was initially seen as the replacement for the Laserdisc (Saunders, N9). It offered an impressive set of features compared to the Laserdisc, the DVD had an arguably better picture, Dolby Digital 5.1 audio, custom menus, and multiple audio and subtitle tracks. Plus, this was all available in a format that was a quarter of the size of the bulky Laserdiscs. Early-adopters fell in love with the

format and with the growing popularity of the Internet, word spread of the DVD's benefits (Hettrick, 1998). With eventual full studio support and a surge in sales, prices fell dramatically. This drop in price meant that consumers found DVDs to be a viable option for home entertainment (Wilner, SW4). Three years after its first release with over thirty-million units purchased, the DVD was seen as the new home entertainment medium (Sporich, E-3). The DVD made it possible for the average American consumer to see the benefits of improved image quality and to realize that digital technology could provide a better home entertainment experience in general. One would think that this realization would help pave the way for a digital television transition and for a small minority it did. Of course, with the average American consumer perfectly happy with the new DVD format, most did not see a need to upgrade further, especially when such a sizable expenditure was required for relatively minimal results.

2.4.2 – Digital Television

Digital television is an over-air medium designed to replace free television. HDTV in its simplest terms is a high quality format that is part of the advanced television standard that exhibits the full capabilities of the new system. The transition to digital television has been mandated, this is a compelling reason for the networks and local television stations to make the transition. However, if one looks at the viewing habits of the early adopters of HDTV, they will see that very few solely watch free over-air broadcast television. Those who can afford the high hardware expenses of

HDTV are more likely to be those looking to premium content services to supply the majority of their content. In fact, the majority of even regular television viewers want something more than over-air television. 60% of Americans subscribe to some sort of pay television service (NCTA, NCTA Statistics) (SBCA, SBCA Facts & Figures). Because the cable and satellite services do not operate on the nation's radio spectrum, they are not bound by the federal mandate to switch to a digital high-definition system, but it is in their best interest to do so in order to remain competitive. This crossover is more complicated than it might seem however. The higher resolution images of HDTV take up more bandwidth than traditional digital SDTV visuals. In fact, HDTV requires approximately four-times the bandwidth of SDTV. This means that upgrades to a home's data infrastructure need to be made and eventually all systems will need to be upgraded. In the meantime there are two options that both premium and free providers can use as stopgaps: use the current bandwidth allocations and run fewer channels or keep the same offerings and use a different compression mechanism.

2.4.3 - Computers

The computer has also begun to play a large role in home entertainment. The convergence of cable and telecom services is perhaps a prelude to the blending of television and data delivery. MPEG-2, the backbone of broadcast HDTV, is a format that can easily be delivered over Internet Protocol (IP) as long as the bandwidth is available. Most Americans have a near or greater-than high-definition specification

screens in their homes already, their computer monitors. Most monitors can show high-quality native or interpolated HDTV video straight from the Internet or even over the air via an inexpensive add-in card. While it may not be likely that in the future everyone will gather around the PC for family movie night, this may give a glance into the role of the home computer in home entertainment in the coming years.

2.5 – End Remarks

In 1996, the American public was ripe for a digital revolution. The Internet was gaining massive commercial appeal, the digital television roadmap was put forth through Congress' passage of the 1996 Telecommunications Act, and the DVD was on the verge of being released to the public. Over the following decade the seeds planted in this digital renaissance would begin to grow and would change the technological and home-entertainment landscape of the United States dramatically.

3

ADVANCED TELEVISION

The forty years following the NTSC color television's introduction showed a constant rise in its usage: slow initial acceptance, gradually starting to level out through the 1980s. In the 1990s and 2000s, however, the limitations of NTSC began to become apparent due to the rise of in-home entertainment. The first step to correct this came in the 1990s with the introduction of digital NTSC content sources. These allowed a greater number of viewing options to be delivered to the consumer while utilizing a minimal amount of space compared to traditional analog means. With these new formats, the content was exceeding the capabilities of the NTSC standard. With the industry always looking to provide a better viewer experience, NTSC had reached its limit, and was therefore no longer a viable platform. A next-generation system would be needed to further the advancement of television in the United States.

3.1 – Finalizing the Format

3.1.1 – The FCC's Prototype

Despite attempts to improve the aesthetic quality of the NTSC system, the FCC decided to start finalizing plans for a new all-digital form of terrestrial television commonly known as high-definition television. The FCC's Advisory Committee on Advanced Television found that a digital system of transmission and content would be the best for the next generation American television system, because it would allow the most flexibility in regards to image quality and efficiency. With these results in hand, the advisory committee set out to create a "Grand Alliance" made up of the groups involved with the development of early all-digital system prototypes. This group would help to finalize a standard of digital television that would eventually be proposed to the FCC for approval. The committee decided that each of the major groups involved with the Grand Alliance would be responsible for a developing a different aspect of the new prototype system (ATSC, The Grand Alliance).

Figure 3.1 – The Grand Alliance Prototype

AT&T	*Video Encoder*
Dolby Labratories	*Multi-Channel Audio Subsystem*
General Instrument	*Video Encoder*
Philips North America	*Video Decoder*
Thompson	*Transport System*
Sarnoff Research Center	*Transport System*
Zenith	*Transmission Subsystem*

The completed Grand Alliance standard proposal was submitted to the FCC in 1995 and was overwhelmingly approved. In 1996 with digital content well established and DVD emerging on the horizon, the FCC announced that the United States would begin a nationwide transition toward digital television. This chapter will introduce the current forms of digital television as well as the current state of affairs of the country's transition to High-Definition.

3.2 – Digital Television

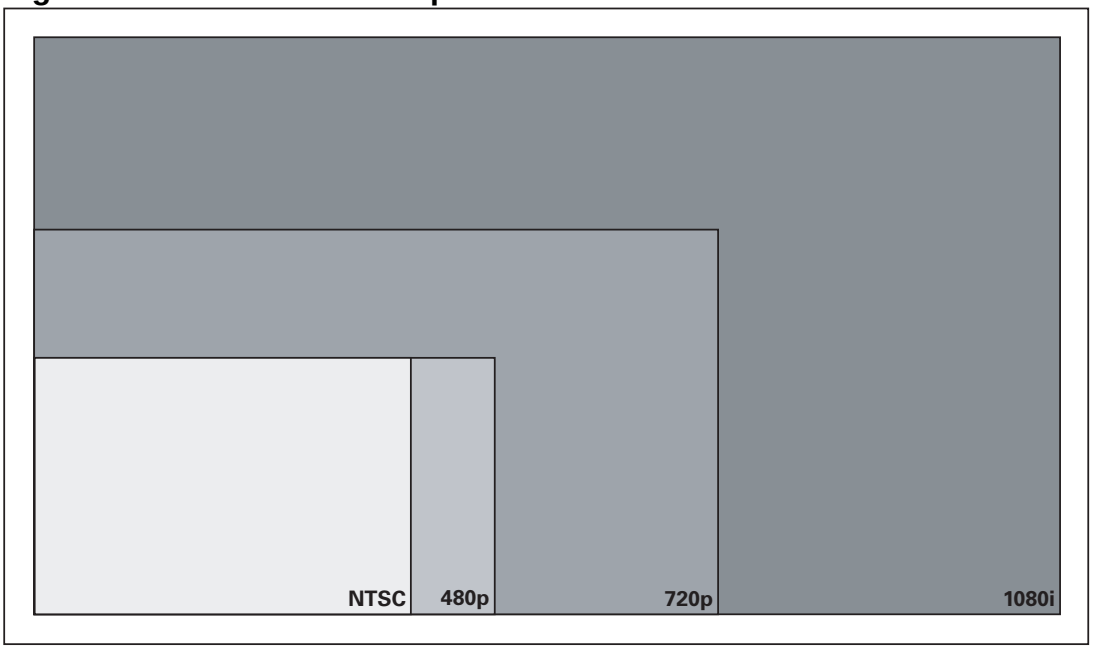
Digital television is not only affecting what we see; it is also changing the way television is delivered to American homes. Digital terrestrial broadcasting is a new technology designed for all American consumers. Digital television was not just designed for the deep pockets of the wealthy enthusiasts, but for all Americans. This means that free over-air broadcasting is just as important as cable and satellite delivery.

3.2.1 – Formats

Throughout the world there are countless digital television formats in use, with each one using a different encoding mechanism, physical or electronic container, and video frequency (Maxell, Digital VTR Format). The vast majorities are found in the professional realm of production, mastering, and archival of material. Of the many formats in use today, only the three formats are of immediate interest to the American consumer: 1080i, 720p, and 480p. These are the three formats chosen by

the Advanced Television Systems Committee for digital terrestrial broadcast in the United States. Every new digital television tuner and television set is configured to recieve these specific formats.

Figure 3.2 – ATSC Size Comparison Chart



3.2.2 – 1080i

1080i is one of the two high-definition formats supported by the ATSC. It utilizes 1,080 horizontal lines of resolution scanned in an interlaced method of delivery. Interlaced pictures scan the even and odd lines of the picture on separate passes (e.g. pass one: lines 1, 3, 5, … , 1079; pass two: lines 2, 4, 6, … , 1080). 1080i exhibits the largest overall screen resolution of 1,920 by 1,080 pixels, which presents the

picture in a 16:9 aspect ratio. The ATSC specifies a frame rate to that of existing NTSC video of 29.97 frames per second.

Figure 3.3 – 1080i Specifications

Resolution	Frame Rate	Aspect Ratio	Data Rate (Compressed)	Data Rate (Uncompressed)	Picture	CEA Designation
1920X1080	29.97	16:9	19.2Mbps	950Mbps	Interlaced	HDTV

3.2.3 – 720p

720p is the second of the two high-definition formats supported by the ATSC. It uses 720 horizontal lines of resolution, but unlike 1080i, they are scanned progressively. Progressive scan exhibits a non-interlaced picture by scanning the lines in sequential order (e.g. 1, 2, 3, 4, … , 720). Progressive scan preserves more of the picture than does Interlaced scanning. While the resolution of 720p is considerably less than 1080i at only 1,280 by 720 pixels, 720p presents an arguably better picture in high-action scenes than 1080i due to its non-interlaced, or progressive image. With the resolution of 1,280 by 720 pixels, 720p utilizes a 16:9 aspect ratio. Due to its progressive nature, 720p has a frame rate of 59.94 frames per second, double that of 1080i.

Figure 3.4 – 720p Specifications

Resolution	Frame Rate	Aspect Ratio	Data Rate (Compressed)	Data Rate (Uncompressed)	Picture	CEA Designation
1280X720	59.94	16:9	19.2Mbps	840Mbps	Progressive	HDTV

3.2.4 – 480p

480p is the enhanced digital television standard supported by the ATSC and while it is not considered high-definition, it does yield a better picture than NTSC. Another way to look at 480p is as a progressively scanned widescreen version of the NTSC image. In fact, 480p quality is commonly compared to today's progressively scanned DVD players. 480p was designed to be an economical option for the digital television broadcasters. Not all broadcasters can afford to spend the extra 50-100% of their current expenditures that is required for high-definition. In addition many proponents of 480p see it as a way to bring a greater number of lower-resolution channel offerings than would be available in full-scale high-definition using the same amount of bandwidth. Since each broadcaster is allotted 19.2Mbps of bandwidth, 480p serves a unique purpose. Because the format is of a lesser quality and thus requires less space, broadcasters also have the option to simulcast multiple channels. These sub-channels offer local broadcasters increased flexibility in regards to what they can broadcast. Anything from a dedicated weather channel to showing re-runs of syndicated programming. More importantly for the station, it also allows them to increase their opportunity to gain additional ad revenue.

Figure 3.5 – 480p Specifications

Resolution	Frame Rate	Aspect Ratio	Sub-Channel Feeds per HD Channel	Picture	CEA Designation
852X480	59.94	16:9	Up to Five	Progressive	EDTV

3.2.5 – Network Support

Although they are not mutually exclusive, each of the three formats requires separate equipment configurations and planning for broadcast. With that in mind, each television networks made a decision early on to specialize in one of the two high-definition formats only. 480p is still used as well to supplement high-definition programming.

Figure 3.6 – American. Network ATSC Format Choices

ABC	CBS	FOX	NBC	PBS	CW
720p	1080i	720p	1080i	1080i	1080i

The decisions for networks be locked in to a single ATSC format meant that the decisions would also be made for their respective affiliates. This in effect locked the regional broadcasters into a specific choice for digital broadcast. The main reason for each network broadcasting in one format was price. At the network level, equipment costs hundreds of millions of dollars. Therefore it was a very cost-effective decision to stay with a single format.

3.3 – Digital Broadcasting

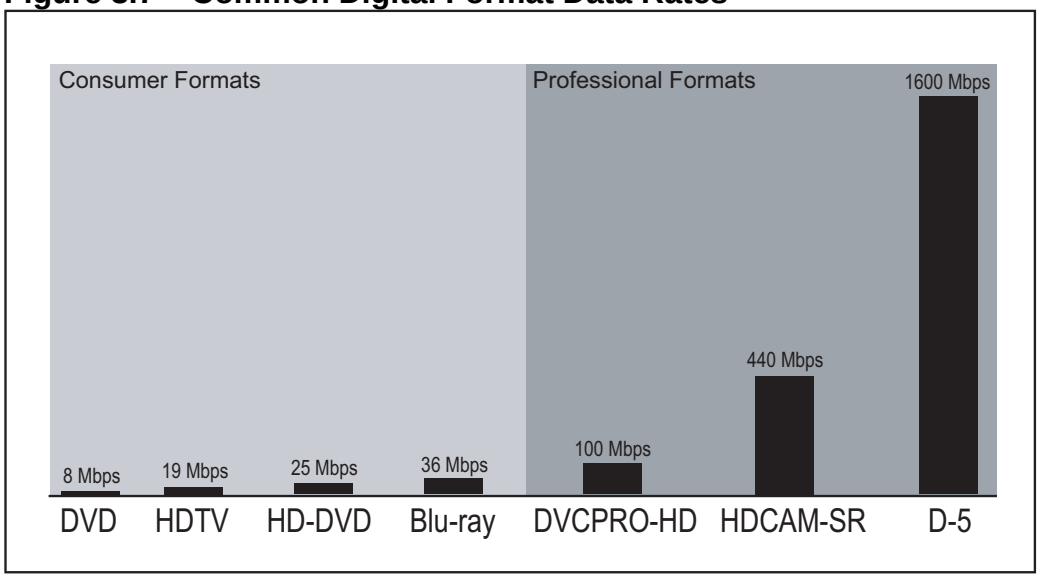
3.3.1 – Terrestrial Broadcasting

Digital broadcasting does vary from the traditional analog broadcasting Americans have been familiar with in the past. Unlike analog signals that gradually degrade throughout the range of the signal, digital signals remain at full intensity until they near the limits of their maximum rangee, after which they drop out completely. This all or none phenomenon is referred to as the Cliff Effect (Extron, Signal Transmission). MPEG-2 was been chosen as the transport medium for broadcast digital television. High-definition signals aree encoded in a 19.2 megabit per second bitstream, which is approximately three to four times that of today's commonly encoded MPEG-2 content.

