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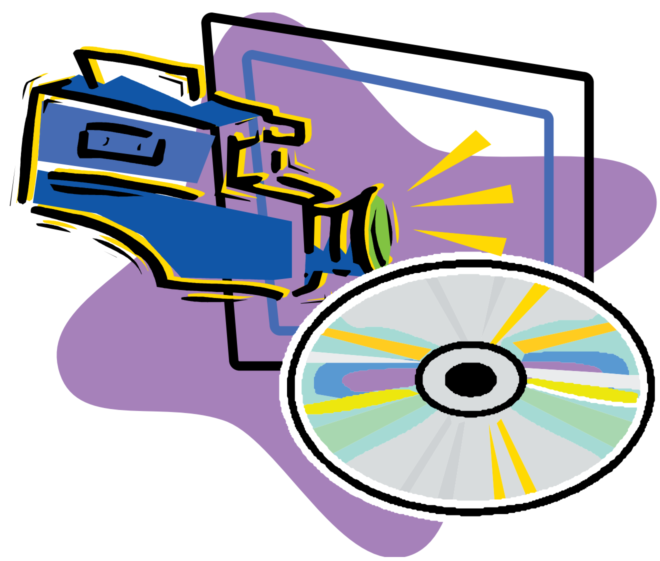
Adobe

A DVD Primer

From DV to DVD: Enriching the experience of high-quality video



from the Adobe
Digital Video Group

INTRODUCTION

From Stone Age to Bronze Age to Industrial Age to Information Age, humans have found new ways to communicate and to tell stories that educate, inform, and entertain. Audiences have evolved from polite passivity, glad to receive whatever reports, hearsay, or diversion might be found locally; through the wonder of entertainment and news choices brought to them by national and international media networks; to an explosion of possibilities that are available on demand via cable, satellite, and the Internet. With digital technology transforming the ways in which we access and utilize information, we have witnessed the dawn of the Interactive Age. We have become a society enraptured with decision-making on every level—empowered to choose exactly what to read, listen to, and view; when, where, and how.

So it comes as no surprise that by 2000, within just three years of its introduction in September 1997, DVD had become the most successful consumer electronics entertainment product ever. Facilitating interactivity unfulfilled by VHS, at a more affordable cost than laser disc, DVD has outpaced the consumer adoption rate of any other product in history. Analysts predict that the total market for all types of DVD systems (players, recorders, set-tops, PCs, etc.) will be over 400 million units by 2006.

While DVD players have rapidly become de rigueur in home entertainment systems, and DVD drives are continuing to replace CD drives in personal and laptop computers, there have also been some other developments that have been changing the way we experience and use video:

- With the availability of the DV format and affordability of DV camcorders, more and more people are producing their own videos—for work and for their own entertainment.
- Nonlinear editing software has made capturing video to computers and crafting compelling video productions affordable and as easy as word processing.
- DVD authoring can transform content into a much richer experience—in other words, DVD is not just another digital video output format.

At the same time, recordable CD technology has enabled even the most unsophisticated computer users to become adept at selecting, organizing, and storing their own collections of imagery and audio. The overwhelming success of CD has paved the way for recordable DVD, offering users still greater media capacity and the capability required for broadcast-quality resolution. Using a new generation of affordable hardware and software, people around the world are discovering how they can prepare their own video and graphics, put them together in a DVD authoring application, and burn their own DVDs.

This Primer is a good way of getting acquainted with DVD technology. It will introduce you to key concepts and help you get started learning about the process of making your own DVDs—for business or pleasure. It won't tell you everything about DVD technology, but it will give you an overview of the basics. You'll find out how you can use DVD to make your video content more dynamic. At the very least, you'll learn enough to be an informed member of a work group planning and producing DVD projects.

If you are a beginner, you'll find out how easy it can be to develop and author your own DVDs. And, if you are already creating video productions, this Primer will introduce you to the state-of-the-art technologies you can use to repurpose your content for DVD distribution.

As you read through this Primer, you might encounter unfamiliar words or abbreviations. Most of these terms (those highlighted in **boldface** type) are defined in the Glossary at the end of this Primer, and many will also be covered in greater detail as you read on.

CONTENTS

WHAT IS DVD?

DVD is an acronym for Digital Video Disc or Digital Versatile Disc—an optical disc storage medium similar to CD (Compact Disc), but capable of holding far more data. DVD stands for more than just the disc itself, however; it represents a whole system of technology standards for DVD discs, drives, and players and for the formats that support them. DVD technology offers the higher quality and speed needed to deliver cinema-like video and better-than-CD audio. DVD has been evolving while it has rapidly been brought to market, so it is not surprising that the basics and variations can be a bit confusing. Let's sort them out.

WHAT ARE THE ADVANTAGES OF DVD?

DVD outperforms other storage media

- ***Storage capacity:*** A CD stores a maximum of 650 MB (megabytes) of data. That's enough for approximately 74 minutes of audio. A DVD stores up to 4.7 GB (gigabytes) per layer, per side. Using **MPEG-2 compression**, a single-sided, single-layer DVD can easily accommodate an entire feature-length film with multichannel digital audio. A DVD-18 disc, with two layers on each side and a capacity of nearly 19 GB, can offer up to eight hours of video.
- ***Quality:*** DVD provides almost twice the video resolution of standard VHS videotape. Because video on DVD is stored digitally, the medium itself is not a source of **noise**. As a result, DVD provides a much clearer picture than what a system based on analog videotape can provide.
- ***Convenience and compatibility:*** Unlike the larger laser disc, a DVD is the same size and thickness as a CD. Most computer DVD drives have been designed to handle CD, as well as DVD. Unlike videotapes, DVDs never need to be rewound. DVDs offer interactive menus that let users randomly navigate content. The interactive capabilities of DVD empower users with a wide variety of choices and enable producers to offer audiences a range of experiences.
- ***Durability:*** While videotapes eventually wear out or break, DVDs are not subjected to wear as they are played because they are not physically in contact with the player's pickup mechanism as they spin. Therefore, video and audio recorded on DVDs suffer no loss of fidelity over time.

Designed to meet industry demands

- ***Computer industry:*** After CD, recordable and rewritable DVD provides the next-generation of convenience and higher capacity for data storage and archiving. Increasingly complex multimedia applications are continually being developed, which can easily be delivered via DVD.
- ***Motion picture industry:*** The movie industry sought a disc capable of holding a full-length feature film and delivering excellent quality video with surround sound audio.
- ***Music industry:*** The music industry wanted higher quality than CD, as well as greater capacity.
- ***Video game industry:*** DVD delivers realistic video content with longer playing time.

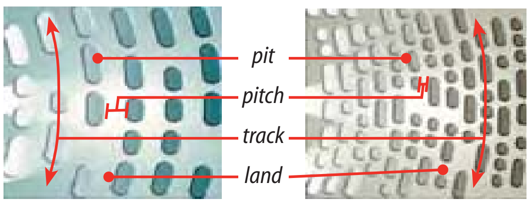
Standards are set by a single association

Considered the most successful consumer electronics entertainment product ever introduced to the marketplace, DVD owes its phenomenal success largely to the organization that governs its standards and promotes its acceptance—the **DVD Forum** (*www.dvdforum.org*). An often uneasy alliance of hardware manufacturers, software firms, and other users of digital versatile discs, this international association was established in 1995 as the DVD Consortium by 10 companies: Hitachi, Matsushita, Mitsubishi, Philips, Pioneer, Sony, Thomson Multimedia, Time-Warner, Toshiba, and JVC (Victor Company of Japan). Today, virtually every major company involved in DVD is a member of the DVD Forum, renamed as such in 1997. Unlike some memorably unsuccessful consumer electronics introductions in the past, DVD has benefitted from the industry-wide commitment to implementing consistent standards. While the road to achieving this unilateral vision has been fraught with discord and even intrigue, and has resulted in some uneasy compromises, the ultimate benefits for the consumer have been undeniable.

DISC CAPACITY AND UNITS OF MEASURE

The **pitch**, or space between **tracks** on a DVD disc is less than half the pitch between tracks on a CD, enabling more tracks to be placed on a DVD disc. Because the laser that reads them is more precise, the **pits** in which data is stored on a DVD are much smaller than CD pits, affording more pits per track.

CD: *Wider pitch, larger pits* ***DVD:*** *Less pitch, smaller pits*



Disc storage capacities

Disc type	Number of sides	Layers per side	Storage capacity	Hours of video
CD	1	1	650 MB	-
DVD-5	1	1	4.7 GB	2
DVD-9	1	2	8.5 GB	4
DVD-10	2	1	9.4 GB	4.5
DVD-14	2	2/1	12.32 GB	6.5
DVD-18	2	2	17 GB	8

Why you may not be able to fit a full two hours of video on a DVD-5 disc....

The chart above indicates what the medium *can* achieve, using the very best equipment and methodology. You'll learn how high-end pros can cram more data onto a disc using proprietary compression techniques and variable bit rate (VBR) encoding, later in this Primer.

An important note regarding the actual storage capacity of discs

You will usually see 4.7 GB given as the capacity for a single layer of DVD, just as you will typically see 650 MB given as the capacity for a CD. This is a convention that can cause problems when you are developing content, as you might have already learned the hard way. Trying to record too much data on a disc can result in having to throw away a spoiled disc.

In actuality, a single layer of DVD holds 4.7 ***billion bytes*** (aka G-bytes or BB), which is only 4.37 GB. A CD-ROM holds 650 ***million bytes***—really only 635 MB.

Some confusion arises because a kilobyte (KB) is commonly, but erroneously, thought to be 1,000 bytes, when it is actually 1,024 bytes. Why is this so? In the digital world, measurements are not metric, but based on a binary system (powers of 2). So a kilobyte represents 2 raised to the 10th power (2^{10}), which equals 1,024. 1 MB is *not* 1 million bytes, but precisely 1,048,576 (2^{20}) bytes; and 1 GB is *not*, in fact, 1 billion bytes, but is actually 1,073,741,824 (2^{30}) bytes.

THE COMPONENTS OF DVD TECHNOLOGY

The DVD disc

DVD discs look much like CDs (compact discs): both are the same diameter (120mm) and thickness (1.2mm). However, each layer (up to two) on each of the two sides of a DVD can hold up to seven times the data that can be stored on a single-sided, single-layer CD—up to 4.7 GB per layer. While the second layer on a dual-layer side of a DVD does not provide quite as much capacity as the first layer, a double-sided dual-layer DVD (DVD-18) can hold up to 17 GB of data!

