



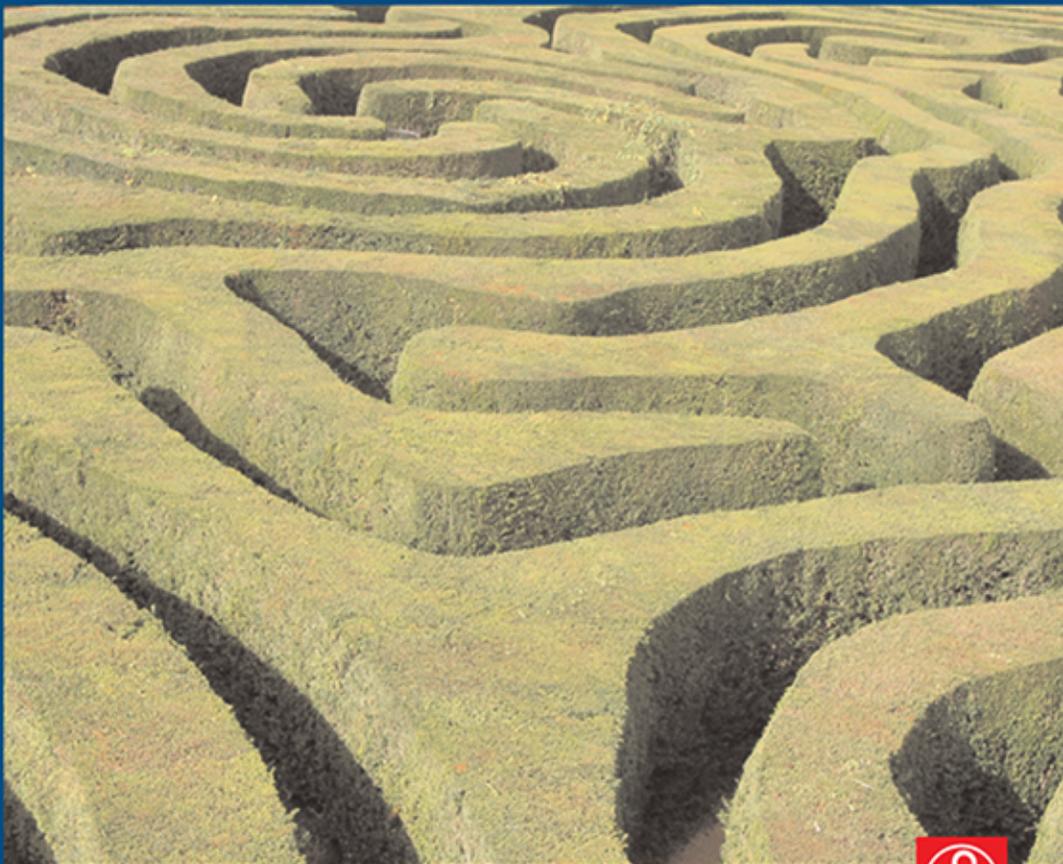
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High Definition Postproduction

Editing and Delivering HD Video



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CHAPTER 1

High Definition— A Multi-Format Video

“High definition” refers to a family of high quality video image and sound formats that has recently become very popular both in the broadcasting community and the consumer market. High definition (HD) in the United States was initially defined as any video format that had more than 720 (horizontal) lines of vertical resolution. The ATSC (Advanced Television Systems Committee) created a digital television (DTV) broadcast table that defined not only the vertical resolution but also other aspects of the HD frame rate and size. This table defined two sizes of high definition images: 720 (horizontal) by 1280 (vertical) lines and 1080 (horizontal) by 1920 (vertical) lines of resolution. Along with the two frame sizes, there is also a choice of frame rates: 23.98, 24, 29.97, 30, 59.94, and 60 frames per second.

Why This Book Exists

Just looking at the previous paragraph, it is apparent that there are quite a few format choices in HD. To add to the confusion, there is an issue of manufacturers and even professionals mislabeling technical formats and processes. My goal is to identify the misinformation issues and generally describe what is happening in the HD world, giving the reader a basic understanding of what high definition is and what its possibilities are in the near future.

