



Technology Committee “Enhancing the HD Experience” May 2007

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I. Introduction

Last year, the DEG Technology Committee drafted a technology primer that provided a comprehensive overview of HDTV standards and compatibility issues. It includes an introduction to relevant HDTV terminology, definitions of signal formats, a summary of digital television industry definitions, an overview of different connectors (from good to best), a description of display technologies, and finally, a summary of issues adjusting source HDTV resolutions to displays.

With this basic knowledge of HDTV technologies, the current white paper is designed to build upon these core definitions and capabilities to describe the following:

- Sources of great high definition (HD) entertainment;
- Variety of devices for enjoying HD content; and
- Ways to optimize the HD viewing experience.

Background

High definition content provides numerous benefits: superior picture quality (including support for display resolutions up to 1920x1080 pixels; support for progressive scan; enhanced sound reproduction including support for up to 7.1 channel surround); and new audio technologies such as DTS-HD and Dolby TrueHD; and convenient operation and improved versatility including support for HDMI which provides consumers with a simple, single cable solution for video, audio and system control.

In addition, due to the introduction of more advanced platforms that bring high definition content to the living room, consumers have come to associate HD content with other new capabilities:

- *New forms of interactivity*: The recent introduction of next-generation gaming consoles and new optical disc formats is raising the bar in terms of interactivity and online connectivity. Both Microsoft Xbox 360 and Sony PlayStation 3 consoles offer interactivity and Internet connectivity as part of the HD gaming experience. Similarly, players based on the new optical disc formats, Blu-ray Disc and HD DVD, also enable a host of new interactive features combined with HD content. These devices can also integrate interactivity and Internet connectivity to enable a more dynamic consumer HD experience.
- *Device connectivity*: The advent of HD content requires faster inter-device communication. Technologies such as HDMI provide greater convenience (through single cable connection), higher speeds (for supporting HD resolution content), and content protection (such as HDCP). Technologies such as USB 2.0 and IEEE 1394 enable the transfer of user-generated, HD content at data speeds up to 480Mbps and 800Mbps, respectively. CableCard is yet another connectivity feature to watch, as it allows cable programming to plug directly into a digital TV set without the need for a set-top box.
- *Support of portable devices*: In addition to high definition content, consumers are increasingly seeking more flexibility with their entertainment options. At the other end of the spectrum, consumers have come to expect the ability to connect their portable devices (via direct connections or “docking stations”) to their home entertainment system.

Scope

This white paper assumes that the reader has a basic understanding of HD technologies, including the HDTV itself. For purposes of refreshing the reader, the following considerations are important when selecting an HDTV:

- One major factor in choosing an HDTV is the type of display technology – micro display, LCD, or plasma. Each of these has their respective benefits. For example, rear projection micro displays offer a cost effective HDTV solution. LCD offers a thin form factor that can be hung on a wall. It also offers more resolution for the dollar compared to plasma. Plasma, however, generally provides the best brightness and widest viewing angle.
- Another major consideration is screen size. HDTVs have a different aspect ratio (16:9) compared to Standard Definition Televisions (SDTVs) (4:3), so a 42” SDTV will not equal the size of a 42” HDTV in terms of screen area when measured diagonally. Another key factor is viewing distance. As a general rule of thumb, the viewer should not sit closer than 1.5 times the diagonal size of the screen, and not further away than 2.5 times.
- Yet another major consideration is screen resolution in relation to the scan mode. The screen of an Extended Definition TV (EDTV) consists of 480 lines whereas HDTV screens consist of either 720 lines or 1080 lines. Note that every HDTV can handle all three resolutions by scaling the picture to the actual number of lines of the set. The number of lines of an HDTV is often advertised followed with the letter “i” or “p.” The screen of a U.S. SDTV is refreshed 60 times per second. In the first “scan” all odd lines are written then in a second “scan” all even lines; this is called “interlaced,” hence the “i.” A slightly better quality can be achieved by refreshing all lines in one scan; this is called “progressive,” hence the “p.” A HDTV screen with 720 lines is always progressive, i.e. 720p. A 1080 line HDTV may have an interlaced or progressive scan mode, i.e. 1080i and 1080p. As a rule of thumb keep in mind that one hardly sees the difference between 720 and 1080 lines on screens that are less than 42”. The difference between 1080i and 1080p is very small although the latter is theoretically better in combination with a HD source that has a 1080p output.
- Other considerations are the number of HDMI connections, what version of HDMI, black levels, contrast ratio and brightness of the display.