(Please see the Disc Capacity sidebar to the left for an important note on storage capacity measurement units.)

At best, a CD provides only 74 minutes of audio—the approximate length of Beethoven's Ninth Symphony. With a storage capacity of 4.7 GB, a single layer on a single side of a DVD disc can deliver 7 hours and 24 minutes of CD-quality music—arguably all of Beethoven's most significant symphonic works*—or up to 2 hours of high-quality video.

Etched into the surface of the metallic discs that are bonded within the acrylic coatings of both CDs and DVDs are microscopic marks called **pits**. The surface area surrounding the pits is called **land**. The pits, arranged on spiral **tracks**, are "read" by a laser in the DVD drive or player. The device interprets the information, translating it into a signal that can, in turn, be utilized by a computer, television set, or audio receiver.

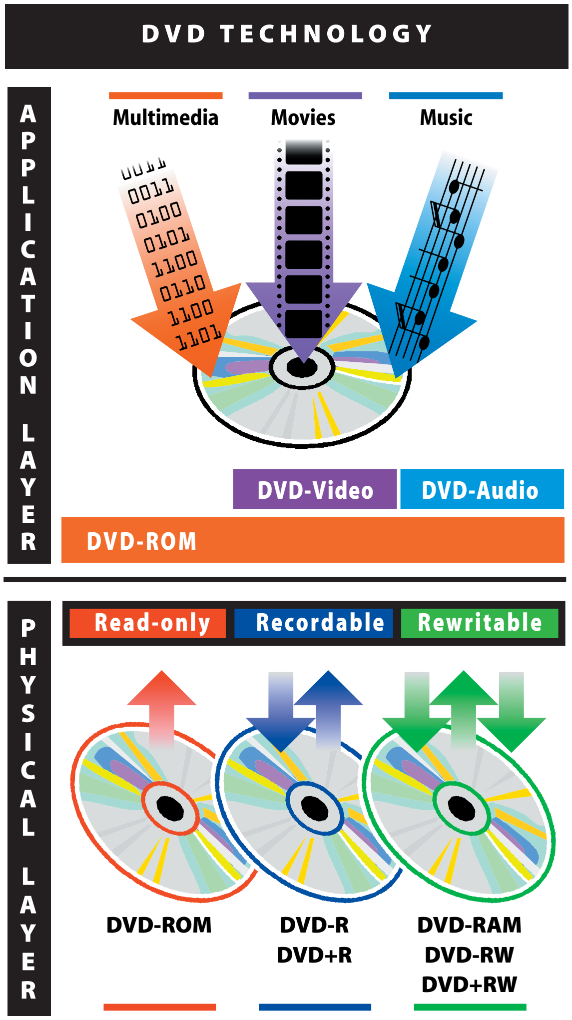
DVDs have greater capacity than CDs primarily because of better laser technology and a number of interrelated improvements. A smaller spot of laser light, produced by shorter wavelengths, enables the DVD laser to read smaller pits. The ability of the DVD laser to change focus gives it the ability to scan and read multiple layers. To make it easier for the laser to focus on the smaller pits, a thinner plastic substrate is used, resulting in a storage medium half the thickness of a CD, but too thin to withstand handling and playing. So DVDs are actually two discs bonded together (whether or not they are single- or double-sided), potentially doubling data storage capacity. Additionally, DVDs use a more efficient method of error correction than CDs, leaving more room on the disc for actual data.

Understanding DVD formats

Now we get to the confusing part. Just as in digital video, where the term "format" may be used to refer to a variety of different things, such as tape formats, broadcast formats, aspect ratios, or even content formats; in DVD, the term "format" also refers to different sets of characteristics, sometimes known as "technology layers."

At the most basic level, in the realm of DVD, we are primarily interested in two format types: the physical layer, which determines the recordability of a DVD disc, and the application layer, which governs how the data is stored on a disc and how it is played. There are three broad physical formats: read-only (DVD-ROM), recordable (DVD-R and DVD+R), and rewritable (DVD-RAM, DVD-RW, and DVD+RW).

* *Our apologies to Beethoven fanatics—no insult intended to the Master's less popular symphonies—just trying to make a point here.*



And there are three broad application formats: DVD-ROM, DVD-Video, and DVD-Audio. Confused? As you can see, the name "DVD-ROM" is used for both a physical and an application format, making the differentiation quite confusing!

Physical layer: Three DVD formats

Sometimes referred to as the physical layer, the capability of a DVD to be recorded to (or not) and to be rewritten (that is, erased and rerecorded) defines a format.

- ***Read-only:*** **DVD-ROM**, with its large data storage capacity, is perfect for delivering copyright-protected content such as movies and music, as well as multimedia and interactive applications like video games, training materials, and more.
- ***Recordable***: **DVD-R** and **DVD+R** are write-once, read-many storage formats akin to CD-R and CD+R. They cannot be erased and re-written. DVD-R and DVD+R discs can only be written to once, with the data being recorded sequentially. There are two types of DVD-R:
  - **DVD-R(A),** or DVD-R for Authoring, is aimed at the professional market and is used to generate masters for production recording.
  - **DVD-R(G)**, or DVD-R for General, was developed for the consumer market.

The "authoring" and "general" formats use different recording laser wavelengths, so they cannot be *written* interchangeably by the same devices. They can, however, both be *read* by DVD players or drives that support DVD-R media. DVD+R may, according to its proponents, through a different technology approach, offer some advantages over DVD-R, depending on your needs. (Read more about the +R and +RW formats in the list below.) But DVD-R(A) is still one of the most compatible formats available and has remained, therefore, the choice of many DVD professionals.

- ***Rewritable:*** The three variations of the rewritable format—DVD-RAM, DVD-RW, and DVD+RW—can be written to, erased, and rewritten, over and over again.
  - **DVD-RAM**, the first rewritable DVD format brought to market could, in its infancy, only be written while in a special cartridge because even a fingerprint left on the disc surface before writing would cause errors. Double-sided DVD-RAM discs came in sealed cartridges, which meant they couldn't even be inserted into standard DVD-ROM drives. But DVD-RAM technology is evolving rapidly, becoming more and more compatible to remain viable and competitive. Some DVD-RAM writers can now also write to DVD-R and DVD-RW discs.
  - **DVD-RW** (formerly known as DVD-ER and DVD-R/W) eliminated the protective cartridge that was at first required by DVD-RAM, making it compatible with the disc-loading mechanisms in DVD players and DVD-ROM drives. However, a variety of issues prevent some DVD-RW discs from being recognized by some DVD players and drives.
  - **DVD+RW** was (according to its advocates) designed to be compatible with most existing DVD drives and players but has not proven to be a perfect solution to the compatibility issue. While Minus-R (-R) and Minus-RW (-RW) are the recordable and rewritable formats supported by the DVD Forum, several manufacturers got together (including DVD Forum co-founders Philips, Sony, and Thomson) to create and manufacture the Plus RW (+RW), and later the Plus R (+R) formats. We won't go into the details here, but the features and benefits of the technology are somewhat different. If you are interested in the details, please see: ***www.dvdplusrw.org*** and ***www.dvdplusrw.org/resources/docs/howitworks.pdf***

FUTURE RECORDING FORMATS

The next generation: HD-DVD

The DVD Forum has been struggling to gain agreement on a single standard for the next-generation DVD format, to be known as **HD-DVD** (high-definition or high-density DVD). Current standard DVD technology accommodates up to 4.7 GB per single layer on a single side; HD-DVD proposals specify single-sided capacities of up to 27GB. Several formats are contenders including (but not limited to) those mentioned below.

Blue versus red laser technology

Blu-ray and several other HD-DVD technologies are based on a short wavelength blue-violet laser, rather than on the current-standard red laser. Of the major contenders listed below, all but HD-DVD-9 use blue-laser technology, which is not compatible with legacy red-laser DVD devices or with industry-standard replication equipment.

- While **HD-DVD-9**, backed primarily by Warner Brothers, is red-laser based, it will require players to handle a new video encoding format and a higher data rate.
- **Advanced Optical Disc (AOD)** or **DVD2**, primarily supported by Toshiba and NEC, is a modification of the existing DVD physical format to enable about 15 GB per layer using a blue-ultraviolet readout laser. AOD is designed to improve data capacity while theoretically being able to use existing replication equipment.
- Under development by LG, Panasonic, Philips, Pioneer, Hitachi, Mitsubishi, Samsung, Sharp, Sony, and Thomson, blue-laser based **Blu-ray Disc (BD)** will require significant changes to production equipment and all-new players. Blu-ray Discs will hold 23 to 27 GB per layer. Blu-ray is initially intended for home recording, professional recording, and data recording.
  Sony released the first BD recorder in Japan in April 2003. Mass-market distribution of prerecorded movies will come later, after the read-only format, called BD-ROM, is developed and the details of video, audio, interactivity, and copy protection are hammered out.

Will HD-DVD make DVDs obsolete?

HD discs (red- or blue-laser based) will not play on existing players, although HD-DVD-9 discs could play on DVD PCs with the right software upgrades. HD players are likely to read existing DVDs in addition to HD discs, so you probably won't have to replace your whole collection.

None of the recordable or rewritable formats currently available are fully compatible with each other or with legacy players and drives. Information can be found on the Web regarding specific player compatibility with different formats, but beware that results may vary, depending on media quality, player tolerances, handling, etc. For more information on the compatibility of specific devices, you might want to check out the following Web sites:

- *www.dvdmadeeasy.com*
- *www.vcdhelp.com/dvdplayers.php*
- *www.dvdplusrw.org/Compatibility.asp*

The industry is working to rectify this problem with manufacturers now offering combination devices. The DVD Forum has developed a certification program that guarantees compatibility with DVD-R, DVD-RW, and DVD-RAM for those devices displaying the **DVD Multi** logo. A DVD Multi player can read all three formats; a DVD Multi writer can record all three formats.