3.3.2 – Compression

Even with a seemingly large bitstream, broadcast HD is shown in a highly compressed form. In order to understand how compressed it is, it may be helpful to look at HD formats worldwide. Most of these formats differ from each other in resolution, scan rate, and scan type. The vast majority of them are designed for use in the professional end of content creation. The professional realm has been using HD systems since the 1980s, with technology provided by NHK and Sony (NHK 2002) Professional production facilities currently run HD formats for mastering and archival work, which utilize uncompressed bitstreams up to 1.6 gigabits per second: more than eighty times that of broadcast high-definition video.

Figure 3.7 – Common Digital Format Data Rates



One might wonder then, why HDTV is presented in such a compressed format. The answers lie in the bandwidth and the equipment used. While the amount of bandwidth related infrastructure leading to one's house is multiplying on a regular basis, HD is confined by the technical limitations of over-air transmission. In addition most HDTV sets cannot display the full range of information that a master-quality source can present. Lastly while there are differences in quality between the uncompressed and the broadcast forms of HD, the visual improvements, at this point in time, would not be worth the added bandwidth required for transmission.

3.4 - Transitions to High-Definition

3.4.1 – Current Status

Today the question is no longer if we will switch to HD, but when. Billions of dollars have been invested in consumer level HD technology and content creation.

When the government passed the FCC's Telecommunications act of 1996 it, among other things, mandated a public migration timeframe for the adoption of digital terrestrial television (United States Congress, 1996). Over the ten years following 1996, Americans were expected to upgrade their television sets from an analog NTSC set to an ATSC compatible one. For the broadcasters, the federal government provided an additional incentive: a new portion of the radio spectrum that would be provided free of charge for the simulcast of digital TV signals over the period of the transition (Grossman, 58).

3.4.2 - Timeframes

The FCC imposed many goals that the content providers had to meet, such as networks picking their broadcast format and forcing TV stations in the country's ten largest cities to be broadcasting digitally by the end of 1998. Ideally 85% of all Americans were to have completed the transition phase to digital by 2006: so that broadcasters could easily subsidize the remaining 15% and cease analog broadcasting in Early 2008 (Martin, 1997). Unfortunately things have moved much slower than anticipated, so slowly that at the beginning of 2006, consumers had not even come close to meeting the requirements of the analog switch-off deadline. A revised cutoff date was moved to February 2009, however this may not allow enough time for a successful transition without the heavy use of government subsidies. A more reasonable unsubsidized deadline would be anywhere from 2011 to 2016.

3.4.3 – Affiliate Costs

One reason the transition has not been accomplished is the great expense to the regional broadcasters. According to the FCC's timeline, all broadcasters from the largest in New York City to the smallest in Glendive, Montana were to be switched over to digital broadcast capability by the end of 2002. While this may have been easy for broadcasters in large markets reaping millions of dollars in profits every year, it has been a different story for the smaller cash strapped stations of rural America. For a station to acquire the bare minimum of equipment required for digital broadcast, millions of dollars must be spent. Station upgrades for high-definition transmission and production are extra (Tremblay, 18).

3.4.4 – Consumer Costs

Adoption is further hampered by the fact that equipment to view HD information is still very expensive. And while some digital compatible sets are dropping below the $500 mark, their high-definition signals are interpolated and the television set often times does not include a tuner. The ramifications of this are that HD is currently not readily available to the general public. Traditionally, new technology adoption starts at the top of the economic ladder and works its way down. We have seen this in the past with NTSC Color TV, VCRs, and most recently in DVD players. History shows us that while digital television is not quite in the reach of the general populous today it will be eventually.

3.4.5 – Historical Perspective

Given the problems previously addressed, there has been much skepticism about the timely transition of HDTV for the American public. Deadlines are being missed and quotas are not even close to being met. The critics of HD are pushing for the government to admit failure and give up on the transition (Grossberger, 1997). As it stands, the current adoption of HD in the United States is highly reminiscent of the adoption of NTSC color TV in the 1960s and 1970s.

3.5 – Attracting Consumers

3.5.1 – Increasing Content

In the long run, the true test of HDTV will be the adoption by the general public. Unfortunately, as previously discussed, this presents a paradox. An HDTV set is harder for an average family to afford than it is for an affluent family. As a result, very few digital television sets have been sold, resulting in very little content available for HDTV users. While the marketplace has been offering HD content in addition to the federally mandated over-air content, it is still in small quantities and limited to general-interest programming. Sporting events often garner TV's top ratings; so content providers have been shooting sporting events in HD for sometime, in an attempt to exhibit the realism that HDTV can convey. Limited HD cable and satellite services have been operating major urban areas. While these services only offer a handful of HD channels, they may be enough to entice the first

of the general public's early adopters to adopt the new technology. These enticements will be essential in persuading American consumers in transitioning to digital television.

3.5.2 – Appealing Hardware

HDTV has been touted as an elite solution for one's home entertainment not only in an attempt to lure the wealthy and early adopters to HD, but also helps to build consumer lust for the products. One product used to do just this is the plasma television. The general public did not notice the high-definition CRT and projection sets, or anything HD related until the thin HD Plasma sets started in on the market for $15,000. The term HD has become synonymous with flat and wide televisions. It seems that the flat TV will be the key device that brings digital television into the mainstream, perhaps single-handedly (Wilson, 30). Currently entry-level plasma sets are priced around $1000: much more affordable than when first released, but still far out of reach by the general public. As the price of plasma and LCD televisions drop further, we should expect to see more and more Americans making the switch to digital television.

3.5.3 – The Effect of the Internet

Another reason for the general public's unwillingness to switch over is the popularity of the Internet. The Internet has been one of television's largest competitors since its commercial introduction to the public in the late 1990s. It has

been luring away TV viewers with its interactivity and virtual community aspects for years (Gold et al., 21). In response, content providers have added upgrades to their existing services: offering additional channels for a moderate increase in monthly fees. Services such as digital cable services or extra channel packs on satellite were popular at first, but lately interest has waned. These extra channels tended to be specialized in nature, with very little mass appeal. In response, people have begun to drop the packages, it is apparent that viewers are looking for quality over quantity in their viewing experience (PR Newswire, 1998)

3.6 – End Remarks

All of this has brought content providers to look for ways to improve existing lineups as an alternative to adding additional channels. In recent years, services such as video-on-demand, electronic program guides, context-specific interactive program information, and digital video recorder (DVR) services have been making their way into American homes with great success.

4

PREMIUM CONTENT DELIVERY SOURCES

The federal government is requiring the broadcast of digital terrestrial television signals to the American public, but this alone will not excite advanced television's early-adopters nor will it drive the format's popularity. As far as content is concerned, the draw will come from premium media sources such as cable, satellite, and other physical media. For many people, these content sources will not only be the reasons for switching, but will also determine when and how to make the transition to advanced television. In this chapter we will examine many of these premium content formats that will be introduced alongside HDTV. In addition, we will look at the technical upgrades and modifications existing technologies need to make in order to offer HD content.

4.1 – The Need for Supplemental Content

The American public is currently in the early stages of its transition to HDTV. While less than 20% of homes have an ATSC spec television set, content providers have started the first steps in offering premium HD services (Krause, A04). These initial services are a response to satisfy the emerging customer base, rather than

fully accommodate the relatively few HD customers. This shows that content providers are starting to notice their newest ever-growing customer base and have begun taking steps toward eventual mass consumption.

4.1.1 – Early Adopter Demographics

Currently, the costs associated with making a full transition to HDTV for an American consumer are around $1000. This is an entry-level price targeted toward affluent consumers. Lesser quality digital-ready television sets can be found for under $500, but these along with most early digital television sets lack the image processing internals, requiring the interpolation of some ATSC formats such as 720p. Most of today's premium television sets are HD ready and all of these sets have SD tuners. Since wealthy consumers will more than likely buy one of these high-quality sets, chances are that they will be purchasing a HD capable set regardless of whether or not they were planning to buy one specifically. This accomplishes broadening the potential HD market base as well as planting an idea in the consumer's head that they should take advantage of HD services because their new television can handle it.

With the current demographic for HDTV being affluent consumers, premium service options are essential to appease the customer base. Very few wealthy television viewers prefer to watch free terrestrial broadcasting. These consumers opt instead, for premium pay services such as cable or satellite. This can be seen in the

initial configurations of HD hardware: in the first ten years, very few of the HDTV sets sold included an integrated HD over-air tuner. Not including these tuners lowered the prices of the first HDTV sets, keeping set prices as low as possible in the early years of their availability and potentially opening up the market to other financial demographics that would not otherwise be able to afford HDTV.

4.1.2 – Premium Content

The digital terrestrial broadcast of HD will not carry the format alone: HD needs to increase its content availability to that of today's standard definition offerings. This means that there is a need to further the development and enrichment of HD content to prepare for the gradual increase in viewers. As with SD the most popular content sources are not those of terrestrial broadcast, but premium content options such as cable, satellite and DVD.

Premium content can be divided into two categories: electronic and physical media. Electronic media formats use an infrastructure-based delivery system for content delivery. Services such as terrestrial broadcasting, satellite, and cable are all examples electronic media sources. Physical media formats store their content on a tangible device such as the popular standard definition DVD and VHS formats. Beginning with electronic media sources, we will discuss the formats that will offer advanced television support.

4.2 – Electronic Media

4.2.1 – Unicasting versus Multicasting

Terrestrial broadcasters offer a single channel of content to a given region whereas cable and satellite providers offer multiple broadcasters' channels to a region. In a sense terrestrial broadcasters are unicasting while premium service providers are multicasting. The idea of multicasting has been around since the early days of cable TV, when all the members of a community would share a single high-power antenna to receive distant terrestrial broadcasts (Winston, 309). The purpose of multicasting is to provide as many channels as possible to a market in the attempt that at least one channel will appeal to a given viewer.

4.2.2 – Digital Systems

When digital satellite and cable services began to show up in the early 1990s they fulfilled a demand for additional premium content, which had heretofore been unavailable. Digital services were able to offer hundreds of channels many times the number available from the existing analog cable and C-band satellite systems, which were severely limited by their available bandwidth. Digital broadcasters were able to achieve this by encoding the analog video into the MPEG-2 format. MPEG-2 offers ample compression and image quality, while at the same time not requiring an excessive amount of computing power to decode in real-time. These are the same reasons MPEG-2 was chosen for use with HDTV and in turn first generation HD satellite and cable services.

Today's HD cable and satellite services are currently being advertised as extensions of SD services: usually five to ten HD channels among an average of two hundred in a SD lineup. The low number of channels available is due not only the lack of HD content but also a lack of potential viewers. The costs of obtaining HD feeds from networks are far greater than the revenues made for distributing the content (Business Wire, 2003). Even with these shortcomings, however, multicast systems are beginning to provide premium HD content into American homes. This is a long-term investment in HD, relying on the idea that eventually Americans will be required to use digital television, guaranteeing premium content providers millions of HD customers.

4.2.3 – Cable Infrastructure

SD digital multicast systems require the use of an MPEG-2 converter, a device that changes the digital signals into analog video. HD based systems no longer require a converter but still need a unit to capture the MPEG-2 signal and decode any proprietary copy protection mechanisms cable providers may use. Currently, cable and satellite providers offer set-top decoder boxes for this task. While analog cable-ready SD TVs are commonplace, cable companies wanted a way to develop a standard for digital cable-ready televisions. Called CableCard, the new system allows a cable provider to supply an encrypted security decoder card that fits into the slot on the back of a compatible HDTV set (Musgrove, 2005). The card handles

the decryption of the cable signal and since both cable systems and ATSC tuners are designed around MPEG-2 there is very little additional equipment needed.

4.2.4 - IPTV

The rapid growth of the Internet brings a third alternative to premium in-home entertainment. Internet Protocol Television (IPTV) is in experimental trials within a few cities around the country (Chuang, 2006). Telecommunications companies are designing IPTV as prime competition to the cable and satellite services. IPTV is much like digital cable except it uses the Internet as its transmission infrastructure. Its current stumbling block is the lack of available bandwidth, but this will eventually remedy itself as the bandwidth to American homes steadily increases over the coming years. In the meantime, the telecommunications companies are using advanced codecs such as MPEG-4 based systems in their test systems to lessen the bandwidth requirements of MPEG-2 systems. This however, comes at the expense of increased processing requirements that in turn also raise development costs substantially.

No matter which delivery method is used, in-home broadcasting will be the primary electronic source of premium HD content. Due to the bulk of SD demand, providers will be slow to adopt full HD packages, especially because once full-range HD packages are offered they will be priced higher than equivalent SD or SD/HD combo offerings. Because of this, most of the larger HD packages will begin once

HD is widely adopted. Cable and satellite companies will do their part in assisting the transition of the public to HD, by offering HD channels on SD subscribers' channel guides in attempts to remind consumers that something "better" is out there.