The main purpose of this book is to explain the choices that HD offers and to point to some of the current “accepted” production

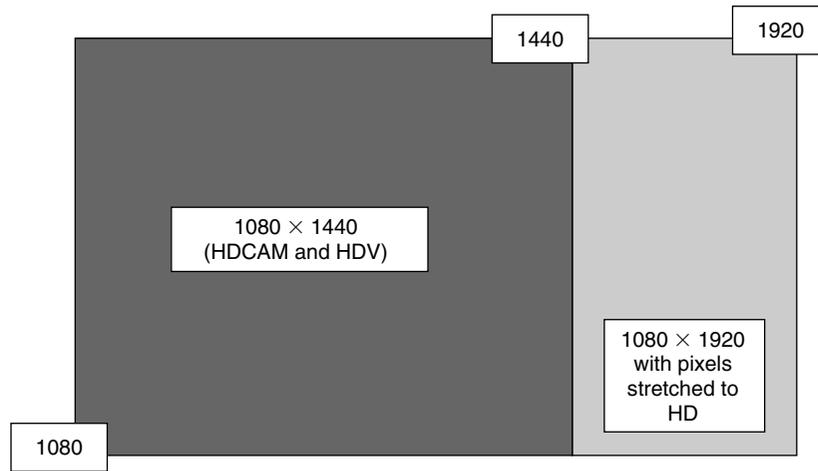


Figure 1.1 Several camcorders do not record the full 1920 lines of resolution when storing 1080 format. Instead, 1440 lines are recorded, and then on play out the horizontal pixels are stretched by 33%.

paths that are being used today. Incredibly, there is still a great deal of confusion even in the professional world concerning HD. There are a few established workpaths—certainly with daily broadcasts of HD programming on cable and OTA (over the air) broadcasting this has to be true. Yet a lack of understanding or just a lack of communication has created costly mistakes that show up in the postproduction phase.

This book should, at the very least, clear up some of the misconceptions and point to the easy path from production to delivery.

Also known as “HD” and “high def,” high definition video has rapidly become a consumer buzz word. After years of languishing in the shadows of the popular and totally accepted standard definition (NTSC) format, high definition has finally taken the step into the spotlight. With exciting, low cost, and high quality HDV cameras, new camera lines coming along with even more rapid developments in editing and video displays, consumers

Table 1.1 The HD ATSC Broadcast Table.

Format Level	Vertical Pixels	Horizontal Pixels	Aspect Ratio	Scan Mode	Frame Rate
HD	1080	1920	16:9	Progressive	24 or 23.98
HD	1080	1920	16:9	Progressive	30 or 29.97
HD	1080	1920	16:9	Interlaced	30 or 29.97
HD	720	1280	16:9	Progressive	24 or 23.98
HD	720	1280	16:9	Progressive	30 or 29.97
HD	720	1280	16:9	Progressive	60 or 59.94

The HD ATSC broadcast table shown displays the 12 high definition broadcast formats, six of which are designed to integrate with the NTSC broadcast frame rate. When the analog NTSC broadcasting frequencies are returned to the federal government in February of 2009, the integer frame rates will probably be used more often. Many professionals think there are only six high definition digital broadcast formats, but these are the NTSC compatible frame rates. The others are integer frame rates either used for true film transfer or for future integer frame rates. Note that the only interlaced format is the 1080 frame size.

and professionals alike are diving into HD with money, interest, and passion.

HD has gone from obscurity to being a household term. High def flatscreens have become a “must have” technological “cool item” like the iPod and cell phone. HD has left the esoteric video world and plunged headlong into the mainstream. High definition video televisions, cameras, and recording devices are now being embraced by retailers, beleaguered broadcasters, excited independent filmmakers, and even reticent movie studios. Even more exciting is the extremely rapid pace at which improvements are being made in the manufacturing of production equipment, editing, and effects, and probably most importantly for continued growth, consumer products are getting better and cheaper.

Rather than being a single record and playback format, the high definition family offers a matrix of choices that include frame rates, frame sizes, and compression processes. Along with these obvious differences noted in the ATSC digital television table, there are many other production choices in high definition.

These options of what format to shoot and deliver are usually decided by the network or the broadcast company long before production commences so that the postproduction workflow runs smoothly. Students, independent filmmakers, and documentary producers are choosing alternative workflow paths. These creative individuals are pioneering new ground and techniques, some of which have been embraced, while others have been left behind as unsuccessful.