Application layer: three DVD formats

The application layer defines how data is stored on the disc, and how it is played in a DVD player or computer drive. The DVD-ROM application format, based on the UDF file system for optical media, is the foundation of the application layer. Some portion of what is recorded on every DVD will be in the pure DVD-ROM format. DVD-Video and DVD-Audio each define a more restricted logical format, comprised of video or audio (or both) format specifications, interactivity, and other rules including file-naming conventions. DVD-Video and DVD-Audio files must be placed in special folders within the DVD-ROM directory, called VIDEO-TS and AUDIO-TS, respectively. You don't need to understand all the nuances of DVD file structures to create DVDs; your DVD-authoring application will create valid DVD volume and file structures for you.

Any or all of the three application formats—DVD-ROM, DVD-Video, and DVD-Audio—can be stored on any of the three physical formats (with some variations). But, as you may have guessed, not all application formats can be played back on all devices.

- ▶ **DVD-ROM** has significantly larger capacity and achieves higher speed data retrieval than the CD-ROM application layer, making it an excellent medium for video games and other multimedia applications. For the most part, the DVD-ROM application format can only be played back by computer DVD drives. There are some proprietary DVD-ROM formats that may only be played back by specialized devices (video game platforms, for example, like Sony PlayStation, Xbox, Nintendo GameCube, and so on.)

  Note: Don't confuse the application format with the physical format—remember that DVD-ROM discs (the physical format) can have any or all of the three application formats recorded on them, and are compatible with most any DVD device; it is the application format, DVD-ROM, that can only be played back on computers or other specialized devices.

- ▶ **DVD-Video**, often referred to as simply DVD, provides excellent picture and sound quality, as well as the functionality needed to support interactive entertainment. How good is "excellent?" With capabilities far superior to VHS, DVD-Video offers near-cinema-quality video and can provide better-than-CD-quality audio. But, as with any medium capable of delivering high quality, the methods used in content creation and reproduction can diminish the ideal. DVD-Video typically uses **MPEG-2 compression**, a method that may result in occasionally noticeable **artifacts**, especially when backgrounds are complex or scenes change quickly, but more often when the compression process is not

DVD-VIDEO FEATURES

The DVD-Video format accommodates all of the following features. However, not all DVD-Video productions take advantage of all the available features.

1. **MPEG-1** or **MPEG-2**; **CBR** or **VBR** (constant or variable bit rate) encoding
2. Up to eight tracks of digital audio may be associated with a video track to accommodate multiple languages or **DVS**, for example; and each audio track may have as many as eight channels; each audio track can be in one of five formats: **Dolby Digital**, **MPEG-2** audio, **PCM**, **DTS**, or **SDDS**
3. A choice of **aspect ratios** and formats: **fullscreen** (4:3), **widescreen** (16:9), and **pan-and-scan**
4. Up to nine different **video tracks**, also known as **camera angles**, typically used for different viewpoints (for example, view of entire concert orchestra versus close-up on soloist)
5. **Subpictures** allow up to 32 subtitle sets for multilingual or other titling options, in addition to Closed Captioning
6. Interactivity made possible by automatic seamless branching of video, for varying story lines or audience ratings (for example, PG versus R)—a way to provide parental management
7. Menus and features that facilitate interactivity such as random navigation when video is chapterized, as well as edutainment opportunities such as Q&A, multiple-choice and true/false games and quizzes
8. Web enhancement that can extend the audience's experience beyond the DVD
9. Region Coding, limiting playback to devices purchased in the same region —a plan to control distribution
10. Built-in Content Protection

performed optimally. As MPEG encoding technology has evolved, and as technicians' compression skills have improved, the bar has been raised for generally accepted levels of quality for DVD-Video.

The quality of the audio portion of DVD-Video is similarly dependent upon the quality of the original material and how well it is processed and encoded. Capable of higher sampling sizes and rates than audio CD, DVD-Video offers the potential for superb sound quality. The audio for most prerecorded movies available on DVDs typically takes advantage of multichannel surround sound using **Dolby Digital** or **DTS** audio compression similar to the cinema sound formats used in theaters.

DVD-Video can be played by DVD players and computer drives, although some incompatibilities may occur depending on the physical format.

► **DVD-Audio** is a separate specification, designed to replace CD as the standard distribution medium for music. It includes the capability for even higher quality audio than DVD-Video. The DVD-Audio format delivers what Toshiba Corp. characterize as "a vivid, you-are-there audio experience." With fewer than 200 DVD-Audio titles available at the end of 2001, you might wonder why music DVDs have not proliferated at the same rate as movie DVDs and why DVD-Audio is not often found in combination with DVD-Video on major motion picture releases.

The completion of the DVD-Audio format specification came late, with the introduction of DVD-Audio to the mass market lagging behind DVD-Video by nearly four years. The music industry has been less than enthusiastic about retooling for music DVD, and issues related to copyright protection remain at the forefront of ongoing delays. Furthermore, there is a shortage of good authoring software for DVD-Audio. But the most significant hurdle, at present, is that DVD-Audio content is stored on the DVD disc in a separate DVD-Audio zone (the AUDIO_TS directory) that legacy DVD-Video players were not designed to read. So the DVD-Audio format, when recorded on a disc, requires a separate device for playback, or a new universal player, also known as a VCAP (video-capable audio player), that can play both the DVD-Video and the DVD-Audio formats. DVDs can, however, be authored to include both DVD-Audio and a Dolby Digital version of the audio stored in the DVD-Video zone, so that audiences can have a choice, depending on what type of player they have.

THE FEATURES OF DVD-VIDEO

DVD-Video offers an array of features that give audiences unprecedented choices. Other DVD-Video features, such as Region Coding and copyright protection, limit audience options. When you create your own DVD content, you can choose which features to incorporate into your DVD productions.

The next section explores DVD-Video features, focusing on the video basics you'll want to understand to make the best decisions for your DVD productions. In this Primer, we do not cover digital video basics. To learn more about digital video, please download the ***Adobe Digital Video Primer*** at ***www.adobe.com/motion/events/pdfs/dvprimer.pdf***

If widescreen had not found popular acceptance at the movies in the 1950s, 3D might have been a feature choice on DVDs today, and we'd all be wearing those silly 3D glasses in our living rooms. Find out why in the next section!

A single frame of uncompressed video takes about 1 megabyte (1 MB) of space to store. You can calculate this by multiplying the horizontal resolution (720 pixels) by the vertical resolution (486 pixels), and then multiplying by 3 bytes for the RGB color information. At the standard video rate of 29.97 frames per second, this would result in more than 30 MB of storage required for each and every second of uncompressed video! It would, therefore, take over 1.5 gigabytes (GB) to hold a minute of uncompressed video!

—Adobe DV Primer*

DVD-VIDEO BASICS

VIDEO COMPRESSION

A single layer of DVD can hold up to 4.7 GB of data. That may sound like a lot, but we're talking video here. It takes more than 1.5 GB of data to describe just a minute of broadcast-quality video at full resolution and frame rate. "So just how," you are probably wondering, "Does DVD cram two Hollywood hours onto a single-layer, single-sided disc that should only have enough capacity for about three New York minutes?" Through the magic of video **compression** and the evolution of a technology so significant that it was awarded an Emmy.

What is compression? What's a codec?

In order to conserve storage space, as well as to make data easier to convey and process, the amount of digital information used to describe video is reduced, or compressed, before being recorded onto DVDs. DVD players decompress the data for playback.

Compression is a form of encoding, but not all encoding is compression. Compression and decompression is handled by a **codec**, which is an acronym for "compressor/decompressor." You may also hear that it's shorthand for "encoder/decoder," but that is not an entirely accurate representation. The compression process is often part of the encoding process, but encoding may encompass more than just compression. For example, the process of encoding DVD-Video may also include adding Content Protection.

Codecs are found in hardware and software. A codec is a set of algorithms—that is, computer code—that is specifically designed to compress and decompress video or audio information. A codec may be hardwired into a circuit, as is the case in DVD players and on some video capture cards. A codec might also be entirely software-based. You may be familiar with software-based codecs available in video editing software such as Adobe® Premiere® Pro. Adobe Encore™ DVD software, delivering creative authoring for professional DVD production, offers integrated transcoding. Adobe Encore DVD can automatically convert your source files to the MPEG-2 video and Dolby Digital audio formats you need, or you can manually adjust the settings to optimize your DVD compression.

The codec used for decompression must match the codec used for compression. Different types of codecs have been developed to handle different types of tasks—some codecs are better than others for compressing and decompressing video during the editing process; some are better suited than others for streaming video across networks; some are fine for use in consumer video camcorders, while professionals might prefer equipment based on others. Data compressed by a specific type of codec can only be decompressed by that same type of codec. The DVD specification calls for MPEG compression—currently either MPEG-1 or MPEG-2. MPEG-2 is typically employed.

Making video fit into less storage space isn't the only reason to compress it. At a hefty 1 MB per frame, uncompressed broadcast-quality video would have to be read and processed at a rate of approximately 30 MB per second, assuming the 29.97 fps (frames per second) rate of NTSC, to be displayed in real time. If we convert the more familiar "storage" units (megabytes) into standard "shipment" units (megabits) by multiplying by 8 bits for every byte, the result is a rate of approximately 240 Mbps (megabits per second). But DVD technology can retrieve information at a maximum rate of only 10.08 Mbps. So, in addition to economizing on storage space, compression also reduces the amount of data that needs to be processed over time to a much more manageable rate.

If you would like to learn more about the basics of video compression, please refer to the ***Adobe Digital Video Primer*** at ***www.adobe.com/motion/events/pdfs/dvprimer.pdf***

MPEG

MPEG stands for the Motion Pictures Expert Group, a working group of ISO/IEC (International Organization for Standardization and International Electrotechnical Commission) responsible for the development of standards related to the coded representation of digital video and audio. Among other initiatives, the film, video, and music industry professionals comprising MPEG define the specifications for several video encoding formats that include compression and other features:

* *www.adobe.com/motion/events/pdfs/dvprimer.pdf*

The National Academy of Television Arts and Sciences (NATAS) awarded its 1995-1996 Engineering Emmy for Outstanding Achievement in Technological Development to the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) for their standardization work in media related to the coded representation of video, audio, and continuous-tone still images and systems for digital compression: MPEG-1, MPEG-2, and JPEG.

MPEG-1, limited to a frame size of 352x480 pixels (NTSC) or 352x576 pixels (PAL) and a fixed data rate of 1.15 Mbps, was the first MPEG standard established and is still used for CD-ROMs, video CD (VCD), and some Web video. It can be (but is only occasionally) used for DVD.