4.3 – Electronic Media Accessories

4.3.1 – Digital Video Recorders

In addition to the traditional electronic content delivery services, over the past few years, consumers have started to use another method of electronic content delivery. Digital Video Recorders were first introduced in 1999 with the release of the Tivo and ReplayTV systems (Furchgott, 2000). Since then, the popularity of these systems has skyrocketed. A DVR can best be thought of as a traditional VCR that uses a hard drive and video encoder to record content. Thanks to this technology, consumers are no longer bound by tape length when it comes to recording television programs. People can also configure DVRs to record only the shows that they want to watch. Because DVRs have recording capacities of over thirty hours consumers can literally record every show that they may want to record: in a sense no longer having a need for live television. The Tivo has become extremely popular among those who enjoy broadcast television yet don't have the time to adhere to its schedule. One can watch all of their favorite primetime shows at anytime they like (Rose, 2003). DVRs have become so popular that cable and satellite providers have integrated DVR devices with digital cable and satellite devices. While it is not a complete replacement for a VCR, the DVR has begun to replace the VCR as a

home's primary recording device. However, although it outperforms the VCR at almost every level, the VCR still provides a portable recording medium, which is something the DVR cannot do.

4.3.2 – DVR Design

A DVR is basically a computer that is designed to capture and playback video. In fact, the Tivo DVR runs off of a modified Linux operating system (Ihnatko, 50). Advancements in technology have been able to provide DVRs based around low-cost computers, in part because at the heart of the DVR is the low processor power MPEG-2 video format. Integrated DVR cable and satellite systems require even less computing power to operate because the cable and sat systems are already MPEG-2 based. In this case, a DVR system would just have to copy the data stream to the internal drive rather than encode and decode the video. With its current reliance on MPEG-2, the DVR's convergence with HDTV is inevitable. While high data rate MPEG-2 will be utilized in the first HD-DVRs, the video capturing elements will remain fundamentally the same as SD units. To be effective and successful, HD-DVRs will need the ability to receive and control terrestrial, cable and satellite sources. There also needs to be ample HD content available. Currently, there are very few HD recording devices on the market. Because of this, HD-DVRs will become more of an asset with HD consumers. New rewritable HD disc players will inevitably come on market but they will be limited by record length, media costs, and will primarily be used for archival purposes rather than mass recording.

4.3.3 – Video-on-Demand

Offering a new take on personal digital recording is Video-on-demand. While this system does not actually record video programs for future viewings, it is very similar to the DVR concept. Unlike the DVR however, it uses a remotely located central server system to hold various pre-recorded programs that are available for viewing (Mitchell, 2003). These programs can be retrieved at will, giving the user instant access to the content. Video-on-demand operates much like the viewing of archived streaming media on the Internet: allowing the delivery of media to a consumer's screen at their command. This system can be seen as a kind of multicasting, offering a wide range of available programming broadcast over a single channel. Video-on-demand is the ideal of what electronic content delivery can be. It offers the convenience of physical media, while offering the simplicity and speed of electronic media.

4.3.4 – Video-on-Demand Requirements

The process is based on the user controlling the playback of their video image on a service provider's central server. Video-on-demand allows for full flexibility in playback control for the user. Because of this bi-directional communication the system is currently limited only to hard-wired systems such as cable and IPTV (Christie, 14). While video-on-demand has started to make its entrance into some SD cable systems, vast infrastructure improvements are required. As it is being

designed from scratch, IPTV has the luxury of being able to integrate video-on-demand into its system from the beginning. Unfortunately as previously mentioned, IPTV systems are currently restricted by available bandwidth, so video-on-demand is still primarily seen in cable environments outside of the few IPTV test systems. While the services are limited, supporting cable providers are offering approximately one thousand hours of programming for instant access playback (Dickson, 20). Video-on-demand is currently progressing into the mainstream of SD cable systems therefore it is inevitable that it will transition into future HD cable systems. Video-on-demand will be integrating with cable more in the coming years and with HD as a new medium, it is only logical to see HD Video-on-demand in the near future. If consumers upgrade to HDTV and want to view premium content without having to buy into the physical media expenses, when it becomes available, Video-on-demand will be a very viable option.

4.3.5 - Limitations

Technical limitations are preventing the integration of Video-on-demand and satellite services. In response to these limitations, satellite providers have been actively pushing the integration of satellite receivers with DVRs. While DVRs cannot provide a random on the fly playback of content, they can offer a user-customized viewing experience. Both systems offer personalized viewing choices and ease of use, they also have simple upgrade paths within HD systems due to their reliance on MPEG-2. The fact that DVRs and Video-on-demand systems are taking

the place of HD recording devices is a reassuring thought to content providers. These devices are limited in the portability of their content, so that the media will be for the most part, limited to playback on the machine that recorded it. This not only lets users exercise the majority of their fair use rights, but also keeps the media in a relatively secure environment that does not allow for much copying (Baumgartner, 36).

4.4 – Physical Media

Physical media are tangible formats that are transportable and modular. It has been the traditional transport medium of choice since the beginning of the home entertainment revolution of the 1980s. Historically, physical media has allowed the user more control over how, where and by whom the media is viewed. It has also been seen as a more secure form of media in terms of ownership and fair use. Currently there are two main styles of physical media that are designed to hold recorded HD material: magnetic tape and optical disc.

4.4.1 – Magnetic Tape

While magnetic tape was an essential element to the rise of home entertainment in the 1980s and 1990s, there doesn't seem to be much demand for it in today's consumer HD marketplace. The most famous example of Magnetic tape was VHS. JVC invented VHS in 1976, resulting in one of the most popular video formats ever (Winston, 128). JVC made an attempt to get VHS tape based media in the HD realm

by offering a digital VHS tape system. This format did not succeed, however, while one could buy a D-VHS recorder for $1000, there was little, if not any, support for it from content providers. In the no-limits professional marketplace, magnetic tape is the format of choice. However, with professional level HD playback devices costing on average, over $50,000, the costs are prohibitively expensive for consumer interest.

4.4.2 – Optical Disc

Optical discs provide more flexibility in content, special features, and overall economy in regards to manufacturing and distribution when compared to tape. The most successful of optical video disc formats is the Digital Versatile Disc or DVD. Released in early 1997, the DVD was the first consumer video disc format based on digital technology (Yoshida, 1997). DVD uses a multiplexed standard definition MPEG-2 stream at an average data rate of 6.5mbps. The result is one of the best standard definition pictures ever available to the consumer (Pevere, 1999). Through cheaper media, hardware prices and overall aesthetic quality the DVD became the enthusiasts' format of choice. In the subsequent years leading up to early 2000-2001 the DVD became a hit among the public (Entertainment Wire, 2001). After three years on the market, DVD prices came down to the mainstream. Enticed by the DVD's low price, clear picture, and the disc's bundled extras, DVDs have constantly out sold video tapes every year since 2003 (Garrett, 1). DVD is considered to be the replacement for VHS (Netherby, 1). With this immense

popularity it was inevitable that optical discs would make it to the HD realm. The demand for HD caused various technology providers to start laying out the framework to create a high-definition video disc.

4.4.3 – Optic Advancements

Due to the complexity of HD video signals, new technology was required for these HD discs, but consumer HD equipment needed to maintain a level of backwards compatibility in order to play existing SD DVDs. Advancements in compression and data retrieval widened the options that could be used in the new hardware, the biggest being blue lasers and MPEG-4 based compression. The blue laser produces a beam of light that can be focused much more narrowly than its red counterpart. This means that almost five times as much data can be recorded in a given space if read by blue lasers as opposed to red lasers. In the mid-1990s a practical solution was found for the manufacturing of blue lasers, bringing down the cost and making mass production feasible (Johnstone, 1995).

4.4.4 – Compression Advancements

The other new advancement was in compression. Since the standard was finalized in 1994, MPEG-2 has been the staple codec in both the broadcast and consumer content-delivery industry due to its compression ability, speed, and international compatibility (MPEG, Achievements). The compression amount of MPEG-2 can be demonstrated through its processing of the HD broadcast signal, which at 19.2mbps

is over 85% smaller than HD's 1.4Gbps uncompressed data rate (Wiseheart, 2002). While MPEG-2 uses a lossy compression scheme, the differences are negligible in most consumer applications. In addition MPEG-2's speed allows real-time compression using very simple equipment, which keeps processing costs down. Moreover, the fact that MPEG-2 is an international standard means that very little has to be changed in the encoding process in order to distribute the content around the world. All of these factors have contributed to making MPEG-2 the codec of choice for DVD, digital video recorders, digital satellite, digital cable, and high-definition broadcast systems. While MPEG-2 was chosen as HDTV's terrestrial broadcast medium, it is showing its age. MPEG-2 was never designed to be used in such complex environments as it is today (Tong, 1997). Because of its simplicity, the format requires minimal hardware for encoding and decoding high quality images in real-time. In 1996 when the average computer could only handle around 300 million instructions per second, the idea of moving to a more complex codec was unheard of. Nevertheless in HD, MPEG-2 files are rather large especially when compared to today's Internet based HD codecs, which can yield equivalent results while utilizing a fraction of the bandwidth.

4.4.5 – MPEG-4

First introduced in 1998, MPEG-4 was designed as a replacement to MPEG-2 (MPEG, What is MPEG-4?). While there are many parts to the MPEG-4 standard, Part 10, advanced video encoding (AVC) is very relevant to how MPEG-4 processes

high-definition visuals. It uses an encoding method that requires considerably less space than MPEG-2 at the expense of increased processing requirements (Shaw, 29). The codec features other elements of expandability and flexibility not found in MPEG-2, such as scalability, metadata, streaming, and support for efficient data rates (Cole, 1997). While still an international standard, MPEG-4 has been integrated into various proprietary formats such as Microsoft's Windows Media, and Apple's Quicktime. The downside is that MPEG-4 requires much more processing power in order to process high quality in real-time. While this can be done today, the components required to do so are much more costly compared to those required for MPEG-2 compression.

4.4.6 – The DVD Forum

Building off of the success of the DVD, manufacturers wanted to get an early start on creating a high-definition disc format for the consumer market. While no one group would oversee these developments. Most hardware manufacturers looked to the DVD Forum as an unofficial governing body. The DVD Forum is the organization that was charged with establishing and maintaining the DVD standard. Founded in 1995 the DVD Forum is made up of over 230 hardware and content providers (DVD Forum, FAQ). Every major corporation that is involved with the creation of DVDs is a member of the DVD forum. If the industry could have agreed on a standard for High-Definition DVD early in the developmental stages of the product, a costly format war could have been avoided, but this was not the case. By

mid-2003, five different options for a forum-supported high-definition disc were proposed for consideration. Of the five formats submitted, two, The Blu-ray and HD-DVD (at the time called the Advanced Optical Disc) had major hardware and studio support. Because of this industry support the two became the most likely candidates for standardization.

4.4.7 – Blu-ray

The core of the Blu-ray group is made up of almost a dozen major hardware and content creators, all of which are also members of the DVD forum (BDA, Supporting Members). The first prototype Blu-ray disc was released in February 2002. The medium is based on a dual layer 12cm disc that will hold an average of 25GB per layer. The physical components required for a Blu-ray disc are different from a classic DVD disc (BDA, Blu-ray Disc and DVD). Because of this, disc fabrication equipment needs to be upgraded for Blu-ray disc production. Blu-ray discs have a data depth of 0.1mm as opposed to 0.6mm for legacy DVDs. The 0.1mm data depth allows for more storage area on the disc surface. The discs will be contained within a plastic cartridge to keep the media surface as clean as possible. Sony released a Blu-ray unit to the Japanese HD market in early 2003 (Japan Economic Newswire, 2003).

Figure 4.1 – Major Blu-ray Group Members

	Country of Origin	DVD Forum Member
Panasonic	Japan	Yes
Philips	The Netherlands	Yes
Samsung	South Korea	Yes
Sony	Japan	Yes
Thompson	France	Yes
Twentieth Century Fox	United States	Yes
Walt Disney	United States	Yes
Warner Brothers	United States	Yes

4.4.8 – The HD-DVD

Shortly after Blu-ray's initial debut, the HD-DVD was first announced to the public. Designed by Toshiba and NEC, the HD-DVD closely resembles the current DVD disc that consumers are used to. Like legacy DVD discs, the HD-DVD utilizes a data depth of 0.6mm, which allows existing replication equipment to be used in the creation of the discs with only a minimal retooling. With a capacity of 15GB per layer, the storage space is almost half that of Blu-ray but can still hold sufficient HD quality video encoded video using a dual-layer format (Newmerique, HD-DVD).

Figure 4.2 – Blu-ray vs. HD-DVD vs. DVD

	Blu-ray	HD-DVD	DVD
Data Depth	0.1mm	0.6mm	0.6mm
Laser Type	Blue (405nm)	Blue (405nm)	Red (650nm)
Video Encoding	MPEG-2, AVC, VC1	MPEG-2, AVC, VC1	MPEG-2
Audio Encoding	Dolby Digital +, DTS HD, PCM	Dolby True HD, Dolby Digital +, DTS HD, PCM	Dolby Digital, DTS, MPEG Audio, PCM
Disc Caddy	Yes	No	No
Storage Per Layer	25GB	15GB	4.7GB
Highest Display Option	1080p	1080p	480p

There are similarities and differences between the formats. Both will offer re-writeable formats shortly after their public release, both use blue laser technology, and both support the MPEG-2, MPEG-4/AVC and SMPTE VC-1 codecs. On paper, the similarities between the two formats are apparent, but while the HD-DVD is more of an evolution of the existing DVD format, Blu-ray appears to be more of a revolutionary format. This is not necessarily and advantage for Blu-ray. The format's 0.1mm data depth and the use of a disc caddy offer technical and physical differences compared to the HD-DVD and legacy DVD formats which dramatically add to the production costs of the Blu-ray format.