High Definition is Settling Down and Growing Up

When one first realizes the great number of production format choices that currently exist, making the decision as to the correct one for your project can seem overwhelming. But there are some consolations. There are several production formats that have become established as standards.

High Definition Size

In the broadcasting world, most professionals refer to HD as video that is compatible with the 12 standards as defined by the ATSC DTV broadcasting table. As mentioned earlier, the ATSC DTV table cites two frame sizes for high definition: 720 (vertical) by 1280 (horizontal) lines and 1080 (vertical) by 1920 (horizontal). However, there are several video recording processes that record 1440 horizontal lines of resolution in a horizontally reduced ratio. Then, when it is played out, the horizontal pixels are stretched by 33% to produce 1920 lines of resolution (HDCAM and HDV) (see Figure 1.1).

Delivery Determines Production Format

When considering a production's acquisition format, one has to examine the delivery aspect of the program to determine how the high definition image will be recorded.

The particular aspects that should be considered are the following:

- Frame size—either 1080 or 720 vertical lines of resolution

- Frame rate—23.98, 24, 29.97, 30, 59.94 or 60 frames per second
- Bit depth—usually eight bits but sometimes 10
- Compression—a variety of types exist, the most common of which is chroma subsampling

At this time, there are over 60 production and manufacturer choices in the high definition family, and more are on the way.

History

The HD choices began when the ATSC created the digital television table of 36 digital broadcast (DTV) formats. Of those 36 formats, 12 are high definition. These are the formats that the United States government has determined will be the standard for digital broadcasting.

Just as there are many compatible production formats developed for NTSC broadcast, the 12 high definition formats also have a number of compatible production formats to choose from. However, where NTSC has a single frame rate and a single frame size, the DTV high definition format has a dozen different choices. As a result, there are even more possibilities when it comes to the hardware that captures and records those images.

Also, as technology improved, each NTSC production format was basically compatible with the next. However, in the high definition world, not all the frame rates are compatible with each other.

The net result is that there is often confusion about which format should be used.

A Typical Family

In reality, high definition is not a single format at all, but a family of broadcast and production formats with a variety of choices on the set, in postproduction, and even for broadcasters.

- There are three elements that are usually indicated in a high definition notation: frame size, recording method, and image rate. Because this format is new to many people, the order of these aspects is not standardized, and there are verbal shortcuts.
- For the purpose of consistency, this book will notate HD in the following pattern:
- Frame size, recording method, and image rate. So a 1080 frame size shot progressive segmented at 29.97 would be notated as the following:
- 1080psf29.97
- However, a 1080 interlaced at 29.97 is usually notated as 1080i59.94

The reason for this is that the interlaced 29.97 format has 59.94 images per second, and this notation sets it dramatically apart from the progressive frame rate. It could also be notated as 1080i29.97, but one can see the potential for confusion. It can also be called 1080i, 29.97i, and 1080i59.94.

For the purpose of this text, interlaced 1080 will be noted as 1080i59.94.

Because not all the high definition frame rates are compatible with each other, preproduction planning is vital to the success of any high definition project, much more than for a standard definition project.

Ideally, the delivery frame size and frame rate should be established well before any production begins. This allows for testing of specific cameras, editing equipment, and even effects. There are so many new developments occurring in the HD equipment world, one should always check to see what the current workflow, equipment, and other devices are that have become accepted into the HD community.

Some formats can only be digitized or edited on specific editing systems. Shooting at an incompatible or different frame rate and/or frame size from the final delivery format can potentially cause



Figure 1.2 Sanyo HD1. Sanyo's HD1—a low cost consumer HD camera that shoots progressive 720 frames, uses MPEG4 compression, and can take 5 mega pixel stills. Many videographers are purchasing HDV cameras even if their end product is going to be in standard definition because the higher quality of HDV is apparent even when down converted. (Photo courtesy of the Sanyo Corporation.)

costly delays and expensive problems during the postproduction process.

It is important to note that although HD can be recorded in specific frame rates and sizes, different cameras have different “looks.” HDV and HD cameras can record their high definition images at various data rates by employing different types of compression. Again, because there are so many production choices beyond the 12 DTV broadcast formats, care must be taken when planning an HD production.