MPEG-2 has gained wide acceptance in the marketplace, and is the format most often used for DVD, as well as for satellite and cable television transmission. MPEG-2 can provide extremely high-quality video with frame sizes up to 720x480 pixels (NTSC) or 720x576 pixels (PAL). Readily supporting data rates in excess of 8 Mbps (equivalent to 1 MB per second), MPEG-2 is ideal for DVD.

MPEG-3 was abandoned as the industry moved on to complete MPEG-4. *(Note that MP3—which stands for MPEG-1, Layer 3—is an audio-only compression format and should not be confused with MPEG video formats. MP3 audio files, or "MP3s" as they are popularly known, may be saved onto DVDs, but not all DVD players will play them).*

MPEG-4 was developed to facilitate streaming video on the Web and over wireless networks, as well as providing mechanisms for multimedia interactivity. MPEG-4, with its lower bit-rate approach, may be adopted for HD-DVD, as previously mentioned in the "Future Recording Formats" sidebar on page 7.

Other MPEG formats are being developed, but we don't need to go into those here.

MPEG-2

The MPEG-2 video format includes a sophisticated codec that performs *both* **intraframe** (aka **spatial**) compression *and* **interframe** (aka **temporal**) compression.

Intraframe compression basically reduces the amount of data *within individual frames* by removing color information that will be undetectable by the human eye. (This is a simplification—other compression schemes also play a part in the intraframe compression used in the MPEG-2 format).

Interframe compression reduces the amount of data by replacing parts of some frames with mathematical predictions or interpolations, based on preceding and (sometimes) following frames.

MPEG-2 compression generates three different types of frames:

- ***I*** frames (which serve as the **keyframes** in MPEG-2) take advantage of intraframe compression, reducing the amount of information within the individual frames through **color sampling**, among other means. ***I*** frames preserve more information than ***P*** or ***B*** frames and are, therefore, the "largest" in terms of the amount of data needed to describe them.
- ***P*** frames are predictive frames, computed from previous frames, and may require less than a tenth of the data needed for ***I*** frames.
- ***B*** frames, or bi-directional frames, are computed from both previous frames and from frames that follow. ***B*** frames can be even smaller than ***P*** frames.

A typical MPEG-2 sequence might look something like: ***I B B P B B P B B P B B P P B***. Each sequence in MPEG compression is called a Group of Pictures (GOP). In the DVD-Video format, each GOP is limited to 18 frames for NTSC and 15 frames for PAL.

How each frame is compressed depends on the type of content. If the content is fairly static—for example, a "talking head" shot against a plain, still background—where not much changes from frame to frame, then few ***I*** frames will be needed, and the video can be compressed into a relatively small amount of data. But if the content is action-oriented—for example, a soccer game, where either the action or the background moves or changes rapidly or dramatically from frame to frame—then a greater amount of data is needed to maintain good quality and, therefore, the video cannot be compressed as much.

While MPEG-2 is an excellent compression choice for distribution, it is rarely employed while editing video. Relying on relatively complex algorithms for their sophisticated combination of intraframe and interframe compression, most MPEG-2 **codecs** take much longer to compress video than they do to decompress it, so it just isn't very practical for video editing. Perhaps it's even easier to understand why MPEG-2 is a poor choice for editing when you think about specific situations—for example, if you wanted to edit frame number 128 of your video. If frame number 128 is a ***P*** frame, the editing system might have to read frames 124, 125, 126, and 127 to compute what frame 128 actually looks like. Or what if you want to remove frame number 556, which happens to be an ***I*** frame? ***P*** and ***B*** frames that rely on the data describing frame number 556, may not be able to be completely recreated. So, depending on your video editing system and how ambitious your editing plans are, you might do some very basic editing to MPEG-2 video, but you will probably want to do most of your video editing before applying MPEG-2 compression.

It is important to note that not all MPEG-2 codecs are the same. MPEG-2 is not a patent; it is a set of standards—that is, specifications that must be met for the codec to qualify as MPEG-2 and for the encoding and decoding sides of the process to mesh. Codec developers have created and continue to create a wide variety of applications based on MPEG standards, some more eloquent or efficient than others. This is most significant when considering the ***en***coding side of the process, which can greatly impact the quality of the resulting decoded video. So long as the standard continues to be MPEG-2, the decoder chip in players will not need to change to yield better quality for video that has been compressed with better encoding technology.

CBR and VBR

MPEG-2 can be encoded in either the **CBR** (Constant Bit Rate) or **VBR** (Variable Bit Rate) mode. Which you choose is likely to depend on the length of your program and the nature of your content.

CBR, or ***Constant Bit Rate encoding***, as its name describes, means that compression is applied to yield a fixed, or constant, bit rate throughout the program. Meanwhile, the quality of the compressed video is allowed to vary. If CBR is used, it is important to be sure that a high enough data rate is selected to compress all the content well. So the data rate should be based on the portions of the video that are the most complex. If too low a data rate is selected, too much compression may be applied to portions of the program with lots of motion and change, causing the quality to degrade. Conversely, in those portions of the program without much action, the compression may not be very efficient—in effect, wasting bandwidth. CBR is fine, and often preferable, for short subjects and non action-oriented video.

VBR, or ***Variable Bit Rate encoding,*** considers quality first, adjusting the data rate to yield an appropriate amount of compression, depending on the content. VBR may yield the same average data rate as CBR, but the actual rate will vary from scene to scene *(see example to the left)*. Less compression is applied (that is, more data is allocated) to the more complex portions of the program, more compression (less data) to the simpler sequences. A minimum and maximum allowable rate are specified, providing the guidelines needed to keep the entire program to an acceptable size and data rate. When trying to fit a long program onto a DVD disc, VBR can make the difference between success and having to choose a more costly alternative.

It may seem like we've come back to math, again, when you just want to make video DVDs, but this is probably a good place to point out that the more extra features you want to include on your DVD, the more you will need to be concerned with keeping an accurate accounting of how the data is adding up. In addition to the video, you'll need to consider the data rate of the audio, at 192-448 Kbps per Dolby Digital stream, with up to eight streams supported; the rate of subtitles, at 4 Kbps per language or other track, with up to 32 tracks allowed. The math is really easy—just take the maximum data transfer rate of 10.08 Mbps for DVD-Video (i.e., video, audio, and subtitles combined) and subtract the total of the audio and subtitle tracks, as well as approximately 0.4 Mbps for headroom. What's left is the maximum available data rate for your most complex scenes. (Note that the maximum data transfer rate for video alone can be no greater than 9.8 Mbps.)

The bottom line is, if you are planning a complex project, plan ahead—and understand that sometimes compromises need to be made. Even on Hollywood-produced DVDs, the featurettes are often more highly compressed than the main feature.

If the content planned for a DVD is short relative to the disc capacity—under an hour for a DVD-5, perhaps—there is no need for VBR (Variable Bit Rate) encoding because the entire program will fit, even if it is all encoded at the 8.6 peak video bit rate for DVD. If the content is long—two hours, for example—the average rate would need to be cut by half—to approximately 4 Mbps—in order to fit. But complex scenes generally require at least 6 Mbps for acceptable quality. VBR encoding allows bits to be saved in the simpler scenes—such as a conversation between two people shot against a relatively static background—that may require no more than 2Mbps. Saved bits can be reallocated to the more complex scenes—such as those with lots of action.

BANDWIDTH MATH FOR DVD

For example:

Maximum DVD-Video transfer rate	10.08 Mbps
Headroom	- 0.4
5.1-channel (surround) English soundtrack	- 0.384
Two 2-channel (stereo) soundtracks in French and Spanish, each 0.192 Mbps	- 0.384
Peak data rate available for video	8.912 Mbps

AUDIO FOR DVD-VIDEO

Digital audio for the DVD-Video format is capable of producing extraordinary sound quality, as well as many flexible options. Up to eight audio streams, or soundtracks, can be delivered on a single disc, including different language versions and **DVS** *(see sidebar)*. DVD-Video can also deliver multiple audio coding formats on a single disc, for mono, stereo, and 5.1-channel surround sound. The number and types of streams that can be combined is flexible, but all must fit into the available bandwidth.

Because this Primer is on DVD-Video, this section focuses on digital audio for the DVD-Video format. It does not address the DVD-Audio format.

Digital audio basics

Sound engineers toss around a lot of technical terms. But the basic principles underlying digital audio are not too dissimilar from those upon which digital imagery and, therefore, digital video are based. Film and video work by stringing together still snapshots and relying on "persistence of vision" to recreate the sense of continuous motion. Similarly, digital audio takes audio snapshots, or **samples** of sound, thousands of times each second. The number of samples—that is, the **sampling rate**—is quoted in thousands of samples per second, or kilohertz. The kilohertz measure is abbreviated as KHz, where the "kilo" (K) number stands for 000s of samples, and "hertz" (Hz) denotes "per second." For example, 44,100 samples per second would be represented as 44.1 KHz, which is the sampling rate of audio CD. ***A higher sampling rate results in greater accuracy in digitally mapping the analog audio waveforms of the original sound.***

There's a lot to know about audio for DVD-Video... Adobe Encore DVD makes preparing your audio assets for DVD projects easier with automated transcoding presets for the audio formats you need. Easily convert audio source files to 48KHz using the integrated sample rate conversion capability. And Adobe Encore DVD supports two channels of Dolby Digital audio.

The **bit depth** used for samples is also an important factor in determining the accuracy of digital audio. Bit depth is the number of **bits** used to describe each sample. Because bits are binary (that is, representing a value of 1 or 0), each bit added doubles the potential for accuracy. At 16-bit depth, there are 65,536 possible levels; at 24-bit depth there are 16,777, 216 levels available to describe the audio sample. The zones between these discrete levels are called "quantizing intervals." When a sound falls between levels (that is, within a quantizing interval), it cannot be accurately represented and must be aproximated by rounding up or down to the nearest level—such rounding is referred to as "quantization noise." This is all getting a bit complicated. What you should take away from this Primer is that higher resolution (that is, more bit depth) usually leads to greater dynamic range: the dynamic range of 16-bit is 96 dB (decibels); the dynamic range of 24-bit is 144 dB. In other words: ***a greater bit depth yields a more accurate digital representation of the original, analog audio waveform.***

When you multiply sampling rate by bit depth by the number of channels used (for example, 2 for stereo; 6 for 5.1 surround), the result is the **data rate**—which is equivalent to the bandwidth needed to deliver the audio. The maximum data rate of audio CD, for example, can be figured as follows:

44,100 (sampling rate) X 16 (bit depth) X 2 (stereo channels) = 1,411,200 bits per second (1.4 Mbps)

The digitized audio waveform, when uncompressed, is known as **PCM**, short for "pulse code modulation." PCM may be "linear" or "nonlinear": **linear PCM** (LPCM) (which may be used for DVD) spreads values evenly across the range from highest to lowest; nonlinear PCM uses a nonlinear quantization curve to allocate values based on dynamic range.