In November 2003, the 230 members of the DVD forum voted to put their official support behind the HD-DVD (DVD Forum, Member List). It was now the DVD forum's goal for all of its members, including those in the Blu-ray group, to embrace the HD-DVD.

Figure 4.3 – Major DVD Forum Members Supporting HD-DVD

	Country of Origin	Blu-ray Group Member
Microsoft	United States	No
NEC	Japan	No
Paramount Pictures	United States	Yes
Sanyo	Japan	No
Toshiba	Japan	No
Universal Pictures	United States	No
Warner Brothers	United States	Yes

4.4.9 – Format War

With the hundreds of millions of dollars invested into the Blu-ray format by its creators, it was not a simple task to cease operations and switch to HD-DVD. As the Blu-ray group is made up of almost every major DVD player manufacturer, the group decided that it was in their best interests to run the format in competition to HD-DVD. The Blu-ray disc had spent more time in development than the HD-DVD, already having working second and third generation Blu-ray prototypes shown at

events around the world in the months following the DVD Forum announcement. Both Blu-ray and HD-DVD units have begun entering the American markets since mid-2006, but initial offerings have been limited due to complications with anti-piracy software implementation (Consumer Electronics Daily, 2004). This competition is causing a format war between manufacturers poses an interesting dilemma: the Blu-ray group has support of the vast majority of studios and hardware manufactures, while the DVD Forum has hardware and fabrication support. This format war could lead to three short-term outcomes.

Traditional format war. In this eventuality, HD-DVD gets enough studio support to offer a reasonable title catalog with the exception of Sony owned, Columbia Pictures and any other Blu-ray loyalist studios. Consumers could only buy HD-DVD players from Toshiba and a limited second-tier manufacturers. At the same time, Blu-ray content will be from Columbia and other supporting studios and offers players from a number of different brand name manufacturers. Survivability is determined by the market demand. Due to the manufacturing costs, HD-DVD should be noticeably cheaper to produce and in turn should offer a lower street price than Blu-ray. Most consumers would take a "wait and see" approach until one format was deemed a safe investment.

Laserdisc relationship. This scenario has HD-DVD and Blu-ray growing together and sharing the marketplace. With Blu-ray's disc capacity at almost twice that of

HD-DVD, higher data rates could be used with Blu-ray marketing it as more of an enthusiast's format over HD-DVD. While HD-DVD currently has enough studio support, the majority of studios could produce content for the lesser quality format. HD-DVD is technically a lesser-quality format than Blu-ray it still offers a higher bit-rate than terrestrial HDTV. Blu-ray being sold as a premium format could offset its higher manufacturing costs but as premium formats go, they will never be as economically viable as the common formats.

Hybrid relationship. The members of the Blu-ray group also make up part of the DVD forum. Not wanting to lose out on the next generation video disc revolution, but not wanting to kill off their format either, it is possible that the manufacturers could make Blu-ray enhanced HD-DVD players. These dual-format players could play both HD-DVD and Blu-ray discs. Unfortunately hybrid players require electronics to decode both formats that would keep prices high and in turn limit interest.

Whatever the result, the disc format war does two things. It makes consumers apprehensive as to which format to buy into because they do not know which format will win out. It may also push consumers toward the electronic HD media sources offered by cable and satellite companies, in order to get HD content without committing to one disc or the other. Because of this potential loss of sales, the current format war could hurt the physical media industry as a whole.

4.5 – End Remarks

With the mass implementation of MPEG-2 and now, MPEG-4/AVC and SMPTE VC-1 for HD content combined with the digital video infrastructure on devices; the question may no longer be which format looks better, because all formats may in fact look closely the same. The comparisons instead may begin to focus on a format's supporting media factors such as ease of use, price, and bundled features. With this in mind one can see that in an equally matched environment, physical content delivery mechanisms will have an advantage early on. Where costs are less and the delivery infrastructure is not limited by a home's bandwidth. Unfortunately, in the current environment we're seeing that the format war between physical formats is hindering the medium significantly. The physical media format war and copy protection stumbling blocks have allowed electronic media to gain in the marketplace. With more advanced Video-on-demand systems coming in the near future, the physical media industry need to settle their internal battles or risk being marginalized entirely by the electronic content delivery systems.

5

POLITICS AND SOCIAL APPREHENSION

The dilemmas facing America's transition to digital television are social as well as technology related. With the high costs involved and initial limited public availability, consumers are naturally apprehensive about this digital high-definition television. Politics are also a concern, not surprising, given the amount of money involved. Political issues include everything from the authorizing of the radio spectrum for digital terrestrial broadcast to maintaining fair use while hindering piracy. This chapter will look at some of these issues in detail, as well as address the social apprehension of consumers.

5.1 - Price

The public's primary concern about switching over to HDTV is cost. It has been discussed that in its early years, HDTV will be expensive while offering relatively little content as compared to existing standard definition broadcasts. This is further complicated by the economic climate of the United States, which has changed significantly since the federal mandate was proposed in 1996.

5.1.1 – Historical Trends

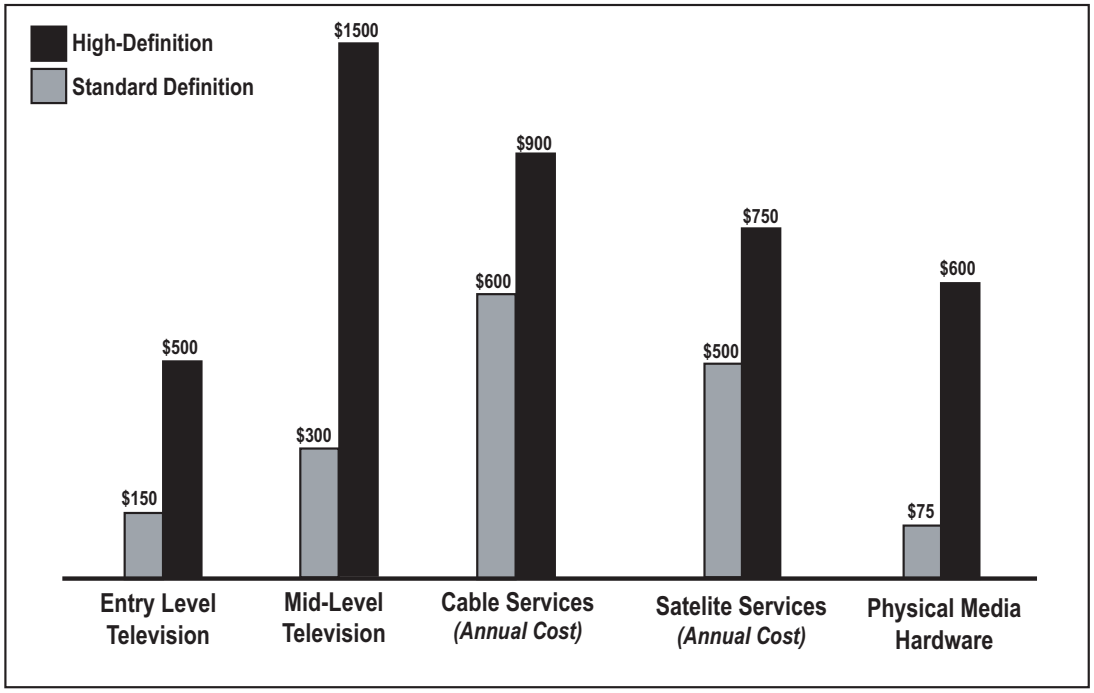
Looking back at previous American technology transitions it is not surprising to see a trend of delay with the adoption of HDTV. The publics has to first trust, and then embrace a new technology before it can be fully accepted (Gentile, 2006). Trusting that the format does not disappear from store shelves and that it will last long enough for consumers to get sufficient use from it is a difficult step for the general public to take. While at the same time, consumers need to be swayed to embrace the new technology by understanding its improvements and how it will impact their lives, and whether or not the technology will make them better. The difference between trusting a technology and embracing a technology determines not only its success but also its longevity in the marketplace. Once American consumers do accept a technology it is often times difficult to find a successful future replacement for it.

5.1.2 – Unknown Need

The average American consumer does not know why they would need a new digital TV set, and many are happy with their current ones (Weber, 1). This is a hard sell that the electronics industry has fared with. A difficulty that is compounded by the fact that consumer interest will be restrained until substantial content is available in the marketplace. American consumers only began to make the transition to DVD after the format had been out for three years, gone through a format war, offered over ten thousand titles, and players could be had for $100. Looking at what it took

for an accessory of NTSC television to be accepted by the public, we can see the potential skepticism American consumers are displaying toward HDTV. HDTV equipment costs many times that of the DVD equipment, initially offering very little content, all the while having a physical media format war. Not to mention the American populace have just spent their "risk-money" on a DVD player, thereby making it tough to take a chance on another new, expensive technology. Especially when the last technology, DVD, already looks and sounds better than what they had been used to. What hardware providers have learned from this, is that since consumers are always weary of spending money on a new or emerging technology, they need to present a viable future with an immediate payback of entertainment value. While the initial ten-year digital television switch over has proven all but a failure, prices have still not come down to a point where the general public would want to risk their money. Prices have come down enough where the more affluent portions of the general public can make the transition to HDTV. However, the investment required to start receiving HD signals on an HD compatible monitor is still far beyond the reach of the vast majority of American consumers.

5.1 – Estimated Costs HD vs. SD



5.1.3 – Common Requirements

What the general public is looking for is a Kmart HDTV solution. The ability to walk into a store and spend $200 or less on a fully-functional HDTV of average quality, and have the ability to plug the set into their homes either via cable or antenna to begin receiving HD content regardless of where they are located (Sorkin, A-10). For the average American, the television set is an important part of the household but it is in no means considered to be an icon of visual aesthetics, nor is it anything to be intimidated by. Today's HDTV is still geared toward wealthy enthusiasts, with a precedent on quality and aesthetics gearing toward the home theater market rather than a low-end stand alone (Liberman, 4B). While we are still

away from the days of the low priced, low build quality HDTV sets, prices have been gradually dropping over the years.

5.2 – Digital Usage Rights

5.2.1 – Rise of Piracy

Monetary issues are not the only concerns surrounding HDTV. The industry's content and hardware providers have slowed their HDTV development while adequate anti-piracy solutions are implemented (Tarr, 1). Since the inception of digital media, unauthorized duplication has been on the minds of content providers. Whereas before in the analog realm, copying suffered a generational loss in quality: thereby making copies that were not as good as the originals. In digital media, exact copies can be made without any quality loss. Furthermore in the analog days a pirate's distribution means were severely limited to expensive large-scale operations. Today with the advent of broadband and personal file-sharing networks the perfect copies can be sent anywhere in the world in just a matter of minutes. High end video codecs allow for making near-perfect copies of digital content, that only take up a fraction of its original size: piracy is the top concern in digital content security (Westbrook & Vuong, 1).

5.2.2 – Copy Protection

Since HD content is a high-resolution digital medium, content providers do not want to make any large-scale releases without an anti-piracy mechanism in place (Ryall,

2006). Anti-copy systems are nothing new, the first started showing up in the retail sector with the VHS home video market. Macrovision is the primary anti-copy system in the home video market (DVD Newswire, 1998). It is also used as the anti-copy solution for the DVD video standard. The easiest solution to combat piracy is to not allow for any copying. But under the guidelines of fair use, this is not possible under current US copyright law. It states that consumers are allowed to make a limited use backup copy (Gross, Understanding your Rights). This has been at the center of HDTV's debate in recent years. According to fair use laws a single personal copy is allowed, but much of modern digital technologies prohibit the creation of digital copies.

5.2.3 – Analog Piracy

Recent digital advances have brought the growing issue of piracy to the forefront of the medium. In the days of VHS, consumers could make copies of movies, TV programs, and sporting events for friends and family with little impact on the industry. These copies were in usually poor condition, suffering not only from VHS's poor recording quality but also from the generational loss that analog recording creates. Because of this, a VHS copy would not be a reasonable alternative to buying an original or going to the cinema. The only major threat that impacted a content provider's bottom line came from large scale bootlegging operations, which while creating a less than perfect original were large, complicated,

and expensive to the point that they could not pose a critical threat to the content providers.

5.2.4 – Digital Piracy

With the advent of digital media, the pirated copies rivaled the equivalent look and feel of the originals. The nature of digital imaging means that the content can be represented in terms of ones and zeros. Rather than traditional analog forms based on voltage and physical means, which can degrade from one copy to the next. Perfect quality digital copies are both a good and a bad thing. It is great for consumers who wish to make an identical copy to backup their media. However it also makes illicit copies yield the same qualities as the legitimate ones. With HDTV the threat of bootlegging was even greater. Since HDTV yields a picture quality that is several times greater than standard SDTV, very high quality bootleg masters can be created from HD source material. This, combined with the access people around the world have to ever increasing computing power and internet bandwidth the ability to distribute studio quality bootlegs has been easier than ever (Phillips, 2003). The latest fear of piracy has been coming from consumers rather than the bootleggers and street vendors. With broadband's increase in availability, the growth of peer to peer file sharing has skyrocketed. Peer to peer networks allow users to exchange files with one another. The problem is that the vast majority of the files are copyrighted digital content. Through digital compression these files retain comparable quality to the originals. With broadband's ever growing presence in the

United States the peer to peer piracy of HD quality content will become more and more of a reality.