Finally, this white paper is aimed at the North American market. It is important for the reader to note that some of the material in this white paper may not apply or may be different for other regions.

II. Sources of HD Content

Regardless of what type of HDTV(s) a consumer purchases, in order to truly enjoy the high definition aspect of the TV, the consumer needs to have high definition content. Two key considerations here are the types of HD content the consumer wishes to experience and the method used to distribute that content to the consumer.

A. Types of HD Content

1) Primetime and News

When the U.S. Congress adopted the Digital TV legislation in 1996, it also introduced a schedule that mandated local TV stations to dedicate a certain amount of their digital programming in HD quality by certain dates. Over time local stations as well as their broadcast network providers ABC, CBS, NBC and Fox, have all introduced shows in HD quality. Most of this migration to HD started with content in the primetime slot since this is the content most widely viewed on television, followed by local news broadcasts that have also begun the transition to HD.

2) Sports & Special Events

Watching live sports in HD greatly enhances the viewing experience. The big screen creates an intense and immersive environment while the level of detail in the image gives a feeling of being there. Having to turn your head while the stock cars roar by, or actually being able to see the puck going into the goal, or the golf ball land on the green adds dimension to the experience.

All the broadcast networks, and many of their local affiliates, have adopted the HD format for their major sports programs. This means that a lot of HD sports content is available to free television viewers.

For the sports aficionados who don't mind paying a small premium for television content, access to dedicated sports channels is a must. Market leaders ESPN and Fox Sports Network have their dedicated HD channels but also channels like TNT and TBS provide sports in HD.

Sports that are not in the U.S. mainstream, but have huge audiences in other regions of the world like soccer and cricket, now reach U.S. viewers with niche channels like WorldSport, who have also adopted HD.

Like sporting events, music concerts are better in person, and HD enables the consumer to feel like they've got a front row view, with intense effects such as bright concert lights, booming bass and hazy crowds seen and heard in vivid detail in HD.

3) Movies

Movies have always been a larger than life experience in the theater and now HD brings the consumer so much closer to the motion picture experience at home. A wide variety of movies are now available in HD in a number of different genres.

4) HD Video Gaming on Next-Generation Platforms

The video game industry has a tradition of dramatically increasing the wow factor every time a new hardware platform is launched. Both Microsoft with the Xbox 360 and Sony with their PlayStation 3 have upped the ante of image quality that is better appreciated on a big screen HDTV. New video games have been released that look more like a Hollywood movie than a traditional game. Both platforms have high quality video outputs that can be connected to any HDTV set.

5) User-Generated Content

Changes in still image photography have developed at a rapid pace. The desire to share one's latest baby pictures or exotic vacations is as strong as ever. Instead of stacks of prints going around, the pictures appear on the TV. Using an HDTV set for this makes a lot of sense. It is typically the centerpiece in the living room and the screens are large enough for everyone to have a good look. Moreover with ever growing camera resolutions, mega pixels in geek-speak, at very affordable prices, the HDTV quality of the screen can really be utilized for the crisp and detailed images.

Although not as widely spread as still image cameras, video camcorders are still a popular tool to record the family milestones and beyond. Where else to better show video than on the TV set in the living room? Also in camcorders the migration to HD quality has started with the relatively recent introduction of HD format camcorders. These can support either 720p or 1080i resolution.

Still images as well as consumer videos have found their way to the Internet. Whereas the former is mainly aimed at sharing with friends and family by means of services like Flickr, Yahoo Photo, Snapfish and the like, consumer videos have sparked a huge hype of exhibitionism on sites like YouTube and Google Video.

B. Distribution Methods

1) Television

The HD capabilities in TV production, distribution infrastructure and not to forget the sizable audience with HDTV capable TV sets have made HD quality broadcasts almost a mainstream commodity. The real question for the consumer is how to get that broadcast content to their HDTV.