DVS (Descriptive Video Service) is a national service (in the U.S.) that makes visual media accessible to people who are blind or visually impaired.

A DVS audio track on a DVD describes key visual elements such as action, costumes, gestures, and scene changes. Descriptive narration is carefully crafted and applied so as not to interfere with the program dialogue or original soundtrack.

For more information, visit ***http://main.wgbh.org/wgbh/pages/mag/services/description***.

Audio compression

In addition to **lossless**—that is, uncompressed—digital audio (LPCM), DVD-Video supports four types of **lossy** audio compression: MPEG audio (both MPEG-1 and MPEG-2), Dolby Digital, DTS, and the ATRAC compression format used by SDDS *(for descriptions of these formats, see "Audio formats for DVD-Video" on page 13 of this Primer).*

Humans notice loss of detail in what we hear much more than in what we see, so when encoding for DVD, less compression is applied to the audio than to the video. Because audio takes up a lot less space to begin with, you might wonder why we would bother to compress it at all—but the bottom line is that even the small amount of space gained by compressing audio provides enough room to yield a significant improvement in the quality of the video.

Video compression, as we have seen, uses two basic methods to reduce data:

- **perceptual** (intraframe) compression ***removes <u>irrelevant</u> visual information*** (mostly color) from individual frames that the human eye is incapable of perceiving or unlikely to perceive
- **temporal** (interframe) compression ***removes <u>redundant</u> information***, from frame to frame.

DOLBY DISTINCTIONS

Dolby Digital is the audio encoding format (and associated compression method) most commonly employed for commercial applications of the DVD-Video format. Dolby Digital is ***not*** synonymous with 5.1 surround sound; it is an encoding format that can be used for mono, dual-mono, stereo, Dolby Surround or any of eight different configurations *including* 5.1 surround. Dolby Digital encodes each channel separately (rather than matrix encoding—*see below)* to produce discrete multichannel audio (as opposed to psychoacoustic surround systems—like Dolby Surround—that use two speakers to create the *illusion* of surround sound). Virtually every DVD player, worldwide, has a built-in Dolby Digital decoder. If the system does not support discrete multichannel audio, the Dolby Digital decoder in the DVD player can downmix multichannel audio to two channels.

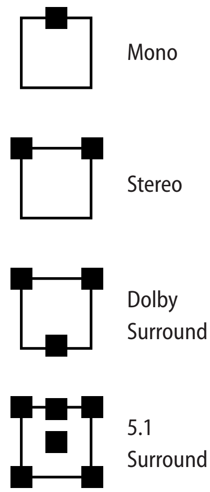
Dolby Digital Surround EX can, with the appropriate decoder installed in the system, extract an additional matrix-encoded surround channel, known as the back surround channel, to be sent to a speaker in the center rear of the listening environment. In effect, this can yield 6.1-channel surround sound. Listeners with a 5.1 channel set-up don't lose the back surround channel information; it remains mixed with the left surround and right surround channels.

Matrix encoding is the process of combining multiple channels into a standard, two-channel stereo signal.

Dolby Surround is an audio-encoding technique that uses matrix encoding to blend rear and center channels into a two-channel signal. Dolby Surround can be played on any stereo or mono system to achieve a psychoacoustic surround simulation. However, when Dolby Surround is played back on a multichannel system that has a Dolby Surround decoder, the left right, and rear channels are separated and fed to the designated speakers.
If the playback device is equipped with Dolby Pro-Logic, the center channel is also extracted. The Dolby Surround technique can be employed by analog audio, broadcast audio, PCM audio, Dolby Digital, DTS, MP3, or virtually any audio format.

Dolby Pro-Logic is the process of (and the processing circuit for) extracting the center and rear audio surround channels from matrix-encoded audio. The newer Dolby Pro-Logic II also processes the signals to generate more of a 3D audio experience.

Sound mode icons



In digital audio compression, blocks of samples are divided into frequency bands of equal or varying widths, and these bands are analyzed to determine how the compression will be applied. Audio compression uses similar methods to video compression:

- **Perceptual coding** ***removes irrelevant audio information*** the human ear won't perceive—either because it is out of the range of our hearing or because it is **masked** (that is, ignored by the human ear in favor of much louder sounds occurring concurrently, just prior to, or immediately following softer sounds).
- **Channel reduction** ***removes redundant audio information*** between channels, especially when there are six or eight channels.

Audio formats for DVD-Video

MPEG-2, Dolby Digital, and linear PCM (LPCM) are the three primary audio formats supported by DVD-Video. The DTS and SDDS (Sony Dynamic Digital Sound) formats are optionally supported, but, because these two formats are not required, not all players support them. DVD-Video for NTSC is required to include at least one track of either Dolby Digital or LPCM audio; DVD-Video for PAL must offer at least one track of Dolby Digital, MPEG, or PCM audio. Dolby Digital is currently the format most widely used for audio on DVD-Video.

Linear PCM (LPCM) is the lossless digital audio format used on most studio masters, as well as on audio CDs. For DVD-Video, LPCM can be sampled at 48 or 96 KHz at up to 24 bits, but some DVD players may subsample 96 KHz down to 48 and may not use all 20 or 24 bits. From one to eight channels are available, but sample rates and bit depth may be limited when five or more channels are used. The maximum bit rate is 6.144 Mbps. LPCM is rarely used for DVD-Video because of the bandwidth needed for multichannel implementations. However, tests indicate that the average listener is unable to tell the difference between uncompressed LPCM and MPEG-2 or Dolby Digital audio for DVD, which are usually compressed at about 10:1.

MPEG-1 audio delivers either monophonic or stereophonic audio and can only be CBR. It divides samples into frequency bands of equal widths, which is easier to implement but less accurate than using variable widths. MPEG-1 offers three compression techniques, called "layers." Layer II is the only one of the three MPEG-1 formats specified for DVD. (Layer III, also known as MP3, is the popular compression format for music distributed via the Internet and, although not supported in the DVD standard, some players will play MP3 files).

MPEG-2 audio allows VBR encoding to efficiently accommodate transient increases in signal complexity; although, in practice, this can prove to be problematic in passages where video and audio require simultaneous peaks, thereby pushing the combined data rate past the limit. It also adds multiple channels to produce (with the use of extensions) 5.1- or even up to 7.1-channel audio. Because MPEG-1 and -2 audio encoding for stereo is identical, MPEG-2 audio is backward compatible with MPEG-1 decoders.

Dolby Digital was designed with consumer delivery in mind and has, thereby, achieved a lead position in adoption over other multichannel systems. Most all DVDs offer a Dolby Digital soundtrack, and there's a Dolby Digital decoder built into virtually every DVD player, worldwide, that turns Dolby Digital into standard analog stereo audio, which can be played back by most any type of audio equipment including a standard TV. Dolby Digital audio compression, aka **AC-3**, enables frequency bands of varying widths that match the critical bands of human hearing, 5.1 audio offers five full-range channels—left, right, center, left surround, and right surround. A sixth channel, specifically for the rumbling LFE (low-frequency effects) which, in theaters, are more often felt than heard, is given the ".1" designation because LFE requires only about one-tenth the bandwidth of the full-range channels.

resulting in smoother sound than what can be achieved by fixed-width schemes. Dolby Digital also offers other features, such as dynamic range compression (DRC) and dialog normalization (DN) that allow volume levels to be tweaked by the listener to accommodate various situations. Dolby Digital provides for up to 5.1 channels of audio to create surround sound.

Digital Theater Systems (DTS), an optional format, was originally developed for theaters, but a home-theater version was developed that has become popular for DVD among audiophiles. DTS for DVD is usually compressed at 6:1 or 3:1, and some listeners report that the quality is better than MPEG-2 or Dolby Digital (both compressed at about 10:1). But differences may only be perceptible for playback on very high-end audio systems. DTS requires a special decoder, either in the DVD player or in an external receiver. Dolby Digital or PCM audio are required on NTSC discs, so all DTS DVDs also carry a Dolby Digital soundtrack because PCM and DTS together don't usually leave enough bandwidth for the video encoding of a full-length movie.

Sony Dynamic Digital Sound (SDDS), an optional multichannel audio format for DVD, is based on a theatrical soundtrack format that uses a type of compression called ATRAC. While SDDS is written into the DVD specification, it is a professional format intended only for motion picture theaters. Its eight-channel configuration, with five loudspeakers behind the screen, is not intended for typical 5.1 channel home systems so, unless SONY develops a consumer-targeted version of SDDS, it is unlikely to be used for DVD.

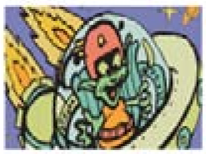
	SAMPLE RATE	BIT DEPTH	CHANNELS	BIT RATE
Linear PCM	48 or 96 KHz	16, 20, or 24 bits	From 1 to 8	6.144 Mbps maximum
MPEG Audio	48 KHz	16 or 20 bits	From 1 to 7.1	32 to 912 kbps *(384 kbps normal average)*
Dolby Digital	48 KHz	up to 24 bits	From 1 to 5.1 *(5.2 with new DTS-ES—Digital Surround ES*	64 to 448 kbps *(384 or 448 kbps recommended for 5.1 channels)*
DTS (Digital Theater Systems)	48 KHz	up to 24 bits	From 1 to 5.1 *(5.2 with new DTS-ES—Digital Surround ES*	64 to 1536 kbps *(typical rates of 754.5 and 1509.25 for 5.1 channels and 377 or 754 for 2 channels)*
SDDS (Sony Dynamic Digital Sound)	48 KHz	up to 24 bits	8 *(in theaters)*	Up to 1280 kbps

THX (Tomlinson Holman Experiment) is *not* an audio format. It is a patented certification and quality-control solution applied to commercial and home sound systems, theater acoustics, and digital mastering processes. The LucasFilm THX Digital Mastering program is a patented process and service for tracking video quality, step-by-step, through the multiple video generations needed to make a final format disc or tape.