5.2.5 – Fair Use

Threats of piracy have left the content providers in a dilemma: how best to restrict unauthorized viewings of content, while at the same time allowing for a consumer's fair use of the media. The best solution for content providers would be to have full-control of the media distribution channels. However that not only would not only be against fair use stipulations but would not be very appealing for consumers. The content providers lobbied the United States congress in 1998 to pass the Digital Millennium Copyright Act (The Computer Lawyer, 30). Among other things, it gave the power for content providers to defend against groups and individuals that the providers see as not falling within the guidelines of fair use (Krim, E04). This sounds like a reasonable solution. The only problem is with the growth of modern technology, no one has really defined what modern fair use is. The previous legal discussion of fair use was at the beginning of 1984 at the time of the Betamax-MPAA Supreme Court verdict (Grier, 3). It was determined then, that consumers have certain rights when it comes to their usage of media. Namely the ability to transport content as well as allowances for personally created backup copies.

According to copyright law, when a consumer purchases a piece of media for personal use, they are not actually buying the media itself, but a contract allowing

for the use of the media (Siegel, 2004). Traditionally consumers were allowed to make backup copies as long as they were solely used for backup purposes. Ideally these personal copies were to be used only in the case of the original media failing: but never at the same time. Throughout the analog media years fair use violations were never a pressing issue. Even if consumers were making illicit copies for friends and family members, the content providers could rest assured that the copies in question would be of a lesser quality than the originals: still allowing for an obvious benefit to purchasing the media outright. With the digital revolution this has changed, not only are copies exactly the same as their sources but content providers also face the threat of illegal mass distribution.

5.2.6 – Anti Piracy Techniques

With this multi-billion dollar dilemma facing the content providers, some are looking to re-define fair-use. Fair-use for digital media is scarcely defined. The threat of exact copies is too great of a threat for the content providers to deal with. With the introduction of modern media, the fair use of a legal backup is being restricted. This combined with the growth of illegal distribution through the Internet, and legal backups as we know them today will unlikely be a part of the next generation media. With fair use in question the content providers have come of with a series of proposed compromises that could allow for a form of fair use. These compromises attempt to force consumers to adhere to the bounds of fair use,

limiting much of the flexibility consumers have been used to. Unfortunately for the consumer, often times the content providers end up restricting actual fair use rights.

One example of this practice is the pairing of content to a specific device. The concept is that if a piece of media is paired to a playback system it cannot be paired with any other devices. This concept is designed to work primarily with short-term recording technology such as digital video recorders and on demand services. This system enforces a consumer's fair use by not letting the media be distributed to any other playback devices. Unfortunately, this may also limit the media from being played back on another device in the consumer's household such as a TV set in the bedroom. Another proposed method is the use of a Broadcast Flag. A flag is a piece of code that is included in the video signal, that talks to your recording devices and verifies not just what programs can be recorded, but to which media they can be recorded to or if they can be recorded at all (Tarr, 2004). Fair Use advocates feel that the Broadcast Flag goes to far and impedes consumers' rights (McConnell, 8). Both of these solutions are still in experimental stages and have yet to be widely enacted.

5.2.7 – Provider Controlled Content

Copy protection illustrates a fundamental issue within modern digital content politics: who ultimately controls the media? In the analog and early digital eras, the ultimate control rested with the consumer. Once the media was purchased, the

consumer could use it as they pleased, wherever they wanted, and could view it whenever they wanted. Proposals for increased content provider control have been met with much skepticism from consumers who demand unchanged full access to their purchased content.

Video-on-demand takes a new approach to the fair-use dilemma. Incorporating digital media with broadband distribution, video-on-demand does away with purchasing tangible media all together. In exchange for a fee the consumer has full access to the provider's media library. This offers a unique compromise in the hot topic area of digital rights. Consumers have to give up the concept of buying media and, in a sense, move into a lease-based viewing mindset. Whereas content providers will need to give full access to consumers who will be watching what they want when they want and however many times they want. In an ideal video-on-demand setting the provider would offer their entire library, this would be very appealing to most consumers. At the same time however in order for full acceptance by consumers they will need to feel as though they are in control. If, for instance a content provider were to suddenly change the availability or limit access of its lineup, the consumer would feel as if they no longer controlled the content.

5.2.8 – Potential Solutions

What is needed is a hybrid solution that satisfies the securities of the content providers while still providing a reasonable flexibility for the consumers. This

flexibility in usage is very important for consumers as it allows them the feeling of being in control. Whether they are fully in control or just operating inside the bounds of fair use will be an issue, however, if consumers only have to worry about playback and operation of the media rather than usage restrictions and limitations, then modern day solutions may be a success. In order for a system to satisfy fair use guidelines and media conglomerates' bottom lines, portability and archival mechanisms must remain for consumers to retain trust in the media. However, the system must be robust enough to limit piracy and unauthorized distribution. Finding the right balance will be the challenge.

5.3 – Media Ownership

Media conglomerate control is a large factor in today's advanced televison's politics. Not only in the realms of content and distribution but also because the majority of major content providers have direct connections to consumer-electronics manufacturers.

5.3.1 – Content

Today's content, be it television shows, compact discs, or movie features are all created from within a corporate culture. While some content providers have more creative freedom than others, the bottom line is that any product is made or distributed under the watchful eye of a parent company. Most of today's media conglomerates have business is other non-entertainment related fields (Mermigas,

12). Many times the content produced needs to reflect all of the parent companies interests in a good light. The positive side to this is that with the conglomerate producing, distributing, and advertising the content, the workflow is easily defined. Take for instance, Universal Pictures, along with having several smaller studios under its banner it has controlling stakes in the NBC television network, a number of smaller cable networks and local affiliates as well as partnerships with Microsoft. Universal's parent company is General Electric, which has stakes in everything from Nuclear Reactors and Aircraft Engines to Blenders and Light Bulbs. In the eye of the corporate media enterprise, content is not entertainment or an art form, but a product to be bought and sold. While this may seem obvious to a degree there are unfortunate side effects of creating content, which is profitable as opposed to content that will better society (Holson, 2005).

5.3.2 – Effects on the Market

A physical media format war is looking very likely over the next few years. These format wars could be made worse by the involvement of content providers only supporting their technology partners companies. The infamous Betamax versus VHS videotape format war of the early 1980s taught consumers that the only thing guaranteed to come out of a format war was uncertainty. Twenty years later a potential format war between HD formats, fought by giant media conglomerates which not only own the electronics companies that build the hardware, but also the studios that develop the content, and even the media outlets that manage the

commentary about the new technologies. This could lead to a worst-case scenario where in a competing format market we could have various providers supplying formats that are exclusive to each other. You can be sure that Columbia Pictures movies will be distributed by whatever format that Sony develops as it would be in the best interests of its parent company, Sony Corporation. Following that line of thought it would also be strategically wise for Columbia Pictures to not release anything on Sony's competitors formats as it would also be in the parent company's best interest.

5.3.3 – Access

The corporate content providers have established distribution paths as well as sales mechanisms to get their products to consumers. One of the biggest driving forces behind consumer purchased content is the concept of flexibility in media. This is the concept of a consumer having free reign to do what one wishes with purchased content with in legal limits such as watching a DVD at another house or using a music track in a video postcard to a friend or family member. These flexibilities in copyright law are in a legal gray area of what constitutes fair use. This allows consumers to worry about how they can utilize the media rather than the semantics and limitations of where or how they can use the content. With the aforementioned rise in digital and Internet based piracy, content providers have been imposing further restrictions on the usage consumers have in regards to some of the gray areas of fair use. As media conglomerates try to get the most revenue out of their products

they are looking to restrict access or charge for increased flexibilities. The other element of corporate control of media providers is how they could seemingly limit the distribution of content. As most major media conglomerates own the media distribution and sales channels for produced content it would be very easy to limit availability of content, which would be deemed unacceptable or could hurt the corporate image.

5.4 – End Remarks

There are a number of potential problems facing the general public when it comes to switching to advanced television. Digital media in general, represents a warning in how the American public treats their usage rights. The average consumer feels as though they should have full control to use their purchased digital media in any way they deem reasonable. The content providers, however, in the interest of combating piracy, feel that the usage should be limited to a much more restricted feature set.

6

OUTLOOK

The long-term future of digital television in the United States is very good. Congress has mandated the transition from the current analog system and there are plans to supplement this by offering subsidies to those who cannot afford the initial switchover expenses. Even with this assistance, however, digital television's timeline is very unclear. The public's lack of trust in this relatively unknown future staple of American life has slowed the transition greatly. This chapter will analyze the American switchover itself, in order to understand how the HD transition paradox can be broken.

6.1 – Infrastructure

6.1.1 – Upgrades

As has been mentioned before, one of the main stumbling blocks of the acceptance of advanced television is the fact that every part of television's infrastructure must be upgraded to allow for the country's transition. The main reason why the infrastructure must be upgraded is that it is designed to work on a system of digital transmission rather than the current analog standard. In addition, television's radio

spectrum is currently being altered. Switching to a digital method of transmission does makes far more efficient use of the signal, but HDTV requires much more data than standard transmissions. Since the existing analog spectrum cannot be expanded without stepping on surrounding reserved frequencies, a new portion of the radio spectrum was assigned to digital television. All of this means that equipment needs to be radically upgraded on both sides of the signal.

6.1.2 - Broadcasters

Because there was no financial hardware subsidy included with the 1996 congressional mandate, the HDTV process has been proceeding much more slowly than was originally expected (Davidson, 66). Currently, although television stations in major market cities have been broadcasting free over-air HDTV for some time, the smaller markets took an exceedingly long time transition. Budgets are tight in small television markets and since every upgrade is actually a full-out replacement, the overall costs can easily spiral into the millions of dollars. This is too much for many small stations to afford. In the case of affiliate broadcasters, this also means that in order to make a total transition to HDTV, stations will also have to replace not only the transmission equipment but also their production facilities, cameras, internal switching and recording hardware.

Most large market broadcasters and networks are or will be exercising HDTV to its full capability. The majority of smaller-urban and rural stations, on the other hand,

are struggling to upgrade to the bare minimum. The minimal upgrade being the sole addition of digital transmission equipment now, then opting for additional changes for production and news facilities later on. This minimal upgrade allows for the broadcaster to meet federal requirements for digital broadcast, albeit in 480p quality. Another issue broadcasters are facing is the availability of HD content from non-network sources. While Networks have done a good job in producing HD content, they only fill only a portion of a day's programming slots. Broadcasters will have to come up with a mass of HD programming on their own (Srinivasan, B5). Eventually everything, from local news, to first-run syndicated programming and even local commercials will have to be in HD.

6.1.3 – Premium Sources

Although cable and satellite companies are not mandated by the government to upgrade to HD, it is in their best interest to do so. Cable and satellite are considered to be the premium broadcast options, and thus it is not surprising that HD's early adopters are likely to be subscribing to one of these services (Taub, 1). Premium entertainment sources are viewed as an upgrade to terrestrial television, so it is important that the quality be at or above that of terrestrial television. In order for cable and satellite to maintain their premium stance, they will need to have a better HD presence than traditional terrestrial high-definition television. As the battle for premium-broadcasting viewers heats up, HD will be a central focus point in home entertainment.

Cable and satellite providers face the same problems as terrestrial broadcasters in terms of upgrade expenses. Although they do not have to worry about terrestrial transmission equipment upgrades, they do have to update the signal paths into households. Cable and satellite each face unique issues in upgrading their signal. For cable, the physical infrastructure must be upgraded. This means the signal generation equipment, the transmission lines, and the consumer-side converter boxes (Sabatini, C-1). For satellite providers, this means potentially launching new satellites into orbit or buying space in existing satellites. Both systems can also experiment with advanced compression techniques, however this will require new equipment in the client side. Although since equipment upgrades will be necessary for an upgrade to HD, it should not be much of a stumbling block.

6.1.4 - Cable

Cable has begun the process of switching to HD by first upgrading to a digital transmission system, which entails updating their regional operation centers and transmission infrastructure as well as client-side decoder equipment. Since modern satellite television was designed around digital transmission it does not need a transmission upgrade. Because cable and satellite each have a fixed amount of bandwidth available, their goal is to maximize efficiency in using available bandwidth (Grebb, 2006). Client-side decoder boxes are a benefit for satellite providers because typically the consumers had to pay for the equipment whereas

cable companies lease the equipment to consumers. While both cable and satellite are in good order in terms of maximizing their HD content loads, the dilemma of maximizing efficiency in a limited space remains. It is estimated that on MPEG-2 based systems a single high-definition channel uses the same amount of bandwidth as four standard definition channels. Although they have been working on maximizing efficiency within their delivery, cable and satellite companies have been offering minimal HD channel lineups which pale in comparison to their SD offerings. Two different routes are being explored to alleviate this problem. Physically increasing the total amount of bandwidth and using new data compression mechanisms such as MPEG-4 to greatly increase the efficiency of available space (Business Wire, 2006).

6.1.5 - Satellite

Satellite companies will be using a combination of the two options. Adding additional satellites as well as experimenting with new transmission codecs in lieu of MPEG-2. Voom media, a recently bankrupted HD satellite company, was using a variant of Microsoft Windows Media called SMPTE VC-1 that was geared for HD broadcasting (PR Newswire, 2004). For the last few years, cable systems have been upgrading the physical wire and communication infrastructure to homes. It is also very likely that both cable and satellite operators will switch to an MPEG-4 based video system in the next few years. MPEG-2 is a reasonable choice for now due to its low hardware processing requirements and the lack of HD programming in the

marketplace. Soon this will chance, in the coming years, every potential channel on American cable and satellite systems will need to offer a HD based replacement. These providers will need to be able to accommodate potentially over 200 HD channels in the next ten years. MPEG-2 will simply not be able to handle this in the existing bandwidth.

Since space is a concern, why are the premium providers not switching to an MPEG-4 based solution now? To answer this question one needs to look at their infrastructure. The genius behind the premium digital transmission systems is the use of their outboard converter boxes. Once the initial bandwidth has been established the cable and satellite systems can run whatever system they like and viewers won't know the difference. This is because these systems do not need to adhere to the terrestrial broadcast standards, which allows them to use newer and more efficient codecs to receive the signal. Converter boxes will make it easy for future system upgrades to HDTV. The downside is that there is an additional cost associated with converter boxes, either in monthly fees or outright purchase costs.