There are three primary distribution methods for HD content for TV: terrestrial (over-the-air), cable and satellite. All three HD sources broadcast using either 1080i or 720p resolution. Many networks have opted for the 1080i format, while ABC, Fox, ESPN/ESPN2, and the National Geographic Channel use 720p.

While practically all high-profile shows and news broadcasts are available in HD, it is important to note that with these broadcast networks, not all content is in HD. Many of the shows aired during the day are still in standard definition which means not only lower resolution but different aspect ratio. Therefore, the consumer can and should still expect a mix of HD and SD programming.

a) Terrestrial (Over-the-air) Broadcast Networks

The most cost effective means and widely available for obtaining HD content from a consumer perspective, broadcast network signal can be obtained freely in most major metropolitan areas. Of course commercial advertising is still inserted, and often times still in SD quality, into HD programming with the exception of content on Public Broadcasting Systems (PBS). Reception is dependent on limits by geography and channel limitations.

b) Cable & Satellite

i) Pay Television (Part of Cable/Satellite Fees)

Pay television includes channels such as ESPN, CNN, and Discovery, channels that contain commercial advertisements but cannot obtain freely as in the case of the broadcast networks. Consumers must pay a fee to obtain these channels through either a cable or satellite service.

ii) Premium Channels

With the broadcasting infrastructure in place to transmit HD content also the channels renowned for their original movies and drama productions are available in HD. Channels like HBO, Showtime and Starz have all launched HD versions that are available through cable and satellite.

iii) Local Programming

Local programming is provided by cable; but not so with all satellite (although coming with new versions).

2) Packaged Media

A large part of the success of DVD can be attributed to its ability to deliver on the promise of an (almost) theatrical experience in one's own home. In fact in the early days of HDTV the sales of the new big screen TV sets were more driven by DVD than the emerging HD broadcasts. Even the most affordable home theater systems all come with adequate surround sound capability, typically with a subwoofer loudspeaker that can produce rumbling sound effects that most viewers associate with a real theatrical experience. Although the picture quality of the material on the DVD is in standard definition, a new trend in DVD players is their ability to upscale the video resolution. By means of modern signal processing technology new pixels are calculated that are not in the original material. Although not really HD, the results are often stunning, especially on a very big screen. With the huge collection of movies, music concerts and TV shows, DVD is an unprecedented source for high quality home theater experiences.

Two new formats, Blu-ray Disc and HD DVD, provide a pristine image in true HD quality.

3) Video-on-Demand (VOD)

For quite some time cable operators have offered video-on-demand in major metropolitan areas. High-profile movies have always been the big headline for these services, which are all moving to HD quality. Satellite operators offer movies in their pay-per-view service. Although typically with a smaller selection the latest movies can be seen in pristine HD quality. A relative newcomer in the VOD market is MovieBeam, which uses a proprietary box that receives movies from the terrestrial broadcasters. Rather than watching the movies directly they are stored on the box's hard disk and available for selection and viewing at any time. MovieBeam has recently started to provide some HD quality material.

4) Download

On the Internet there are many more newcomers and experiments. For a while CinemaNow and Movielink have offered first tier movies for download and viewing on the PC. Recently both have started to offer material in HD quality. However unless one has the PC directly connected to the TV set, the viewer experience is somewhat limited. Although Apple's offering in the iTunes Store is clearly aimed at the tiny screen of the iPod and YouTube's videos, although popular for other reasons, would not pass a high quality test, one might want to keep an eye on these and other sites. First, if one tries to connect the PC directly to the HDTV, please note that these sets do a much better job rendering Internet graphics and text than older sets did, making browsing the Internet from the couch a real option. Second, there is such a drive to utilize the Broadband Internet to deliver video content to the home that some dramatic developments can be expected - with peer-to-peer networks, like BitTorrent, starting to become deployed for legitimate delivery of video.

III. Playing HD Content

This section describes some of the key devices necessary for receiving and playing the HD content sources described in the previous section. Each type of device is described below, as well as potential issues and advantages.

A. TV Receivers

For most consumers, television broadcasts will be the primary source of HD content. There are three primary sources of HD television broadcast content: (1) HD via terrestrial (over-the-air); (2) HD via cable; and (3) HD via satellite.