Karaoke mode

Karaoke mode allows for five channels: two for stereo left and right (L and R) that are typically instrumental only, two optional vocal channels (V1 and V2) that may be used for harmonies, and an optional melody (M) or guide (G) channel that can help the karaoke singer carry the tune. Karaoke mode can only be fully implemented by DVD players with karaoke features for mixing the recorded audio and microphone input. All five audio formats for DVD-video support karaoke mode.

The yellow crop indicates the 1.37 (4:3) aspect ratio of the standard camera lens, the classic Academy Aperture, and TV. The red crop selects a widescreen, or "scope" view, with a 2.35 aspect ratio.



Shot with an anamorphic lens, the widescreen (red) crop shown above would look like this on film—remember that film frames have a 1.37 aspect ratio, so the widescreen image, with a wider aspect ratio, must be squeezed to fit.

Projected through an anamorphic lens, the image expands to look like this—exactly like the original (red) crop above.

Shot with a standard 4:3 camera lens, the scene would look like this—as indicated by the yellow crop in the top illustration—perfect for standard television viewing.

Masking either the camera lens or the projected image yields a similar widescreen look to using anamorphic lenses, but the quality is not the same—there is a loss in picture resolution.

ASPECT RATIOS

This section has a little math, a little Hollywood history, a little about digital television—and it's a little long. But stick with it—you'll eventually want to understand concepts like "anamorphic," which we've tried to make comprehensible here—even for non-techies. We'll get the math part over quickly, with just a couple of sentences: The width to height ratio of an image is termed its **aspect ratio**. The 35mm still photography film frames on which motion picture film was originally based have a 4:3 (width:height) ratio, which is often expressed as 1.33:1 or, simply, a 1.33 aspect ratio (multiplying the height by 1.33 yields the width). There. That wasn't so bad, was it?

Standard TV matches the Academy Aperture (4:3=1.33:1 or 1.37:1)

In 1927, the Academy of Motion Picture Arts and Sciences endorsed the 1.33 aspect ratio as the industry standard and it came to be known as the Academy Aperture. In 1931, the Academy Aperture was modified slightly to 1.37 to make room for a sound track. For the 60 years from 1917 to 1952, the 4:3 image area aspect ratio was used almost exclusively to make movies and to determine the shape of theater screens. When television was developed, existing camera lenses all used the 4:3 format, so the same aspect ratio was chosen as standard for the new broadcast medium.

Widescreen, aka "scope" formats (1.66:1–2.76:1)

In the early 1950s, the motion picture industry began to see television as a threat. In a frenzy to ensure that audiences left their living rooms and kept frequenting the cinema, all manner of gimmicks were tried, from color and sound innovations to 3D. In fact, if it weren't for the competition from black-and-white TV, it might have been much later before color was widely adopted for movies. Color technology was available as early as 1906 but, despite a few classic films like "The Phantom of the Opera" being shot in color in the 1920s, it was dismissed as too costly.

One crowd-pleaser that withstood the test of time was a wider aspect ratio. **Widescreen** offered audiences a "you-are-there" experience of panoramic cinematography. Based on a technique patented in the 1920s, Cinemascope was the first commercially successful widescreen format, making its debut in 1953 with the film "The Robe." To produce an aspect ratio of 2.35:1 without having to manufacture special film, cameras, or projectors, special **anamorphic** lenses were used. The anamorphic lens used on the camera for shooting widescreen squeezed the image width to fit on standard 4:3 format film. To show the movie, another anamorphic lens, one that stretched the image back to normal, was fitted to the projector. And, of course, this new extra-wide aspect ratio required an extra-wide screen. During the height of "scope" fever, the widest popular American film made was "Ben Hur," with an aspect ratio of 2.76:1. A host of copycat scope formats were introduced (Warnerscope, Technicscope, Panascope, and others), but the prohibitive cost of the special anamorphic lenses needed for both shooting and projecting, as well as the exhibitor's reliance on often unreliable projectionists to remember to attach the special lens to the projector, meant anamorphic "scope" techniques were reserved only for the most extravagant productions.

In the mid 1950s, someone realized that the scope effect could be achieved inexpensively—without anamorphic lenses—by shooting standard film through a viewfinder marked with the desired wide aspect ratio so the cinematographer could properly compose the shot. When the film was shown, the top and bottom of the projected image were masked off by covering the projection lens with a cheap cardboard matte. (The projector was simply slid back a few feet, so that the image would not appear too small to fill the screen.) This technique, known as **soft matte**, was the manner by which cost-effective scope films were made for many years, with aspect ratios ranging from 1.66 to 1.86. But exhibitors still had to rely on projectionists to attach the matte. If they forgot, the occasional microphone boom or prop-man's hand that went unnoticed by a cinematographer focused on the widescreen image area might be seen at the top or bottom of the picture.

The seemingly obvious solution, which put the control back into the hands of the directors, was a technique known as **hard matte** whereby a mask is applied to the *camera* lens when *shooting* (rather than masking the *projector* when *exhibiting*). This is exactly what the industry did for the next many years—to filmmakers' later chagrin.

It wasn't long before the industry realized there was money to be made from repurposing film content for TV and, more significantly, videotapes for sale and rent. But what to do, now, with all these films shot for widescreen, both anamorphic and hard matte, neither very well suited for viewing in TV's 1.33 aspect ratio? There were four apparent choices:

1. ***Slice off the sides***—Initially, the most common solution, because most of the action in most films is in the center of the screen anyway, and the prevailing notion was that audiences wouldn't really know what they were missing.
2. ***Squeeze the image horizontally***—Typically done, as you may have noticed, only for titles and credits of higher-budget, extra-wide, anamorphic productions.
3. ***Pan-and-scan***—Using video editing software, an editor slides a 4:3 mask around, frame-by-frame, following the action. The editor chooses where to pan (or even zoom) each frame, selecting (in the editor's opinion) the most critical portion. When presented on a standard TV, pan-and-scan fills the screen. The choices made by the editor should be an improvement over the simple slice-off-the-sides technique, but all manner of alterations to the original widescreen material may occur, such as unintended cuts where the action switches rapidly from one side of the screen to the other, characters lost from the ends of frames, and so on.

DPs (Directors of Photography) and film connoisseurs of every stripe tend to deplore any and all of the three aforementioned techniques, which alter the film from its intended form. Instead, those in-the-know prefer the last of the four options:

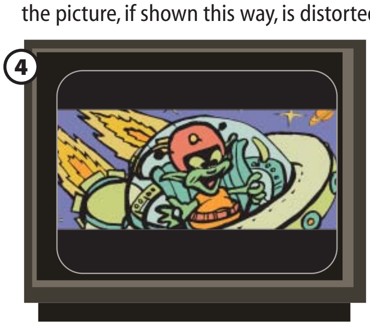
4. ***Letterboxing***—By simply placing black bars above and below the widescreen image to block out the unused portions of a standard 4:3 television set, the widescreen aspect ratio is preserved, as it was originally intended to be viewed.

FOUR WAYS TO PRESENT WIDESCREEN ON STANDARD TV

Widescreen can be made to fit 4:3 TV by **slicing off the sides**. The image fills the screen, but much of it is lost. What if there were ***two*** ships, at the far ends of the shot?

By **squeezing the image horizontally**, widescreen can be made to fit 4:3 TV, but the picture, if shown this way, is distorted.

With **pan-and-scan**, a video editor selects the "best" crop, by panning and/or zooming the widescreen, frame-by-frame. If there ***were*** two ships, the editor would be forced to show just one.

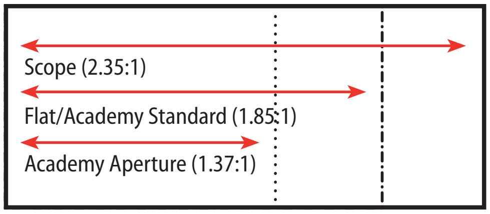


Letterbox preserves all the information in the widescreen format, placing black bars above and below the image.

Aspect ratios and today's motion pictures

Fast forward to the 21st century. Projectors have been permanently fitted with a set of mattes which, when selected, mask soft matte films for either 1.66 or the more common 1.85 widescreen aspect ratios. Most films are shot soft matte, with view-finders equipped with frame indicators for both the standard 1.37 aperture *and* the selected widescreen aspect ratio, to help the cinematographer design shots that will look good when displayed in *either* format. The three most common formats are:

Common production formats



- **Flat**—the *new* Academy standard, with an aspect ratio of 1.85:1, typically shot soft matte (making it easy to repurpose the production for standard TV)
- **Scope**—usually for higher budget features, with an aspect ratio of 2.35:1, shot anamorphically, converted to widescreen in the lab when distribution prints are made (rather than exhibited using an anamorphic lens on the projector)
- **4:3**—the classic Academy Aperture, typically used for made-for-TV features; often used for animated features with an aspect ratio of 1.37:1

Many animated features and some European films are in the 1.66 aspect ratio. Special wide-format films, requiring special cameras and projectors, have also found periods of vogue, most notably 70mm (2.20:1) and IMAX, as well as the Super 35 format used by James Cameron for "The Abyss" and Ron Howard for "Apollo 13."

TV today

Television is going digital. Analog TV is going away. But the transition is going to take some time. No one expects consumers to suddenly throw away all their old TVs and buy all new. And, despite the wide adoption of digital television *delivery* via cable and to satellite, the programming is still, for the most part, engineered for analog broadcast and viewing—that is, set top boxes convert the digital signal back to the analog NTSC standard (in the U.S.) before sending the signal to the TV. The U.S. Government has mandated a full conversion of American television broadcasting to **Digital TV (DTV)** by 2006 to make better use of available bandwidth.