6.2 – Competitions

6.2.1 - Format Wars

Whenever a new video standard is announced, the hardware manufacturers go to work coming up with ideas for a format to accompany the new standard. The manufacturers work to find an ideal system that offers not only great consumer

benefits but will also provide an economic windfall for the company that creates a popular format. Typically more than one company will each create different formats that while similar in performance and characteristics are incompatible with one another. These can be created by anyone as long as they fall within the parameters of the given video standard. In a given market, each of the formats' creators will be vying for consumer support. Eventually the public sorts out what the preferred choice is in turn giving the market share and in turn, the mass earnings to the winning manufacturer and leaving the loser with nothing more than millions in wasted capital and a brief footnote in the annals of media history. Format wars are great examples of the economic theories in which consumers decide what survives in the market. The only downside is that in long and drawn out format wars many consumers may be left with equipment and media from the failed format. There have been several format wars in the arena of television entertainment. The VHS and Betamax from the 1980s is considered to be one of the worst. The end result of this bitter format war was that after several years the many millions of dollars spent by consumers on Betamax equipment ended up going to waste. This result left consumers very apprehensive to embrace new technologies when they are offered against competing technology. As is best illustrated by the public's reaction to the next consumer format war at the beginning of the digital media era between the DVD and DIVX technologies. The result was that little progress was made in the digital video disc market until the format war was settled. After two years the DIVX group declared the technology a failure (Pittsburgh Post-Gazette, W-1). The public

went on the embrace the DVD technology yielding some of the best sales ever seen in home entertainment history.

6.2.2 – How HD Format Wars are Different

HDTV gives us a new twist in the history of format wars. What is different in this HD format war is that much of it is occurring in the developmental stages of the technology. Because the government has mandated HD, its inevitability is guaranteed. Once the format was announced, the hardware manufacturers went to work developing potential content delivery solutions. The idea was that if there was a chance that the format war could get settled before the equipment gets to the mainstream production stages, consumers would be more likely to embrace the new technology.

6.2.3 – Blu-ray vs. HD-DVD

HDTV's physical media will be in the form of a next-generation DVD disc. What is not known at the time is what mechanism the disc will utilize. There are two contenders for physical HD media: HD-DVD and Blu-ray. Both have their pros and cons, and both offer similar performance. In the beginning of this format war, there was a very strong push for the manufacturers to resolve it before the formats arrived in the marketplace. While this ended up not happening actually happen, it is interesting to see that, to a degree, the manufacturers wished to avoid a format war if they could have. Settling on a single format would have raised consumer confidence

and would take much of the risk out of buying into a new technology. When there are competing formats in a marketplace most content providers will typically hold off on fully committing to a format until the format war has ended with a clear victor in sight. Many of today's content providers have strong partnerships with hardware manufacturers, with each one being inclined to solely support the format being offered by their partner company. While this plan does make it easier for content providers to choose sides in a format war, it also makes the issue of potentially ending the war altogether much more difficult.

6.2.4 – Benefits to a Swift Conclusion

The primary incentive to settling the HD physical media format war is that since HDTV involves a federally mandated transition there is no doubt that the base-system will succeed. If the manufacturers can agree on one format, it would allow for a much simpler marketplace eliminating consumer confusion. Overall, the lack of format wars greatly aide the overall advanced televison transition.

An early end to the physical media format war is the ideal result for all the parties involved. Each new format has billions of dollars in corporate funding behind it. Each of these corporations wants a return on these investments. Often each group behind each format with stay their course and wait for the opposing group to conceed. Who will win the format war? Only time and the market will tell. HD-DVD has garnered the support of the DVD consortium a group of the nearly 300

manufacturers behind the standard definition DVD. HD-DVD shares the same recognizable dimensions as the DVD disc: offering a hint of familiarly to the format. While Blu-ray also has major hardware backing it will have a harder time being recognized by the public. While Blu-ray ‘s larger capacity should offer a better picture, its disc-caddy design separates itself from HD-DVD and even DVD. Of course Blu-ray is also looking to be the more expensive option. The caddy system requires that new fabrication lines will need to be built. HD-DVD uses a disc of the same physical dimensions as DVD so it can use existing fabrication lines with minimal modifications: yielding a potentially cheaper initial starting cost. Both formats are expected to have recording capability shortly after rollout, but it will of course be dependant on where anti-copy technology is at in the industry. It is a good chance that the winner will be the format that not only offers the lowest price, but also offers enough content and supplementary features to build a foothold in the market.

6.2.5 – A Third Contender

There is another incentive for hardware manufacturers to quickly end this format war, the public’s acceptance of a third medium. A scenario of two battling physical formats so entrenched that consumers will be afraid to choose sides is not out of the question. This could allow for a third HD medium, video-on-demand, to come in and corner the market. Thereby opening up a new electronic versus physical media format war. As mentioned before, video-on-demand is an electronic playback

system where the media is displayed on a local monitor, yet the data resides remotely on a server. Even with the remote storage of the media, the viewer has full control of the content as if it were playing locally. Cable providers are introducing video-on-demand in select areas with limited available content. Yet the potential is there to give next-generation physical media a run for its money. It also has the benefits of being extremely cheap once the initial infrastructure upgrades have been made. On demand systems have amazing potential in the home entertainment marketplace. With an ideal system in place it could beg the question to consumers of whether or not they even need physical media at all.

6.3 – Costs to the Consumer

Americans have always enjoyed being on the cutting edge. They love the concept of owning the best, but they do not always want to pay to be there. The underlying solution to acceptance will obviously be lower prices. However, it remains to be seen what the best way to lower prices will be; keeping in mind that the solution needs to be worthwhile for both consumers, and industry.

6.3.1 – Hardware Pricing

With all of its new hardware requirements, HDTV proves to be an expensive option for home entertainment. In the end, the bulk of the costs will rest with the consumers. Homes will not only have to replace each TV in the household, but also their signal receivers such as cable and terrestrial broadcast for basic usage of

HDTV. Adding this cost to the costs of further upgrades for media playback is where we can begin to see the amount of money that will need to be brought forth to accommodate the full transition to advanced television.

6.3.2 – Content Pricing

Content delivery fees will continue to be associated with premium media services. Consumers are no strangers to these fees. Cable and satellite customers already pay content delivery fees for their services. Initially HD content delivery fees will be at a premium. Because the main consumers of premium HD content will be from wealthy demographics, there shouldn't be much of an issue with the higher fees at this time. Video-on-demand will introduce added fees; however, these are expected to be acceptable charges due to its additional content.

6.3.3 – Public Spectrum

One cost the American consumer does not traditionally associate with HDTV is the cost of granting broadcasters to use a new portion of our radio spectrum for free (Kerrigan, A17). With the passage of the 1996 telecommunications bill, regulations were put into place to give broadcasters free access to the new spectrum for simulating digital television broadcast signals. While at the time the plan to give the broadcast spectrum away seems a logical as the analog spectrum would be traded out after the ten-year transition. Unfortunately with the full transition looking to extend beyond ten years, the radio spectrum valued in the tens of billions of dollars

will remain free of charge for simulcasting until the public fully adopts digital television.

6.4 – Assisting the Transition

6.4.1 – Increasing Availability

One of the biggest drawbacks to HD at present is the lack of content. While there is HD content in the market, its availability is not even close to that of standard definition. Moreover, as a premium service, it is priced well above its analog equivalents. For the content to be a deciding factor in the public's choice to switch to HD, it needs to meet or exceed the existing offerings. This means offering local terrestrial broadcasting, cable or satellite with at least the "basic" level of channels, and a form of physical media, all in high-definition. The allocation of these services is heavily dependent on the proliferation of HD content. At the same time, these services must remain competitively priced to be a viable option to SD services. The pricing model currently seen in the marketplace is geared toward the affluent, as they are the only ones who can currently afford the full range of HD equipment.

6.4.2 – Transitioning by Default

The American general public is expected to begin actively adopting HDTV when prices drop to those at or near the levels of SDTV. Even if HD content is not available in the area, all newly purchased HDTV sets are designed to be backwards compatible with analog NTSC signals. While raw HDTV equipment sales figures

are good for the electronics industry, it does not represent the full progress of the transition. The real measurement of HDTV's success will be the sale figures and viewing statistics of HD content.

One thing that may assist in the transition is treating HD not as a luxury item, but simply as an option for replacement to SD. With set prices dropping, HD-ready televisions are dropping into more consumer-friendly price ranges. This allows them to be purchased simply as television set replacements, rather than as a new and exotic television set. While HDTV tuners are not compatible with existing NTSC systems, all HD sets are shipping with NTSC tuners as well. The inclusion of these tuners is providing an incentive for potential buyers. Backwards compatibility is helping to ease the transition by offering existing content on the new system. While it will not be of the quality of the new HD material, existing content can be played on the system, allowing a consumer's existing content library and hardware peripherals to remain in use. Because HDTV monitors can display NTSC signals, they will be able to display all existing hardware from Beta VCRs from the 1980s to today's latest progressive scan DVD players. This is arguably one of the best ways to increase the user base. Also, even if these sets are currently being used solely for viewing standard definition content, once HD becomes available, the switch necessary to move to HDTV will be as simple as changing a channel. Once HD-ready television sets are priced competitively, people will be more likely to buy

them, after all if the price is right, people will purchase the TV set that is with their budget no matter the feature set.

6.4.3 – Other Avenues

When you break the components down, a modern day HDTV set is nothing more than a moderately powerful computer paired with a high-resolution monitor. An interesting result of this is that HDTV could really be the start of a true integration between the computer and the television (Belsie, 3). The current owners of moderately powerful personal computers need only buy a HDTV tuner add-in card to receive over the air signals. Likewise we're seeing computers and HDTV sets with DVI and HDMI interfaces which in turn increase their compatibility. HDTV broadcast signals are simply encoded MPEG-2 streams played back on a computer out to a monitor. DVRs are nothing more than computers specially tailored to record and playback MPEG-2 video. The differences between existing computer monitors and HDTV monitors are very small, and both are capable of displaying each other's signals. Consumers are now watching high-definition video trailers downloaded on the Internet and DVR systems are now allowing for program viewing on a computer (Gubbins, 26). The Internet is received in home over cable lines. With its increasing bandwidth, the Internet will be a viable supplier of on-demand HDTV programming. The lure of HD entertainment on the personal computer may be another incentive for people to buy HD.

6.5 - Longevity

6.5.1 – Will ATSC Last Fifty Years?

One of the biggest concerns when switching over to a new broadcast format such as HDTV, is knowing how long the format will last. Looking back at NTSC's timeline of fifty years, we see that the format has adapted well to many technological changes. Will HDTV be able to do the same? This question needs to be addressed for both digital formats as well as for the transmission mechanisms. HD was designed to be the next NTSC, but with the ever-progressing technologies, is fifty years a reasonable goal for the longevity of the ATSC system? Technically speaking, the HD television format will be able to last fifty years. The real question, however, should be, will HD broadcast formats retain the quality to last decades into the future? With the nature of digital technology and its ease of upgradeability, I think that today's interlaced HD formats will likely be phased out over time either due to quality or bandwidth reasons. The terrestrial transmission infrastructure that digital television is introducing, however, will it be able to last the fifty years that NTSC has.

6.5.2 – Terrestrial Television

The uses and overall quality of broadcast television has not changed much in its fifty years: which is a promising sign for terrestrial HDTV's longevity. Moreover, as NTSC matured, the quality of the equipment improved on both ends of the transmission signal. Improvements to HDTV are certain to happen as well. As

impressive as the HD televisions are today, there are still many image and resolution improvements to be made within the broadcast standard itself. The can best be seen when looking at professional video hardware. The image quality, color reproduction, and overall resolution differences between a $2,000 HDTV set and a $50,000 studio broadcast monitor are very obvious (Sony, Monitor Specifications). The studio monitor adds improved color reproduction, resolution, and image processing. In addition, professional monitors are designed for a reference environment where money is not an issue. However, as both displays are designed for the display of high-definition signals, it illustrates that consumer grade displays have much room for improvement. This likelihood of improvements is demonstrated by looking back at the many advances that have affected NTSC through the Cable, Satellite, and Home Video offerings that offer an arguably better quality image than NTSC broadcast simply because they don't follow the same mechanism for distribution. ATSC will offer the same advantages using high capacity formats, better video codecs and direct high-bandwidth connections to TV sets.

6.5.3 - Codecs

One of the greatest challenges to the long-term viability of HDTV is the prolific use of MPEG-2 compression. MPEG-2 was chosen by the ATSC because of its low processing requirements and competitive image quality. Unfortunately, it is not very efficient when it comes to overall file size and, since its age is well into the double digits, its ability to cope in the future with ever demanding audiences will be

limited. Switching to MPEG-4, however, is one of the most viable options that will increase HDTV's longevity.

MPEG-4 is a video codec from the Motion Picture Experts Group. One of the main differences between MPEG-4 and the MPEG-2 codecs is that MPEG-4 was designed to be expandable and upgraded from its original implementations. MPEG-4 is also a more efficient codec in the sense that an equivalent quality can be attained in a fraction of the space MPEG-2 would use. While terrestrial systems cannot easily be upgraded, home entertainment systems can because the decoding equipment is provided within the device itself. MPEG-4 may be the solution to MPEG-2's lack of expandability in the area of home entertainment. The difference in quality between the two formats is similar to that between today's VHS and DVD formats. DVD quality is noticeably higher than VHS even though they use the same NTSC signal path. MPEG-2 and MPEG-4 signals are independent of the integrated tuner and therefore will not have to be restricted to the constraints of the standard. With its high bandwidth consumption, MPEG-2 is reaching the end of its lifecycle in the broadcast industry.