1) Over-the-air (terrestrial broadcast):

To receive and play over-the-air HD a consumer will need an ATSC tuner and an antenna to receive broadcasts from a local tower. While many HDTVs come with a built-in ATSC tuner that can receive high-definition programs over the air by simply connecting an antenna, many do not. Sets that have an ATSC tuner built-in are often called *integrated HDTVs*, and those that don't are sometimes called *HDTV ready* or *HDTV compatible*. If the consumer has an HD-compatible TV that does not have a built-in ATSC tuner, then the consumer will need to connect an external tuner in order to receive local HD channels. Adding to potential consumer confusion is that an HDTV may come with an NTSC tuner which can only receive analog (SD) signals.

When selecting an external ATSC tuner, ideally the external tuner should have an HDMI connector to connect to the HDTV. The consumer should also make sure that the output(s) of the tuner match the inputs of the HDTV.

The other requirement to receive over-the-air HDTV is the antenna. Both outdoor and indoor antennas are available. Outdoor antennas work better than indoor ones, but they also require work, space, and access outside the consumer's home. An indoor antenna may suffice if the consumer's home is close enough to a broadcast tower. Regardless of using an indoor or outdoor, it is often useful for the antennas to have a built-in amplifier to increase the ability to receive weak broadcast signals.

There are also different types of antennas: directional and multidirectional. Directional antennas can be aimed toward a specific point or in a specific direction, and can usually do a better job of picking up distant signals. Directional antennas often reduce multi-path distortion, which occurs when an HD signal is reflected by buildings, resulting in receiving the same signal multiple times. The other kind of antenna is multidirectional, which can receive signals from multiple directions. Multidirectional antennas allow for more flexibility in mounting, and they pick up signals from widely dispersed transmission towers. However, their ability to pick up weak signals from distant towers is limited.

Selecting the right antenna depends on many variables including region, proximity and field of view to a transmission tower. One of the most valuable resources for selecting an antenna is AntennaWeb.org – a web-based database that allows a consumer to access HD information based on their address. This site has database of HD broadcast towers across the United States and offers some sophisticated software that models HD signal broadcasting per region.

2) Cable

There are a few different ways to receive and play HD from a cable provider. The first and most common method is via an HD-capable set-top box from the cable provider. These devices often allow the tuning of more than one channel at a time, which is convenient for devices which also combine recording capabilities. These dedicated set-top boxes also provide two-way communication between the home and the cable provider, enabling pay-per-view programming and use of an interactive programming guide. Increasingly, latest cable set-top boxes are coming with integrated HDMI support.

Some cable providers offer the HD set-top box for free, others rent them for modest fees, and some even offer digital video recorders (DVRs) capable of recording the HD source.

The second method for receiving and playing HD via cable doesn't require a separate, external set-top box. Instead a consumer can use a Digital Cable Ready (DCR) HDTV with a CableCard (a module from the cable provider necessary to descramble premium channels). In addition to eliminating the need for a separate set-top box, CableCard enables the consumer to utilize the remote control provided with their HDTV for all of their TV and cable programming needs.

The current version of the CableCard standard doesn't allow for two-way communication, which means certain features, such as pay-per-view programming or an interactive programming guide from the cable provider, are not available with the current version of CableCard. Instead, the consumer must pick up a phone to order pay-per-view programs. Current generation DCR TVs also have other limitations compared to the set top boxes provided by the cable provider. The current version of CableCard only supports a single-stream, meaning the TV cannot tune more than one channel at a time. An improved, two-way version of the standard, dubbed Interactive Digital Cable Ready, is being considered, and other retail-based alternatives using the OpenCable platform are also under discussion.

It is worth noting that some HDTVs come with QAM tuners but no CableCard access, which means these HDTVs will only work with unscrambled digital cable broadcasts. Depending on the cable provider, an HDTV with such support could potentially receive some HD programming by simply plugging in the cable.

3) Satellite

To receive and play HD via satellite a consumer will need a separate HD set-top box and a satellite dish that can receive signals from the appropriate orbital positions. With satellite service, the consumer is usually required to purchase the equipment up front, as well as agree to an annual contract.