The “Universal” Format

One high definition frame rate, 1080p23.98, is able to be converted to many other high def frame rates and sizes. As a result, this format is informally called a universal format. As an example, if one shoots a program and edits in 1080p23.98 and outputs the resulting program in the same format, the edited master can be converted to almost any format including PAL and standard definition NTSC, often directly from a video playback deck. In many cases, the non-linear editor can also play out the images at other frame rates and sizes.

Although this frame rate has the advantage of being able to convert to other high definition formats, it may not be acceptable as a production format for a particular network. Many networks require that a program be shot *and delivered* in a specific frame rate and size. A rate of 23.98 frames per second has a unique look and may not be the best choice when a production contains a great deal of action or movement. Some clients do not want their camera’s original footage shot at 23.98, even though it could then be converted to the specific delivery requirement.

If a company is creating a show for a specific network, sometimes the choice becomes easier. NBC, HDNet, Discovery HD, HBO, and CBS air 1080i59.94. ABC and ESPN air their programs in 720p59.94.

- Progressive segmented frame (PsF) recording is a recording method that stores a progressive image as two separate fields: odd lines, then even. The difference between a PsF frame and an interlaced one is that the two fields of the PsF image are of the same image and then are combined. The interlaced fields contain two separate and distinct images and are not combined but displayed one after another. This, in effect, halves the resolution of the interlaced frame.
- When the PsF image is reconstructed and displayed, it is viewed as a single progressive frame.
- The progressive segmented frame is a technical way of storing a progressive signal using interlace-type technology.

The best solution to any production question is to obtain the company's delivery requirements before shooting begins.

Careful attention needs to be taken when working with high definition delivery specifications. Networks and other broadcasters are very specific about what kind of high definition is being shot, how it is captured in the editing system, and how it is output to tape. Most delivery specs even dictate the length of the slate, where information is placed, and on what lines the VITC (Vertical Interval Time Code) is recorded. Some clients request separate outputs for protection masters, rather than dubs of the original master.

Even More Choices and Confusion

As one can see from the previous high definition tables, there are 12 HD broadcast (as opposed to recording) formats based on frame size, scan mode, and frame rate. Additional confusion about the various formats has been introduced because of the following two issues.

Multiple Labels

The first problem that has compounded the high definition confusion is that individuals, manufacturers, and reporters have used different names for the same technical process or format. Worse yet,

Table 1.2 PAL-Compatible HD Broadcast Formats.

Format Level	Vertical Pixels	Horizontal Pixels	Aspect Ratio	Frame Rate	Scan Mode
HD	1080	1920	16:9	25	Progressive
HD	720	1280	16:9	25	Progressive
HD	720	1280	16:9	50	Progressive
HD	1080	1920	16:9	50	Interlaced

The high definition format is also designed to be compatible with PAL. Because PAL is an integer format, it does not have additional fractional frame rates. The reason PAL runs at a different frame rate is that it was designed for Europe's power structure, which runs at 50 Hz. The United States power is 60 Hz, thus the 30-frame (60-field) and 60-frame progressive rates.

some have used and continue to use the wrong labels. For instance, one individual might call a format 1080i29.97 and someone else will call it 1080i59.94. They are both the same. Another person might erroneously describe the same format as 1080 60i. Rounding frame rates to the nearest whole number can cause problems because six of the HD broadcast formats are whole numbers.

If one is not very precise about a particular format, mistakes can be made. More than one tape has been recorded on location at the wrong frame rate because someone said the show's format was 1080i at 30 frames per second. That tape came back from the location shoot recorded at a true 30 frames per second, when the producer really meant to shoot at 1080i59.94.

Many manufacturers do not use the fractional frame rates for fear of confusing the consumer. Sometimes a frame rate of 30 can really mean 29.97 frames per second, and other times it actually does mean a true 30 frames per second. As a rule, one should only believe a 30 frame per second claim when there is the capability to record 29.97 frames per second as well. Careful examination of a camera or record deck's manual is the only real way to determine if an integer frame rate is really just that. All too often the sales literature, website, and even sales personnel do not really know the exact technical details. Another indicator of what a production frame rate should be is if the program is intended for broadcast. Currently most productions shoot in frame rates that are compatible with NTSC. All NTSC-compatible frame rates are fractional, not whole numbers.