MPEG-2 is not the most efficient of codecs because it uses a very elementary process. The processing power to decode a HD MPEG-2 file can be had for very little money, allowing for inexpensive content and playback devices. MPEG-4 on the other hand, still requires a high-end computer workstation to decode its HD-spec

video. Because it is an older format, MPEG-2 is commonly found throughout the broadcast industry, MPEG-2 is a staple of the home entertainment market and can be found in everything from Digital Cable to DVDs and DVRs. The broadcast industry has used MPEG-2 for their satellite downlinks and video playback systems for years[5-13]. Because of its prevalence, it is easier and cheaper for content providers to scale up their MPEG-2 systems rather than shift to an altogether new MPEG-4 based system. MPEG-4 can make a file in a fraction of a size of MPEG-2, but the costs of a decoding system far outweigh the costs of high capacity media. Because of it's low price MPEG-2 will probably be around until processing equal to today's high-end computers can be found on bargain priced chips. At that point a switch will be made to the of MPEG-4 based systems. The current HD content delivery systems such as HD discs, cable and satellite are all first-generation offerings. Content providers will be driven by the lure of better compression and quality provided by newer and more flexible formats such as MPEG-4. If nothing else, the mass quantity of bandwidth space that can be recovered from the switch to MPEG-4 will be a strong incentive.

6.5.4 – Moore's Law

One thing that Moore's Law tells us is that processing power, bandwidth and storage are all increasing at a steady rate. This means that future HD formats will be able to take advantage of these growths. For instance, one can get exponentially better quality over time through the use of new codecs. With the space recovered through

the use of these new lower-bandwidth codecs, additional viewing options or interactive functionality could be added to existing content. With emerging systems like video-on-demand on the horizon, we can see the potential of many new content delivery systems. This is the ideal solution. Given enough bandwidth and storage, video-on-demand could in theory allow anyone to watch any movie ever created at any time.

6.5.5 – ATSC's Room for Improvement

In looking at the image quality of NTSC terrestrial broadcasts progress over the last five decades, modifications were made on both sides of the signal in order to improve its quality. Similar procedures will no doubt be made on digital broadcast signals in forthcoming years. While it is currently limited to 19.2mbit MPEG-2, there are still several things that could be done to improve signal and picture. The easiest would be to add multi-pass encoding at the broadcast level. As technology progresses we will also see improvement in the client side decoding, yielding a better picture. This is comparable to the quality gaps between the early SD DVDs in 1997 and those released recently. There is also always a possibility that many years out an extra element of functionality and/or quality will be added on top of the ATSC standard that will preserve the legacy signal for existing systems while adding new benefits for the consumer.

6.6 – End Remarks

Future expandability will be very important in helping HDTV progress into the coming decades. Many of these market adaptations will not be seen for at least the next five to ten years. The key will be to have the HD television set keep up with the converging technologies that new peripherals and content delivery mechanisms present. The biggest challenge to HDTVs longevity will be how it handles the ever-growing home entertainment market. It wasn't until the home-entertainment boom of the late 1980s and 1990s, that consumers realized they were outgrowing the existing NTSC system. Because of the home entertainment demand, a lot of stress will be placed on HDTV in the early years to meet expectations.

7

CONCLUSIONS

The high-definition landscape creates a technology transition much different than any this country has seen before. Not only did the government initiate the transition, but the standard was agreed upon before it was released to the market. These two factors ensure that the switch to digital broadcast television will be free from a format war. Advanced television will happen, it is just a question of when. If the country remains on its current track of a gradual unsubsidized change over, we can expect the conversion to resemble the transition from black and white to NTSC color television in the 1950s and 1960s.

7.1 – Solving the Paradox

The advanced television paradox is a byproduct of a free-market economy. Hardware and content providers have invested millions of dollars into developing new technologies and services, which unfortunately have a limited market. In order for these corporations to recoup their expenses, they need to keep prices high. Conversely, the public is wary about investing in expensive new technologies for both practical reasons and for fear that the new technologies can be short lived. In order to solve this paradox several avenues can be taken. No one solution is right or

wrong, but each offers a unique outcome, which, depending on the socio-political climate may or may not be seen as good policy.

7.1.1 – Government Intervention

If the government intervenes in the transition, it will only solve half the paradox: the switchover digital terrestrial broadcasting. The predicament of high-definition television adoption will remain. While the US government is currently in the process of granting set-top converter box subsidies for homes using free terrestrial television, this alone will not encourage the overall shift to high-definition. What a federal subsidy will do is hurry the transition to digital terrestrial transmission. Once completed, this will allow the government to shut down, and sell off the analog spectrum. High-definition will be left to progress at its own rate.

7.1.2 – The General Public

In a social environment that is filled with a great number of consumers who are satisfied with their current systems, it could take another ten years for the general public to become fully engrossed in the HD format. The average consumer is least likely to take a risk on technology that offers minimal benefits, especially when it is offered at a premium. Therefore, expect to see the same pace of transition that is occurring now. At present, the majority of American consumers are completely happy with their home entertainment equipment and they do not see the need to upgrade to high-definition until it drops to a price point equivalent to today's current

standard definition offerings.

7.1.3 – Without Government Intervention

If left to its own progression, we can expect to see HDTV purchases from the general public follow the same pattern of adoption as any other television hardware in the past. In 1985, for example, one could purchase a good quality 27" TV for $1000. Ten years later and without the assistance of government subsidization, the prices dropped to the point where one could be purchased for under $200. Expect to see the HDTV transition follow the same pattern of pricing over time.

A slow transition would allow for technologies to be solidly developed. In order for a full-use format to reign, it not only needs to be widely available, but also affordable. DVD is a classic example. Three years after its release, it had the buzz and excitement surrounding it, as well as very affordable prices and a wide variety of content. HDTV's slow adoption, high prices, and limited content may closely resemble the DVD-Audio and Laserdisc formats of the past. These higher quality formats lacked popularity due to their high prices and limited content availability. Because of this, they were never able to get a foothold in the market and were relegated to obscure enthusiast formats.

7.1.4 – The Effects of a Prolonged Transition

This is a fascinating time in the consumer electronics arena. A new ultra-high

quality system is being introduced into a market that has just successfully adopted a new format, DVD. The catch, is that the foundation on which DVD is based, is now obsolete. More over, the vast majority of consumers are very happy with the current state of entertainment technology. HDTV will eventually become the de facto standard in the marketplace, due to the government's assistance in forcing the technology change. Until then, content providers need an extraordinary application in order for high-definition to attract the serious attention of the general public. Cable and satellite providers are poised to remain in their current roles as content multicasters, HDTV's slow adoption may cause serious problems for the physical content providers. If the current crop of physical media remains entrenched in a format war, consumers will find it difficult to decide on either of the competing formats. In these situations, consumers are likely to hold off on purchasing any HD disc formats until there is a clear-cut solution. As the American consumer is already satisfied with the existing standard definition system and DVD format, he or she will probably forego this new format or, at the least, buy into it at a minimal level, while continuing to be a cable or satellite customer. This is the ideal situation for the cable and satellite providers, as it gives them time to solve video-on-demand's main weaknesses: available bandwidth and infrastructure. While the American consumer is comfortable with physical media, it pales in potential to electronic video-on-demand. If the HD disc format war continues, expect to see limited HD on-demand service beginning, in larger markets, in an attempt to head off eventual competition from the to-be-decided winner of the physical media format war. Cable and IPTV

providers could potentially move in full force to offer a flat-rate high-definition video-on-demand solution that, with the available bandwidth, could not only corner the market, but would quell any major need for physical media at all.

7.1.5 – Future of ATSC

While it is too early to talk about improvement of the advanced television standard, we can see that with the restrictions imposed by the ATSC standards, there is much room to grow. Improvements can be made both to the screen and signal. When a top quality HDTV set is compared with a professional studio display, the differences are obvious. Looking at the current crop of HD discs, we see that the media are not restricted by the ATSC broadcast guidelines of resolution, codec, and data rate. The first crop of HD discs run in a 1080p resolution, encoded at almost double broadcast HDTV. In time, there will undoubtedly be a platform for higher resolutions, greater bit-rates, and new formats. Comparing the television image quality of NTSC in ten-year segments, we see exponential improvements in image quality and capability. The primary advance is that the screen can be updated as much as desired as long it can display ATSC signals. Experimental screens have been created in resolution that are greater than the digital cinema 2K and 4K standards (Heingartner, 8). However, quality is not only found by increasing resolutions; existing signals can be improved, as well. Just as broadcast quality hardware illustrates flaws in consumer equipment, the same comparison can be made for HD's image quality. This gives the industry a path for improvement.

7.1.6 – Consumer Flexibility

Finding an answer to the high-definition transition paradox is the first part of the problem; the second, and more important part, is what we as a country will do with this new format and how we will utilize digital technology. The transition to HDTV is not just a switch to a new electronic device, it is a switch toward a digital environment. While consumers immediately see the benefits of digital entertainment with better overall quality, additional features, and flexibility it is wise to be cautious. Digital technology allows for greater control of the content, in regard to how, if, and where it can be viewed; affecting one's ability to make backup copies, and view in different locations. With content providers' fears of piracy focused equally on both the Far East and individual consumers alike, they have gone on the offensive by adding new protections to this new digital content. The public will be accepting of some of these measures, others however will blur the line between fair use and copyright infringement.

7.1.7 – Eventual Transition

The majority of American consumers will not consciously decide to make a switch to HDTV. These consumers are happy with their current equipment and they buy their televisions based on price, not features. Sooner or later, however, they will buy a digital television as a result of government intervention. Because of this HDTV will ultimately be a successful product. But it will be the speed of the consumers'

adoption that will be the determining factor in the success and failure of HDTV's accessory hardware and content providers. In summation, digital high-definition television will not only be the next new vehicle for entertainment, it will signal the last hurdle on the road to a complete digital lifestyle.

7.2 – Predictions

The following are my predictions of where television is headed in the coming years. Terrestrial digital television has the potential to last a number of decades. The question is what will the television viewing experience be like in the years ahead? What will be different and what will remain unchanged? Will advanced television remain viable.

7.2.1 – Three Years

The next three years will be essential to the overall acceptance of digital television. Every new medium or larger sized TV set sold will be a digital TV set, not necessarily an HD set, but at the least, a lower resolution set with an integrated digital tuner. Most of these bargain sets will retain NTSC's 4:3 aspect ratio while still supporting ATSC signals. High-definition will still be considered to be the top level, above the cheaper 480p digital sets. While HD will continue to be focused on the more affluent. We will begin to see HD prices continue to drop into the sub-$1000 levels, with a few entry-level units selling below the $500 mark. Set-top digital broadcast receivers will also become more common, alongside older NTSC

sets. We will also see completion of the terrestrial broadcasters' transition to digital transmission. The revised 2009 switch-off deadline will only be met through the assistance of government subsidies; the switch will be made if the price is minimal and there is a proven benefit to the upgrade. The less affluent television viewing public will be unable or unwilling to spend the money simply to view digital signals. The analog NTSC switch-off will require the dissemination of subsidized set-top converters before it can take place. Set top converters will play an important role in the transition, aiding in the television trickle down into households. While more and more homes will be switching to digital TV, not all of the TVs in that household will be digitally compatible. As an average consumer's household usually has more than one television, the extra sets will also require digital conversion.

We will begin to see more availability of HD recorders, first via DVR services through cable and satellite providers, and later via recordable media. Expect high-definition media to be at "Laserdisc" levels in terms of price, exclusivity and availability for the immediate future, carving itself a niche among the affluent and enthusiast markets until prices drop to below the $300 level.

7.2.2 – Five Years

Five years out we should expect to see HDTV sets become well within the reach of the general public. Moreover, I would see this rather than the government's 2009 target, as a more accurate timeframe for a full digital transition. 16:9 aspect ratio

sets will be the common screen size. HD content should be in full-force with HD players well below the $300 level. Cable and satellite will be offering HD services similar to those of the late 80's SD cable i.e. 30-40 HD channels. Cable providers will be able to recover some extra bandwidth from the removal of the analog content and first-tier basic cable networks will all be offering high-definition service. Although the bulk of cable and satellite programmers will be opting for the more economical 480p and some may remain in 480i, HD video-on-demand will start becoming more widespread as cable companies try to compete with the HD disc providers. High-definition media will begin to reach acceptable levels. A clear winner in the physical format war should emerge, allowing all of the software and hardware providers to unify behind a single format.

7.2.3 – Ten Years

Ten years out, HD spec TV sets should be the norm, except at the very low levels of the market. HD-physical media will be running full force, with a catalog similar to today's DVD offerings. Moreover, standard definition DVDs will be all but phased out, much like VHS today. DVR will begin to decline on cable services as on-demand based technology increases. At this stage, I also expect to see a new level of integration between HDTV and the Internet, as well as between the computer and television. This, combined with a wide use of MPEG-4, should begin to lay the groundwork for a new second-generation video-on-demand system. Cable and satellite providers will be close to offering full HD packages on their systems with

very little 480p programming. It is at this point that we will also see the last of any CRT based television screens in society. This is primarily due to the ever-dropping prices of solid-state products and the limited technical capacity of the CRT screen for handling high-resolution progressive images.

7.2.4 – Fifteen Years

Fifteen years out, we should see the next generation in upgrades for cable and satellite services. This will likely be driven from both a demand for better image quality and potential competition from computer/internet HDTV convergence. This switch will allow for a greater quantity of HDTV channels on cable and sat services, as well as higher quality. 1080p will be the mechanism in place for a premium image quality option on both HDTVs and from content services. Video-on-demand at this point should be providing a strong competition to physical media. HDTV sets should be standard faire in American homes, so much so that they will cease to be referred to as HDTV but simply as TV.