There are two satellite TV service providers: DirecTV and Dish Network. Both offer programming using MPEG-2 technology, and more recently, via MPEG-4 AVC technology, which allows twice as much HD video on the same amount of bandwidth as MPEG-2. However, older DirecTV and Dish Network set-top boxes are not compatible with newer MPEG-4 services, and this may require an upgrade to legacy systems and antennas to receive the new broadcasts. Because of this need to support legacy devices, DirecTV and Dish Network both plan to broadcast their existing MPEG-2 HD lineup. However, to watch the new local and national HD channels using the new MPEG-4 services, the consumer will need to replace their current satellite equipment (tuner and possibly satellite dish). Both service providers are offering discounts to existing HD customers to make the transition easier.

Unlike most cable set-top boxes, the receivers from DirecTV and Dish Network offer HDMI connections for the best possible video/audio quality and consumer ease of connection.

4) DVR

An HD digital video recorder (DVR) lets one record, rewind and pause both standard definition and HD source material. Most of the cable and satellite service providers now offer HD DVRs with at least two tuners so they can record two channels simultaneously while playing a third already-recorded program. Third party options are also available for recording HD broadcast content, whether from satellite, cable or over-the-air. The issue is for the consumer to be sure to select a DVR that is compatible with their HD source/provider.

As mentioned above, most cable and satellite service providers offer HD DVRs. In the case of cable, the hardware is usually provided for just a bit more than a standard digital cable box, though at least some or all of the HD channels may be "premiums" that will require an additional charge. An alternative to a device from the cable provider is a TiVo Series 3 DVR, which works with any digital cable system. The TiVo Series 3, however, is a pricey option because of the up-front hardware cost as well as the additional monthly service fee to TiVo (prices were approximately \$800 and \$13/month, respectively at the time of authoring this white paper).

Both DirecTV and Dish Network offer HD DVRs. Dish Network offers a receiver with three tuners (two satellite, one over-the-air antenna), and it receives all of Dish's HD broadcasts. DirecTV is offering a HD DVR device which can access DirecTV's entire channel lineup including local channels broadcast utilizing MPEG-4 compression (eliminating the need for an external over-the-air antenna). Note that DirecTV earlier introduced a HD set-top box with the Tivo service, which will not be able to receive the local channels in MPEG-4.

For over-the-air HD users, DVR choices include Sony VAIO PCs. Consumers can also use a PC with add-in TV tuner card which will work with Microsoft Windows Media Center Edition.

5) Next-Generation Optical Disc Players

A consumer interested in obtaining the best possible audio and picture quality would look to purchase a next-generation optical disc player. These next-generation disc players and recorders can support full 1080 resolution and the latest surround sound technologies including DTS-HD and Dolby TrueHD. Such a player is the best way to demonstrate the full capability and quality of a true 1080 display and home theater audio system.

There are two formats currently available: HD DVD and Blu-ray. Both are based on blue laser technologies. Since blue light has a shorter wavelength than red light used in DVD and CD lasers, information can be packed more densely so that a single disc can hold more data. Both formats support similar audio and video capabilities, although their framework for advanced interactivity is different: HD DVD uses a markup approach called HDi, while Blu-ray uses Java.

Both Blu-ray and HD DVD players support HDMI connectors. In fact, HDMI with HDCP is required for both formats to ensure maximum picture quality and to implement the necessary copy protection requirements of these new formats. This requirement, however, also translates into connection simplicity, as consumers can use a single cable to connect their next-generation optical disc player directly to a TV or AV receiver with HDMI connections.

Since HDMI is still a relatively new technology, compatibility issues may exist between players and TV sets. Also, if an HDTV was purchased with HDMI 1.3 then the consumer should consider purchasing a next-generation optical player with

HDMI 1.3 to take advantage of the added features and to further “future proof” their equipment. (See the HDMI discussion in this section below for more details)

A potential near-term alternative is a DVD player with upscaling capability to full 1080p resolution, which makes DVDs look much better on a true 1080p resolution display. Although an upscaling DVD player improves visual quality, this approach does not achieve true 1080p resolution, but merely scales 480p DVDs to reduce artifacts.

6) Gaming Consoles

As described in Section 2, similar to broadcast and movie content, HD gaming is also growing in consumer interest. Of the three next-generation game consoles currently on the market, two of them support HD: the Microsoft Xbox 360 and the Sony PlayStation 3. Additionally, the Xbox 360 also supports HD DVD movie playback via a separate add-on, while the PlayStation 3 doubles as a Blu-ray Disc player. Both devices can also act as VOD devices via their respective online services, Xbox Live and PlayStation Network.