DTV comes in two flavors:

- **Standard Definition Television (SDTV)** is quite similar to standard DVD. It can have a 4:3 or a 16:9 aspect ratio and has resolution roughly equivalent to a conventional analog signal (525 lines of vertical resolution for NTSC).
- **High Definition Television (HDTV)** offers the potential for approximately twice the horizontal and vertical resolution of current analog (NTSC) television. When combined with the compulsory 16:9 widescreen format, this can result in about five times as much visual information as analog TV. It also takes approximately five times the bandwidth to broadcast as SDTV.

TV sets available on the market today are not all HDTV-capable or -ready—even the Widescreen (16:9) TVs. But the sets that savvy consumers are buying today are, at least, SDTV-ready, meaning that they are equipped to accept a digital signal directly (although most also include analog inputs). This means we can connect our DV camcorders, digital VCRs, and our DVD players to our new TV sets via **IEEE 1394** or **DVI** to achieve a pristine, noiseless picture. But we digress—this section is about aspect ratios.

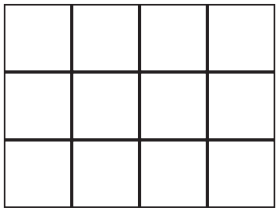
Aspect ratios and today's TVs

Because DTV is designed for two different aspect ratios, so are TV sets:

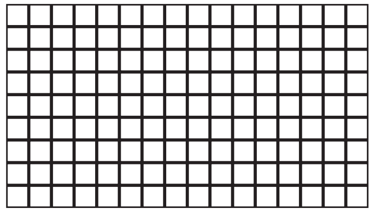
- ***Fullscreen TV:*** In the first decade of the 21st century, the standard television set still has a 4:3 (1.37) aspect ratio, also known as "**Fullscreen**." *(For the rest of this Primer, we'll refer to 4:3 TV as Fullscreen.)* It's the perfect shape for viewing films shot in the classic Academy Aperture format, but not so good for "**Scope**,"

(as widescreen films—Flat, Scope, or any aspect ratio wider than 4:3—have come to be called whether or not they have been shot with anamorphic techniques).

Fullscreen TV = 4:3 (1.37)



Widescreen TV = 16:9 (1.78)



- ► ***Widescreen TV:*** Many consumers have, by now, purchased a widescreen TV, with a 16:9 (1.78) aspect ratio. *(For the rest of this Primer, we'll refer to 16:9 TV as Widescreen.)* But, because most broadcast TV and much of the video recorded on VHS, laserdisc, and DVD is Fullscreen, Widescreen TVs can be programmed to display 4:3 in one of two ways: **pillarboxing** (aka **windowboxing**) which electronically generates black or gray vertical bars to fill the leftover space on the sides, or magnifying the picture to fill the 16:9 screen (but cutting off the top and bottom of the picture to do so). Of course, the Widescreen TV aspect ratio is much better suited than Fullscreen for displaying Scope—it's 16:9 (1.78) proportion is quite close to the Academy Standard, or Flat, proportion of 1.85 in which most of today's films are produced. With even wider Scope aspect ratios, a letterboxed picture fits into the Widescreen shape much better than it fits the Fullscreen shape, with less vertical space above and below the image needing to be filled with black mattes. What's more, Widescreen TV is specifically engineered to showcase anamorphic widescreen—keep reading to learn how.

THE KEY CONCEPT TO UNDERSTAND ABOUT ANAMORPHIC VIDEO

Studio-letterboxed video includes black bars in each and every frame of video stored on the DVD; anamorphic video does not.

Why is this so important?

Each video frame stored on a DVD is comprised of 720x480 pixels. If, as is the case for video that is letterboxed prior to being recorded, 25% of the available pixels are used up for black bars at the top and bottom of the widescreen image, there are fewer pixels available to store the actual video information.

Anamorphic video, on the other hand, uses ***all*** available pixels to store as much video information as possible. So every one of those 720x480 pixels carries video information. (Those of you with calculators handy may note that the aspect ratio of 720x480 is 1.5:1—closer to the standard 1.33:1 aspect ratio than it is to most Scope aspect ratios—which results in anamorphic video stored in DVD format being horizontally squeezed just as anamorphically shot Scope film is squeezed.)

When a DVD player decodes anamorphic video for Fullscreen TV, it unsqeezes the image and generates the black bars electronically; when a Widescreen TV displays anamorphic video, the wide pixels effectively unsqueeze the image. In either case, more video information—which equates to higher video **resolution**—is available in the signal sent to the display. Thus, when anamorphic video is displayed, the picture has better resolution than studio-letterboxed video, which wastes pixels storing the black matte bars in each and every frame.

Aspect ratios and DVD: more choices for better or worse

With VHS and laserdisc, you got the version that was recorded. If the content was Scope, it was either made to fill the Fullscreen TV aspect ratio by slicing off the ends or by using pan-and-scan or it was recorded as letterbox, with the black bars at the top and bottom of the image added in the studio and displayed as part of the video image. When the bars are recorded as part of the image, the picture suffers from a loss of vertical **resolution**—on Fullscreen TVs and Widescreen TVs alike—because **pixels** comprising the digitally stored image must be sacrificed to accommodate the matte bars. Widescreen TVs can be set to magnify studio-letterboxed video to fill the screen, but this may reveal image defects too small to detect in the non-magnified image, thus making the enlarged picture look worse.

To get the best picture possible on Widescreen TVs, digital technology borrowed the anamorphic concept from film. The digitized video stored on DVDs (or broadcast digitally, for that matter) can be anamorphically squeezed. The Widescreen TV pixels themselves have a wide aspect ratio that effectively unsqueezes anamorphic pictures. In fact, when a standard 4:3 picture is sent to a Widescreen TV, if the set is not configured properly to compensate for its wide pixels, the image display is distorted, appearing to be fat.

For Fullscreen TV, where the pixels have the traditional aspect ratio, anamorphically squeezed video is unsqueezed by the DVD player (or set-top box, in the case of digital broadcast) before it is sent to the display. You may have seen anamorphically squeezed video displayed on a Fullscreen TV when the DVD player was not set up properly, and wondered why all the actors looked like tall, skinny aliens! When the DVD player unsqueezes anamorphic video for 4:3 display, it can (depending on how the viewer chooses to set it up) either add black bars to the top and bottom to letterbox the picture or it can allow the image height to fill the screen, in which case the sides of the picture will be sliced off. Some DVD players are capable of automatic pan-and-scan of anamorphic video that includes special coding to indicate the optimal pan-and-scan "center of interest offset." But BUYER BEWARE! Anamorphic video, when displayed as a result of automatic letterbox or auto pan-and-scan modes, can actually produce a *worse* quality picture than


Academy Aperture (1.37:1) fits Fullscreen TV perfectly, because television was originally based on the classic 4:3 film format.


When Academy Aperture is displayed on Widescreen TV, the set generates sidebars to **pillarbox** (aka **windowbox**) the picture.


Academy Standard, aka Flat (1.85) looks like this when **letterboxed** on Fullscreen.


1.85 fits Widescreen TV just about perfectly because the aspect ratios are very similar.


Wider Scope, for example, 2.35:1, looks like this when letterboxed on Fullscreen TV.


When 2.35 is displayed on Widescreen TV, the image is maximized; the matte is minimized.


Scope, when recorded for 4:3, or auto pan-and-scanned, looks like this on Fullscreen.


If magnified (instead of pillarboxed), the top and bottom of 4:3 or auto pan-and-scan get cut off.


Anamorphic displayed on an improperly set up Fullscreen system may look like this.


4:3 video displayed on an improperly set up Widescreen system may look like this.

prerecorded, studio-letterboxed or studio-pan-and-scan versions. Why? Keep reading!

Many current DVDs are marked as *Enhanced for Widescreen, Enhanced for 16:9 TVs,* or *Anamorphic*, and most of these discs offer viewers two options: a studio-generated pan-and-scan version recorded on one side of the DVD disc to give those viewers with Fullscreen TVs the best quality picture, and, on the other side, an anamorphic version designed to take advantage of Widescreen TV. Most current DVD players have four playback modes:

► One mode for the prerecorded, studio pan-and-scan version:

- ***Fullscreen***—If the viewer chooses to watch the studio-generated pan-and-scan version, the DVD player decodes the picture and delivers the signal to the display for playback. On a Fullscreen TV, the picture fills the screen. A Widescreen TV can be set up to either **pillarbox** (aka **windowbox**) the image by placing black bars on the sides or to magnify the image to fill the screen. But magnification results in loss of even more of the picture—at top and bottom—than has already been cropped (by the pan-and-scan process) to fit the widescreen image to the 4:3 aspect ratio. Magnification may also reveal imperfections that might not be noticed otherwise.

► Three modes for the anamorphic version:

- ***Auto letterbox for 4:3***—The DVD player stretches the anamorphic video back to its original Scope aspect ratio and generates matte bars at the top and bottom of the picture. Together, the black bars at top and bottom eat up nearly 1/4 of the usable scan lines, leaving only about 3/4 of them to draw the image. To compensate, a letterbox filter in the DVD player combines every four lines into three—either by simply dropping out every fourth line or by using weighted averaging to combine lines (in other words, not all DVD player letterbox filters are created equal). So, even though the anamorphic video has higher resolution to begin with than studio-letterboxed video would have, this mode does not make the best use of all the available information. The bottom line? Often, Scope video letterboxed by high-end studio equipment, and prerecorded on laser-disc or DVD, produces a better picture than auto-letterboxed anamorphic video when displayed on a Fullscreen TV.

PIXEL ASPECT RATIOS

Even individual pixels have an aspect ratio! Square pixels, like those typically used in graphics programs such as Adobe Illustrator® and Adobe Photoshop®* have a 1.0 pixel aspect ratio. But video images are comprised of non-square pixels, the aspect ratio of which varies from format to format.

Some common formats and their corresponding pixel aspect ratios:

D1/DV NTSC	0.9
D1/DV NTSC Widescreen	1.2
D1/DV PAL	1.066
D1/DV PAL Widescreen	1.4222
Anamorphic 2:1 (film transfer)	2.0

Adobe Encore DVD automatically scales square-pixel graphics to fit the proper non-square pixel aspect ratio, so your images won't look squashed when viewed in a video format.

*Photoshop 7.0 and earlier supports only square pixels, but Photoshop CS allows you to work directly in non-square pixels, so no conversion is necessary.