7.2.5 – Thirty Years

Thirty years from now the technology that we know today will be long forgotten. Much like 8-tracks, Laserdiscs, and Betamax tapes from the 1970's and 80's, various aspects of today's cutting edge technology will be relegated to history. How technology affects our lives will be very different as well. Inventions will no doubt come along that will revolutionize the way we live. As for television, integration

with computers and the Internet should be well present. In addition, bandwidth and storage capability should be near capacity for an ideal video-on-demand system that allows us to watch any movie at anytime. At this time, consumers will be looking for improvements in their televisions. Backwards compatibility will be essential to making an upgrade. The easiest path for image improvement will be to support a variant of the 2K and 4K Digital Cinema standards. In thirty years, broadcast technology will have changed along with the content delivery mechanism. With the inevitable proliferation of next-generation regional wifi, Internet distribution, and video-on-demand, ATSC will likely be the last traditional broadcast television method; next-next-generation wifi will be a better and cheaper medium. Lastly, by this time one will be able to walk into any retail store and buy a cheap, generic, full quality HDTV for $100.

7.3 – Future Research Directions

In the research conducted for this paper, I have identified three areas in which I feel that future analysis would be highly beneficial. Each of these areas stems from what I believe will be the eventual shift in home-entertainment technology.

7.3.1 – Computer, Internet, and Television Convergence

The parallels between the modern HDTV and the computer are striking. All HDTV devices, from an HD tuner to a Blu-ray disc player, are basically specialized

computers designed for playing back encoded video files on a high-resolution screen. This alone alludes to the fact that we should expect to see more computer integrated content paired with HDTV sets in the near future. Additionally, it is important to note that the telecom corporations, in one way or another, now supply virtually all of our entertainment content. Many prominent movie studios, cable providers, and television networks are owned by telecommunications corporations. With providers pushing ultra-high bandwidth lines to the home, the levels of throughput American consumers will have access to will be increasing exponentially. What we have then, is an information provider offering two services for two different devices over a single wire. As this is increasingly becoming the standard data configuration within American homes, it leaves us with an interesting look into the future that these three services will share, and converge upon over the next decade.

7.3.2 - Predicting Future Home Entertainment by Looking at Youth Viewing Habits

"The Children are our Future", or so the saying goes. It is very possible that this phrase will hold true in regards to the next generation of television technology. Looking at the ways one looks at the methods that high school and college students are viewing programs we see a distinct difference from traditional viewing habits. With ever-increasing access to broadband, it is estimated that over half of America's youth are opting to download television shows through both legal and illegal means, as opposed to watching them via traditional sources (Court TV, National Intellectual

Property). Ethical issues aside, we are seeing a shift in the approach to how future Americans will be viewing television content. The data is showing that there is a solid push toward on-demand content, first hitting the mainstream via indirect means with Tivo systems and DVD box sets of current TV series, and more recently, with the networks offering free, web based on-demand viewing of television shows. These observations, applied to the context of a broadband powered hybrid computer-television, indicate that we have a blueprint for next-generation television.

7.3.3 – Next-Next Generation Broadcast Mechanisms:

If on-demand systems grow in popularity as my research leads me to believe, there will be a point in the future when the question of building the next generation's next-gen television system is raised. If the television of the day is driven by an on-demand culture, we can expect to see a move from the centrally broadcast systems of the present and immediate future. Assuming that a bi-directional communication would be required and that by this point in the future the computer and television are highly merged we could look to find something along the lines of today's experimental city-wide wireless, IP-based Internet as an infrastructure for the future of television. If a robust, isochronous wireless system could be put in place, then it would be a viable foundation for terrestrial television's replacement. Given this scenario, television stations would no longer be bound by their regional transmitter capacity and could compete with one another on a global scale.

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GLOSSARY

16:9	Aspect ratio used in HDTV (1.78:1)
5.1	Surround audio specification utilizing five normal range speakers (three front, two rear) and one subwoofer low frequency channel
1080i	Official HDTV spec, 1920x1080 interlaced at 29.97fps
1080p	Non-Broadcast HDTV spec. Progressive scanned version of 1080i for use with higher end applications. Frame rates range from 24 to 60fps
2K	Digital Cinema standard using a progressive resolution of 2048x1080 at 24fps
480i	Standard Definition Television standard. 720x480 interlaced at 29.97fps
480p	The minimum resolution for digital television. 862x480 progressively scanned.

4K	Digital Cinema standard using a progressive resolution of 4096x3112 at 24fps
720p	Official HDTV spec, 1280x720 progressively scanned at 59.98fps
Advanced Optical Disc	High-definition disc format created by NEC and Toshiba. Adopted by the DVD Forum to become the HD-DVD spec
Advanced Television Systems Committee	Group formed in 1992 to oversee the creation and management of digital television
Advanced Video Codec	Encoding format defined in the MPEG-4 part 10 standard. Used as standard transport mechanism in physical and electronic media distribution. Also known as H.264
Affiliate	Local television station that broadcasts content supplied by a major television network (NBC, CBS, ABC, etc.)

ATSC	See *Advanced Television Systems Committee*
AVC	See *Advanced Video Codec*
Beta	Consumer videotape format developed in the late 1970s by Sony Corporation. Lost out market share to JVC's VHS format in 1980s
Blue Laser	Laser with a finer focused beam (405nm) allowing a higher density of stored data as compared to older red laser technology (650nm)
Blu-ray	High-definition disc format originally developed by Sony, Philips, and Panasonic. Discs hold up to 50GB
Blu-ray Disc Association	Group created to oversee the creation and management of the Blu-ray disc. The group has over 90 members including Sony, Panasonic, Disney, and Warner Bros.
Broadcast Flag	Anti-Piracy technology which uses special coding in the broadcast signal to authorize the recording of specific programs on broadcast flag compatible hardware.

CableCard	Credit card sized device supplied by the cable television providers, which allow compatible digital televisions to view cable television signals with out the use of a separate set-top decoder box.
Cathode Ray Tube	The most common display technology used for television viewing. Uses an electron gun to beam images on to the inside of a phosphor coated screen. On the opposite side of which, the television image is displayed.
C-Band	Older analog consumer satellite technology. Required the use of a six-foot satellite dish.
CEA	See *Consumer Electronics Association*
Codec	A piece of software that determines the quality, speed, and size of compressed digital media
Compression	The process of shrinking data while keeping it in a usable form
Consumer Electronics Association	National organization for the American consumer electronics industry

Content Providers	Groups which provide the material that resides on a given format. (e.g. movie studios, television networks, etc)
CRT	See *Cathode Ray Tube*
D-5	Uncompressed mastering tape format developed by Panasonic which utilizes a data rate of 1.6 Gbps
DBS	See *Digital Broadcast Satellite*
Digital Broadcast Satellite	Consumer targeted satellite service that offers digital transmission and MPEG-2 compressed content allowing for a greater number of channels compared to analog C-Band satellite
Digital Millennium Copyright Act	Piece of legislation passed in 1998 that introduced new restrictions on copyright violations
Digital Rights Management	Anti-Piracy technology restricting the use and redistribution of media to specific devices
Digital Television	Television system that uses a digital broadcast transmission mechanism displaying content compressed in an MPEG-2 format in either 480p, 720p or 1080i

Digital Versatile Disc	Optical media the size of a compact disc that uses Red-Laser Technology to store audio and video data in various configurations from 4.7GB to 18GB
Digital Video Recorder	Hardware designed to act as a VCR except instead of recording to tape it records to a large-capacity hard drive, allowing for dozens of programs to be kept on the system at the same time.
Digital Visual Interface	Hardware Connector used to transfer high-resolution/ high-bandwidth digital video signals. HDCP compatible
DMCA	See *Digital Millennium Copyright Act*
Downconverter	A piece of hardware, usually a set-top box, that converts a high-resolution digital television signal into a lower resolution signal that can be viewed by a Standard Definition television set.
D-VHS	Failed consumer high-definition tape format developed by JVC as potential competition to disc-based HD content delivery
DRM	See *Digital Rights Management*
DTV	See *Digital Television*

DVD	See *Digital Versatile Disc*
DVD Forum	Group originally created to oversee the management of the DVD. With the introduction of HDTV the group also oversees the introduction and management of the HD-DVD.
DVI	See *Digital Visual Interface*
DVR	See *Digital Video Recorder*
Early Adopter	A term used to describe a consumer who will purchase cutting edge consumer technology at high premiums
EDTV	See *Enhanced Definition Television*
Electronic Format	Standardized method for transporting content through an intangible means
Electronic Media	Content which is obtained from an intangible object or location, usually played back remotely
Enhanced Definition Television	The lowest quality ATSC digital television standard. Also known as 480p
Fair Use	The concept of being able to legally copy media for personal use for such purposes as backup copies, delayed viewing, etc.

Format	A set physical or electronic standard media for the storage, display, and transport of content
Format war	A term used when two similar formats compete in an open market
Hardware	Equipment used for the playback of an audiovisual signal
Hardware Manufacturers	Groups who make the equipment used to view HD media/signals/formats
HDCAM	Mastering and Production Tape format developed by Sony Corporation that utilizes a maximum data rate of 440Mbps.
HDCP	See *High-Bandwidth Digital Copy Protection*
HDMI	See *High-Definition Multimedia Interface*
HD-DVD	High-definition disc format originally developed by LG, Sanyo and Toshiba that was adopted by the DVD Forum. Uses blue laser technology with a 30GB maximum disc capacity
HDTV	See *High-Definition Television*

High-Bandwidth Digital Copy Protection	Anti-Piracy technology developed by Intel to restrict the high-quality digital HDMI and DVI signals of HDTV components only to the use of system authorized hardware
High-Definition Disc	Physical media used to transport HD content. See *Blu-ray* and *HD-DVD.*
High-Definition Multimedia Interface	Connector used for the transport of high-bandwidth digital audio and video signals. Standard port of choice for HDTV sets. HDCP compatible
High-Definition Television	Two of the three ATSC digital television standards are classified as High-definition: 1080i and 720p in a 16x9 aspect ratio
Hi-Vision	Japanese pre-cursor to American HDTV 1125 lines and Analog Broadcast
IEEE	See *Institute of Electrical and Electronics Engineers*
Institute of Electrical and Electronics Engineers	Professional association responsible for international hardware standards
Interlaced	Interlaced pictures scan the even and odd lines of a picture on separate passes (e.g. pass one: lines 1, 3, 5, … , 1079; pass two: lines 2, 4, 6, … , 1080)

Internet Protocol Television	Full-Quality television distributed over the internet using advanced (usually MPEG-4 based) codecs
IP	Internet Protocol, this more or less the backbone of the modern Internet
IPTV	See *Internet Protocol Television*
LCD Television	Display based on liquid crystal technology. They key feature is their thin and compact size which allows for a greater flexibility of viewing configurations compared to traditional CRT televisions. Due to the nature of the technology LCD televisions can experience response time 'ghosting' issues which will distort the image as well as offer a somewhat limited viewing angle
Line Doubler	Hardware which interpolates an interlaced signal to progressive one
Linux	Open source operating system based on UNIX
Lossless Compression	Compression mechanism which allows the reconstruction of the original file, thereby with zero quality loss. The main trade-off of a lossless system is that the file sizes are considerably larger than their lossy counterparts

Lossy Compression	Compression mechanism, which interpolates the original file in order to create smaller files. But offers a lesser quality version of the original
Macrovision	Anti-piracy technology used primarily on VHS and DVD technology
Medium	Carrier of an audiovisual signal
Moore's Law	Concept developed by Intel co-founder Gordon Moore stating that processor complexity doubles every eighteen months. This concept has also gone on to describe everything from raw computing power to internet bandwidth.
Motion Picture Association of America	National organization for American movie industry
Moving Picture Experts Group	National organization for the technicians and engineers in the American movie industry.
MPAA	See *Motion Picture Association of America*
MPEG	See *Motion Picture Experts Group*
MPEG-2	1994 standard for the compression of video and audio signals, used as the backbone of the digital television standard

MPEG-4	1998 standard for the compression of video and audio signals. Allows a much greater flexibility in what can be accomplished with the format
Multicasting	The process of broadcasting multiple channels to viewers
NAB	See *National Association of Broadcasters*
National Association of Broadcasters	National organization for the American broadcast industry
National Television System Committee	Group formed to oversee the creation and management of American analog television
NHK	Japanese television broadcaster and pioneer in analog high-definition television
NTSC	See *National Television System Committee*
Pairing	Anti-Piracy concept which limits the playback of recorded programs to specific devices
Physical Format	A tangible standardized object that contains content through a standardized process (e.g. DVD, Betacam, VHS)
Physical Media	A tangible object that contains content

Plasma Television	Display based on plasma discharge technology. The key feature is their thin and compact size, which allows for a greater flexibility of viewing configurations compared to traditional CRT televisions.
Progressive	Progressive scan exhibits a non-interlaced picture by scanning the lines in sequential order (e.g. 1, 2, 3, 4, … , 720). Progressive scan preserves more of the picture than does Interlaced scanning.
Prosumer	A term used to describe a consumer who purchases products at the high-end of the economic scale.
Radio Spectrum	The collection of wireless telecommunications frequencies used to transmit everything from cellular phone calls to AM radio.
Red Laser	Laser with a 650nm width used in Compact Disc and Digital Versatile Disc technology
SDTV	See *Standard Definition Television*
Set-Top Box	An outboard hardware device which allows for the display of television signals (Terrestrial, Cable, and Satellite)
SMPTE	See *Society of Motion Picture Television Engineers*

Society of Motion Picture and Television Engineers	Professional organization for equipment standards for use throughout the entertainment industry.
Standard Definition Television	The NTSC color standard for television. Designed for analog terrestrial and cable reception
Terrestrial Broadcasting	Broadcasting in the traditional sense. A television signal is broadcasted from a station via a transmission tower and it is sent over the air to a television set where it is converted into an image
Unicasting	The process of broadcasting a single channel to viewers
VHS	Videotape format developed in the late 1970s by JVC. Became one of the most successful consumer technologies ever
Video-on-demand	A system of content delivery allowing the viewer to choose from a list of various programs to be viewed at will. The content is stored remotely at the cable provider as opposed being kept locally with the viewer
VOD	See *Video-on-demand*