Microsoft Xbox 360 can be enjoyed on a compatible HDTV using HDMI version 1.2 (starting with the release of the “Elite” model) or via a separate Xbox 360 Component HD AV Cable. To use the Xbox 360 as an HD DVD movie player, the consumer must purchase the HD DVD add-on drive. The Xbox Live service can also enable HD movies to be downloaded online directly to the built-in hard drive.

The Sony PlayStation 3 ships with integrated HDMI support (supporting the latest version of HDMI 1.3). As described below, however, to take full advantage of HDMI 1.3 the consumer’s HDTV (or AV receiver) must also support HDMI 1.3.

7) Media Center PCs

In addition to traditional commercial content sources (broadcast and optical disc), consumers are increasingly demanding the ability to access personal and Internet content on their HDTV. While SDTVs made such viewing very difficult, HD displays are ideal for viewing high resolution video, pictures and text. Primary sources of content to be played on a PC would include user-generated content such as home movies, photos, and audio libraries, as well as Internet content, such as that from YouTube or MovieLink.

Microsoft’s Windows Vista operating system and the latest Media Center Experience user interface integrates support for HD quality digital cable, the next-generation optical formats, online content, and personal media in a single device, with the goal of reducing the number of devices surrounding the HDTV. Media Center PCs can also be used as a DVR device for a standard cable set-top box, offering a rich user interface and the ability to stream that recorded content to other HDTVs within the home. Some Media Center PC offerings also include HD 5.1 or 7.1 digital audio outputs as well as built in digital amplifiers, offering a home theater experience within the same device.

Considerations for the consumer looking at a Media Center PC include:

- **HDMI out:** To ensure the best possible picture quality when connecting the Media Center PC to a HDTV, HDMI is very important. It is also important to check what resolutions and outputs are supported as some Media Center PCs do not yet fully support 1080p output. It is also important to keep in mind which version of HDMI is supported by the PC, as some of the more advanced features are only available with version 1.3.
- **Next-generation optical drives:** Both next generation optical formats, HD DVD and Blu-ray, are available to be integrated into the PC. One additional advantage that these drives offer within a PC is that many of them also feature burning capabilities. With the large capacity of these new formats, archiving of HD content captured into the PC is now possible.
- **Built-in amplifier:** Seeking to become a complete replacement for the home theater system, many of the higher end Media Center PCs are also incorporating an amplifier that can power a 5.1, or in some cases, a 7.1 surround speaker system. Even when an amplifier is not built in, most will, at a minimum, offer a digital audio output and/or a pre-amplifier analog output. Whether it is desired to completely replace an AV receiver or “home-theater-in-a-box” or to combine it with a PC, care must be taken to ensure that the needed outputs are present since this may vary for different Media Center PCs. Not all Media Center PCs offer support all audio technologies (such as THX, AC3, etc.), so care should be taken when considering when looking for support of a particular audio technology.
- **Large capacity hard drives:** With the increased resolution of HD content comes the need for greater storage capacity. Media Center PCs most often come with very large capacity hard drives, allowing for storing and capturing of many hours of content in both SD and HD. However, if the intent is to capture and store lots of HD content, the largest possible drive should be considered. The other big advantage of a PC is the ease at which this capacity can be increased through the use of external drives, using USB 2.0 or IEEE 1394 connections.

8) Other Devices & Technologies

In addition to the HD devices described above, there are other devices and technologies that may have a role in playing HD content.

- **IPTV:** IPTV is a technology that enables delivery of television via an Internet compatible device. Unlike video delivered over the Internet, IPTV is different as it is based on a private network, even though it uses the same broadband connection into the home.
- **Broadcast DTV Variants:** New types of devices with their own dedicated delivery services are also providing HD programming to the home entertainment system. Two examples of such devices are MovieBeam and Akimbo. While not within scope of this white paper, they are worth mentioning as alternative sources of HD programming.