Many Manufacturer Choices

The second confusing issue about high definition production formats is that when color sampling and subsampling, bit depth, compression, codecs, and individual manufacturers' tape and media formats are considered, there are many, many choices. It is difficult to understand what the correct choice really should be.

High Definition is Not New

In 1982, the Advanced Television Systems Committee (ATSC) was formed to establish technical standards for the country's digital

Table 1.3 The ATSC Broadcast Format Chart

The following chart summarizes all 36 ATSC digital television formats (DTV), 12 of which are high definition.

Format Level	Vertical Pixels	Horizontal Pixels	Pixel Shape	Aspect Ratio	Scan Mode	Frame Rate*
HD	1080	1920	Square	16:9	Progressive	24/23.98
HD	1080	1920	Square	16:9	Progressive	30/29.97
HD	1080	1920	Square	16:9	Interlaced	30/29.97
HD	720	1280	Square	16:9	Progressive	24/23.98
HD	720	1280	Square	16:9	Progressive	30/29.97
HD	720	1280	Square	16:9	Progressive	60/59.94
ED	480	704	Rectangular	16:9	Progressive	24/23.98
ED	480	704	Rectangular	16:9	Progressive	30/29.97
ED	480	704	Rectangular	16:9	Progressive	60/59.94
ED	480	704	Rectangular	4:3	Progressive	24/23.98
ED	480	704	Rectangular	4:3	Progressive	30/23.98
ED	480	704	Rectangular	4:3	Progressive	60/59.94
ED	480	704	Square	4:3	Progressive	24/23.98
ED	480	640	Square	4:3	Progressive	30/27.97
ED	480	640	Square	4:3	Progressive	60/59.94
SD	480	704	Rectangular	16:9	Interlaced	30/29.97
SD	480	704	Rectangular	4:3	Interlaced	30/29.97
SD	480	640	Square	4:3	Interlaced	30/29.97

This digital broadcasting chart includes standard definition digital formats, enhanced definition, and high definition. In this author's opinion, there are 12 HD formats (listed in Table 1.2) along with the remaining 24 ED and SD formats. Note that although there are 18 formats listed, there are actually two for each when one considers the NTSC-compatible frame rates as well as the integer frame rates. These fractional rates are designed to be compatible with the 29.97 NTSC frame rate. However, digital broadcasting does not require fractional frame rates and these will probably become obsolete as analog broadcasting comes to a close.

advanced television systems. This committee was similar to its predecessor, the National Television Standards Committee (NTSC), which established the United States' television format over 50 years ago.

The ATSC defined the 36 digital broadcast standards we have today. Twelve of these formats with the frame sizes of 720 and 1080 are high definition. Once these ATSC broadcast standards were established, manufacturers began developing and selling the production and postproduction equipment that would be compatible with them.

The ATSC broadcast table does not reflect any of the details of manufacturers' tape formats, color space, bit depth, color sampling rates, or data compression. The ATSC table only includes the formats that are available to broadcasters for OTA broadcasting. In comparison, NTSC is a specific process of broadcasting a composite signal. NTSC is broadcast as an analog signal with the four components of a color picture encoded into a single signal. Today's NTSC compatible production formats use component recording where three of the four components of the color picture are recorded separately (the fourth is derived mathematically from the other three). This component recording method is far superior to composite recordings that were previously used. However, despite being recorded digitally, by using component processing, programs are converted to a composite signal for standard definition NTSC analog broadcasting.

This inferior method of broadcasting is now going to be replaced with the far superior digital transmission that is capable of component delivery.

On December 24, 1996, the Federal Communications Commission (FCC) formally adopted the ATSC Digital Television Standards. Despite the promise of an exciting new visual frontier, economic forces stalled the introduction of high definition video into the mainstream broadcasting and production workflow. In the past, as video technology advanced, not only did the quality improve, the cost of the new machines was also generally cheaper. High definition came with a very different economic model. The large HD image along with technically complicated multi-format machines resulted in very expensive recorders/players that required new editing systems, new wiring, new sync generators, and a lot of training.