IV. Optimizing the HD Experience

Since the advent of DVD, the audio/video (AV) receiver has come to serve as the centerpiece for today's home theater systems. Recently, the rapid growth of HDTV – along with the increasing variety of HD sources that are available – is having a profound effect on the design and performance of these components. All of this has the potential to provide entertainment enthusiasts with a more fully enhanced HD experience. However, a critical challenge remains – how will these receivers offer the flexibility that is necessary for both high and standard definition while still providing more convenient, intuitive overall operation.

1) Video Up-Conversion

Many of today's AV receivers, DVD players and recorders include some form of 1080p upscaling that converts via HDMI lower resolution, standard definition signals to performance levels that approach full 1080p HD. Some of these sources can be connected via composite, S-video or component cables; then up-converted using a single HDMI cable. Some receiver models also incorporate advanced circuitry that reduces noise while correcting color.

2) Video Down Conversion

Most AV receivers also employ circuitry that can down-convert HD signals to lower resolution. This is ideal for use in multi-room systems or other distributed video applications.

3) HDMI Outputs

Many of the newest AV receivers support the latest High Definition Multimedia Interface (HDMI) specifications. This enables consumers to enjoy both optimal performance and convenience by delivering digital video, audio and control signals over a single cable. It also maximizes the resolution of standard definition sources to match any HDMI compatible component.

4) HDMI "Active Intelligence"

Additionally, these HDMI inputs can automatically detect and receive the best high resolution video and audio signals available. This makes source selection and activation of compatible components as convenient as possible.

5) Multichannel Calibration

Virtually every current AV receiver can deliver a compelling multichannel surround sound experience, using a variety of audio codecs (Dolby Digital Plus; DTS-HD, etc.) which offer up to 7.1 channel capability. Many of these models also enable you to optimize your listening position by incorporating sophisticated digital processing. At the touch of a single button, this feature automatically calibrates everything from soundfield effects to time alignment for each individual speaker.

6) On-Screen Display (OSD)

To avoid complexity, simplified AV receiver functionality and system set-up is essential. So most AV receivers include some type of video output, which displays all critical functions on your television screen. Some receivers even offer an auxillary video input for connecting a security camera or baby monitor. This can be viewed as a picture-in-picture option, while still watching your primary video source.

7) **Multiroom/Multizone Capability**

In addition to multichannel amplifiers, many AV receivers employ an additional stereo amplifier which can route audio to another room in the home. This enables you to enjoy and independently control other source components that are connected to the receiver without interfering your primary system.

8) **Home Control**

Many of the newer media center PCs now come pre-packaged with software and in some cases hardware to allow for home control; managing lighting, air conditioning heating, etc. All this adds to the overall HD entertainment experience.

9) **System Integration**

Finally, most advanced AV receivers come supplied with a programmable remote commander which works with a number of products from different manufacturers. Most models also support a variety of other connectivity options in order to expand your entertainment enjoyment.

- USB ports for connecting PCs and compatible MP3 players and other portable devices.
DSP soundfield settings which can be used for enhancing the sound quality of MP3 players.
- “Connect-and-play” antennas which can be used to access either HD Radio or XM and Sirius satellite services.
- Built-in infrared (IR) receivers which enable the user to control a number of home automation products including HVAC, light dimmers and window curtains.
- 12-volt triggers which can be used with compatible HD projectors to automatically activate motorized screens.
- RS-232 interface which seamlessly integrates the control of AV servers and multi-disc changers.

10) **Remote Controls**

The remote commander is a critical component of today’s multifunction AV receivers. Most of these devices can activate and control not just key receiver features but a number of other products that are found in the home entertainment system as well.

Most remotes have a built-in learning function that provides enhanced flexibility for programming the infrared (IR) codes that comes supplied with a variety of entertainment devices. Some remotes even include *Macro* features, which reduce multiple programming operations to a single touch of a button.

Though not specific to HD, the remote control is an essential part of a home entertainment system. While this white paper does not intend to provide specifics of remote control technology, it is worth mentioning that the consumer should look for a remote that will control and “unify” all their existing devices, and offer room to expand as the consumer’s home entertainment system grows. A feature that offers flexibility is a *learning* feature that enables the remote to be programmed with IR codes from any existing or future device. Remotes that also support macros for implanting multiple steps via a single button selection can greatly simplify the control of many different devices.

V. **Summary**

The selection of a new HDTV is merely the first step in an ongoing process that is redefining home entertainment for the digital age.

As this primer dramatically shows, there’s now a variety of outstanding HD content and devices to choose from, all of which have been specifically designed to enhance the HD experience.

A. Addendum: HDMI

It is worth spending a little time specifically on HDMI. As mentioned several times in this section, HDMI, or High-Definition Multimedia Interface, is the best possible connection for the HD devices described in this white paper. Why? Because HDMI offers crystal-clear digital video and audio via a single cable and connector, dramatically simplifying cabling and helping consumers enjoy the best possible home entertainment experience.

HDMI offers the ability to transmit high-definition video (including 1080p) and multichannel audio (up to 8 channels of super-high-quality 24-bit 192kHz audio) over a single cable. Plus, HDMI also allows for 2-way control. An additional benefit, especially for content owners, is HDMI's support of HDCP (High-bandwidth Digital Content Protection). This level of copy protection is mandatory for new devices such as next-generation optical disc players.

Therefore, it is a good idea for consumers to look for a HDTV or an AV receiver that support at least two HDMI connections. The number of HDMI connections required should be based on the number of HD sources/devices that will be connected in the home entertainment system in the future.

The HDMI standard is continuing to evolve to meet the growing needs of new generation home entertainment devices and content. Luckily all versions of HDMI are backward compatible – the standard enables the devices with one version of HDMI to communicate with another device with a different version. Of course, the downside is that in such a situation only the features of the lower version will work. A description of each version is provided below:

- HDMI 1.0 (2002): Initial version of HDMI. Supports single-cable digital audio/video connection and 1080p video, but only two-channel audio.
- HDMI 1.1 (2004): This version added multichannel audio support for DVD-Audio (up to 5.1).
- HDMI 1.2 (2005): This version added support for HDMI connectors on personal computers, and multichannel one-bit audio formats like SA CD (Super Audio CD). Version 1.2a specified the Consumer Electronic Control (CEC) features and command sets for remote control functions.
- HDMI 1.3 (2006): This release added several additional features: (i) support for the "xvYCC" extended-gamut color space standard; (ii) "Deep Color" standard which supports up to 16-bit color (more relevant to HD gaming consoles and HD camcorders); (iii) support for lossless compressed digital audio formats (Dolby TrueHD and DTS-HD); and (iv) ability to correct "lip sync" problems due to device delay issues (often present when audio is sent to an AV receiver and video is delivered directly to the HDTV display).

While HDMI offers several benefits, there are many pitfalls to watch out for:

- Cables: Some components include an HDMI cable in the box, but most do not. This can cause consumer confusion and does not always lead to a successful "out of the box" experience. Luckily, consumers do not need to worry about HDMI versions when purchasing an HDMI cable, as there have been no physical changes to the HDMI connectors on cables and components.
- Device settings: Some HD devices ship with the HDMI output set to "off" as the default factory setting. This requires the consumer to switch this connection to "on", as described in the instruction manual. If this is omitted there will be no picture or sound when using a HDMI connection.
- Sound limitations: Many HDTVs do not support decoding of more than two channels of audio. This means that an HDMI player, plugged directly into such an HDTV, attempting to play Dolby Digital and DTS surround sound may not play any audio. This is often the case when the HDMI player is shipped with a factory setting of outputting multichannel audio. This situation requires the consumer to change the HDMI player's audio setting to 2-channel (PCM) to solve this issue.

B. Addendum: Additional References

- CNET: Ultimate HDTV Buying Guide (http://www.cnet.com/4520-7874_1-5108580-1.html)
- CNET: Three Ways to Get HDTV Programming (http://www.cnet.com/4520-7874_1-5108854-1.html)
- Engadget: OTA HD Demystified (<http://www.engadgethd.com/2006/01/30/ota-hd-demystified/>)
- Yahoo!Tech: Getting Equipped for Local Over-the-Air Availability (<http://tech.yahoo.com/gd/getting-equipped-for-local-over-the-air-availability/153455>)
- Crutchfield: TV and HDTV – The Ins and Outs of HDMI (<http://www.crutchfield.com/learningcenter/home/hdmi.html?page=3>)
- <http://hdtvpub.com>
- <http://antennaweb.org>