As part of the HD spectrum, there are several PAL-compatible formats. Even though HD has been slow to catch on with European broadcasters and consumers, more programming is becoming available both over the air and for pay TV. The three European HD formats are 720p50, 720p50, 1080i25, and 1080i50. With the BBC adding more HD channels and more HD productions migrating to the PAL-compatible frame rates, the HD experience will be felt on both sides of the Atlantic.

- On a recent visit to a television repair shop, I asked the owner what he and his clients thought about the high definition revolution. His answer explained why high definition did not take off as some people had expected.
- “They started to ask some questions, but got this glazed look on their face when I tried to explain what HD was. It was too complicated. Actually, most people who buy a high definition television set do not even know how to get the HD signal into the TV. They become overwhelmed. I’ve discovered some people who bought a large screen HD set were watching standard definition because they didn’t know how to get the HD signal into the set.”
- I tell people unless they really want to see a clearer, brighter picture, they don’t need high definition. It doesn’t make a show any funnier or more dramatic.”

As a result of all this new, complicated technology, the prices for high definition cameras, record decks, rewiring studios, redesigning machine rooms, and even the cost of a multi-format monitor were much higher than the equipment they were replacing. Broadcasters had to purchase and erect new antennas as well as create new infrastructures to handle the high definition signal.

What worsened the problem, from an economic standpoint, was the lack of interest from the consumer market. Consumers did not want to spend thousands of dollars for a new television. Without an audience, there was no reason to create HD programming. The government was pushing broadcasters to use the digital broadcast channels, but the broadcasters were merely sending standard definition programming out on the digital airwaves.

To add to the slow growth, the broadcasters had no additional income to offset the increased cost of an entirely new media path. So, in the beginning of digital broadcasting there was no incentive to pursue the production or broadcasting of high definition seriously. There was very little programming sent out on the digital frequencies, and if there was any, it was mostly standard definition NTSC.

In the past, as new videotape formats and their accompanying record decks were introduced, commercial producers were quick to use the new high tech equipment, increasing their clients’ visibility, pushing

the boundaries of effects, and increasing the quality of their products. Whether it was a leap from analog to digital recording formats, or the even more impressive conversion from composite recoding (a single video signal) to component recording (where three signals comprised the image), the transition was not that expensive. In addition, each new format was compatible with the existing NTSC video and broadcasting environment.

This was not the case with high definition. Advertisers, usually the first to employ new technology, saw no economic reason to support the expensive format. Only a small percentage of the population was watching digital broadcasts. The standard definition simultaneous broadcasts did not show the entire frame, and the expense for the added resolution was lost on most of the population. No one was watching and no one cared.

History had proven that consumers in the United States were not that interested in improved visual quality. After all, the United States' con-

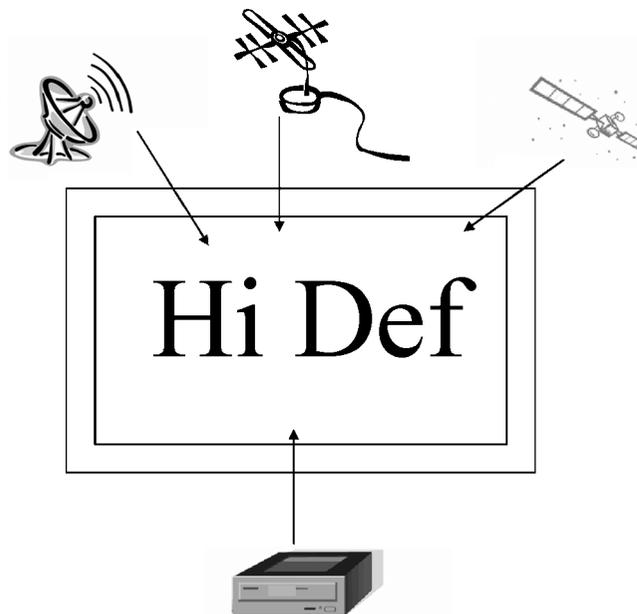


Figure 1.3 Paths to HD TV.

Government Gives Additional Channels for Television Stations

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sumers were the ones who had chosen the cheaper, technically inferior VHS over the more expensive Betamax for their home video format.