- ***Auto pan-and-scan***—The DVD player stretches the anamorphic video back to its original widescreen aspect ratio, but cuts off the sides according to a "center of interest offset" specified for each frame when the video was encoded. Unlike studio pan-and-scan, where the editor can pan from side to side or zoom or both to crop the very best portion of the image, auto pan-and-scan can only travel laterally and must include the full height of the widescreen frame. Moreover, when studio pan-and-scan is recorded on DVD, the entire allotment of 720x480 pixels is dedicated to the cropped frame, while auto pan-and-scan may delete upwards of 25 percent of the video's width. That means that 720 pixels across might be reduced to 540 pixels across, resulting in a significant loss in horizontal resolution. While the loss in resolution might not be too noticeable on a Fullscreen TV, depending on the size of the display, if the picture is magnified on a Widescreen TV, the loss in resolution can become distinctly noticeable. And, just as when any 4:3 picture is magnified to fill the width of the Widescreen TV, the image—which has already been cropped horizontally—will be cropped vertically, as well. The bottom line? Generally, the studio pan-and-scan version prerecorded on the other side of the DVD results in better picture quality on Fullscreen and Widescreen TVs. Therefore, not many DVDs are implementing auto pan-and-scan.
- ***Auto widescreen***—When we all have Widescreen TVs, this is what we'll watch. The DVD player just decodes and sends the anamorphically squeezed video to the display; the wider aspect ratio of the Widescreen TV's pixels effectively unsqueezes the picture. Auto widescreen fulfills the promise of anamorphic DVD. For Academy Standard films, with their near-16:9 aspect ratio, every available pixel is used for image information, and every pixel recorded is displayed, resulting in a stunningly clean, clear picture. Scope pictures that have wider aspect ratios are studio-letterboxed before the anamorphic video is recorded on DVD, so, while there is some loss in vertical resolution, it is minimal—the matte bars at the top and bottom of the picture are often so narrow as to hardly be noticeable.

Aspect ratios and *your* DVDs

Because DTV is looming on the horizon, most of us will indeed make the leap during the next decade. Many videophiles have already done so and have bought into Widescreen TV format. So, many digital video camcorders already have a switch that lets you toggle from the standard 4:3 aspect ratio (Academy Aperture) to a 16:9 (Widescreen) aspect ratio. The less expensive of these adjustable camcorders, however, simply lop off the top and bottom of the image, using only 75 percent of the scan lines to create the widescreen effect, which ultimately results in lower vertical resolution. Some more expensive, professional grade DV camcorders can be fitted with an anamorphic lens. But, if you don't have access to that kind of equipment, you'll find some tips for shooting the best widescreen possible—with affordable equipment—in the "How Do I Make a DVD" section of this Primer.

MULTIPLE CAMERA ANGLES

The DVD-Video specification offers up to nine different **camera angles**. Angles are different views of the same scene, shot by different cameras. They are recorded as different video tracks of the same length, associated with the same audio tracks.

The promise

This feature was intended to offer audiences interactive choices to enrich the entertainment experience. Video recorded simultaneously by multiple cameras can be stored on a DVD, allowing the viewer to select the angle they prefer. For example, you might first watch a high-speed chase scene that is edited for dramatic effect in a film. But the second time round, you might select a view shot from a different point-of-view such as that of one of the drivers. Or, for example, if you are in the theater audience watching a live performance, it can be difficult to observe everything happening on stage. With DVD you can switch back and forth between the full-stage view and assorted angles.

The perception

In reality, not many commercial DVDs actually take advantage of multi-angle capability because it takes more work to produce and eats up disc space. In fact, the term "multi-angle title" has become linked with adult entertainment (i.e., X-rated) DVDs, which often offer this capability as a value-added feature.

The possibilities

Well maybe you aren't a Hollywood producer, and maybe you're not making X-rated pictures either, but if you are a commercial videographer, or if you are responsible for developing and distributing video content for business or industry, if you are a marketer, a trainer, or an educator then you can probably see the extraordinary possibilities that DVD's multiple camera angle feature might enable. Here are just a few ideas:

- A how-to DVD might show the construction, assembly, or maintenance of a complex piece of equipment from several different angles.
- A training DVD could walk retail or restaurant employees through an in-store situation from the perspective of a sales associate, a store manager, or through the eyes of the customer.
- A wedding ceremony might be seen as viewed by the guests, through a close-up of the bride's or groom's face, or from numerous angles that have been artfully edited together.
- A sequence in a science lesson might describe a natural process, such as mitosis, with the option to view either actual time-lapse video or an animated and annotated representation in the place of an alternate camera angle.

32 SUBPICTURE STREAMS AND CLOSED CAPTIONS

What are subpictures?

Subpictures overlaid on top of background video or still images are typically used to provide subtitles, karaoke lyrics, instructions, or other text. But subpictures are not limited to text only. Because they are composed of bitmap graphics, they can include images of any shape. So subpictures are routinely used for menu highlighting, altering—that is, highlighting—a button in some manner, when it is selected or activated.

DVD-Video accommodates up to 32 discrete subpicture streams. Each subpicture stream is synchronized with the video and audio streams and multiplexed into the overall DVD-Video stream, so that it can be selectively turned on or off. Subpictures comprised of text, graphics, or a combination of both can be partial- or full-screen size—up to 720x480 (NTSC) or 720x576 (PAL). Simple motion effects can be applied to subpictures so they appear to change on a frame-by-frame basis: they can fade in and out; wipe in color or transparency; or scroll up and down.

What are subpictures made of?

While the DVD-Video format supports up to 32 simultaneous subpicture stream, the bandwidth allocation for each stream is quite limited. To meet the bandwidth restriction, subpicture text and graphics are compressed with **Run-Length Encoding** (**RLE**). Run-length compression is a form of **lossless compression**, so the original picture can be reconstructed with no loss of detail. This makes it an excellent choice for subtitles and other text where legibility is critical. Run-length compression is one of the simplest forms of digital video compression, using the principles of **spatial compression** to remove redundant areas of information from within the frame. For an area that is all the same color, run-length compression will store the color information for a single pixel, along with an instruction to reproduce similar colored pixels, and how many. So, for an area of 100 pixels that are all the same color, instead of storing 100 pieces of data, run-length compression only needs to store three pieces: a marker indicating a run of similar colored pixels, the color, and the count.

An example of run-length compression

Original □□■■■□□□□□□■■□□□■■■■■■□□

Encoded 2□ 3■ 6□ 2■ 3□ 6■ 2□

Run-length compression is not very useful for compressing photographic images or detailed illustrations made up of many colors—there would be little reduction of data. It does, however, work very well on simple pictures comprised of a limited number of colors. So, to accommodate run-length compression, DVD limits subpictures to just four colors per frame, selected from a fixed palette of 16 colors per program. This 16-color palette may be chosen from the more than 11 million colors provided in the 24-bit color mode, although not all DVD-authoring software allows the full range of choices. The colors chosen should also be NTSC-safe. The 16-color palette can change, from program to program or from menu to menu, on the same DVD. Each pixel is represented by 2 bits, enabling four types: background (BG); foreground, aka pattern (P); emphasis 1 (E1); and emphasis 2 (E2). Each pixel type is associated with just one color, selected from the palette of 16, as well as just one transparency level from 0 (invisible) through 15 (opaque).

While this all sounds pretty complicated, with most entry-level DVD authoring applications you don't even need to know this much to highlight menu buttons and create subtitles. But the more sophisticated the application, the more options you have, and the more useful this information may be.

What's the difference between subtitles, captions, and Closed Captions?

Adobe Encore DVD provides the high level of support for typography you expect of Adobe products, letting you type and format subtitles directly on the screen, or import and format a script containing multiple subtitles.

Subtitles are usually a foreign-language translation of dialogue, but the term can refer to any text that is superimposed over video or film, typically appearing at the bottom of the screen. Subtitles may not include every utterance—for example, if a character in an action scene simply shouts out a name ("Will Robinson!"), subtitling may be deemed unnecessary. Subtitles do not, typically, identify the speaker, as they are not specifically intended to assist the hearing impaired in comprehending the program; subtitles are typically intended for hearing people who do not understand the language of the dialogue.

Captions are almost always in the same language as the audio, although captions of a foreign language translation may be made available. Captions are intended for deaf and hearing-impaired viewers. Ideally, captions impart every utterance and identify the speaker, either by moving around the screen to appear in proximity to the speaker or by denoting, in the text, who is speaking—for example, Red-haired Girl, >>Announcer, [Hamlet]. Captions convey tone and type of voice, where necessary—for example, (whispering), [Russian accent], [Vincent Price narrating]. Captions include descriptions of sound effects and other significant audio—for example, thunderclap, music rising to crescendo, sound of breaking glass offscreen.

Captions *may* be supplied, like subtitles, as a subpicture stream, in which case they are called **open captions**. To distinguish them from subtitles or Closed Captions, open captions are usually referred to as "captions for the hearing impaired." Like other subpicture streams, open captions are multiplexed into the overall DVD-Video stream and extracted into a discrete stream by the decoder in the DVD player, so that they can be turned on or off at the viewer's discretion, assuming the DVD author makes this a choice.

Closed Captions are not comprised of subpictures; they are made up of individual character codes carried in the MPEG-2 video stream and must be generated by a special encoder during the post-production process. Closed Captions are not decoded by the DVD player. The display of Closed Captions requires a special decoder chip which, by law, is built into every U.S. television set (larger than 13") sold since the mid-1990s. When the Closed Captions option is selected on the television set, Closed Captions are displayed. Closed Captioning is an NTSC standard supported by the DVD-Video format. DVD does not, however, support PAL Teletext, the European equivalent of Closed Captioning.

DVD-VIDEO INTERACTIVITY

We have become used to the kind of real-time and on-demand interactivity made possible via Internet applications or application software delivered on a CD-ROM or in the DVD-ROM format—video-game play is a prime example. While DVD-Video is capable of providing random access to all of the content stored on the disc, enabling the viewer to jump to any defined point in a video, in less than one second, the interactivity afforded is comparatively limited. Interactive features can be provided by the DVD-Video format—primarily based upon navigation—and can even simulate searching and game scoring, but results cannot be generated—that is, computed—on the fly. It is important to understand this distinction: choices can be offered the viewer which, upon selection, will display alternative menus, scenes, or sequences, but these permutations must be prepared in post-production, in their entirety, and stored on the DVD; interacting merely selects them for playback.

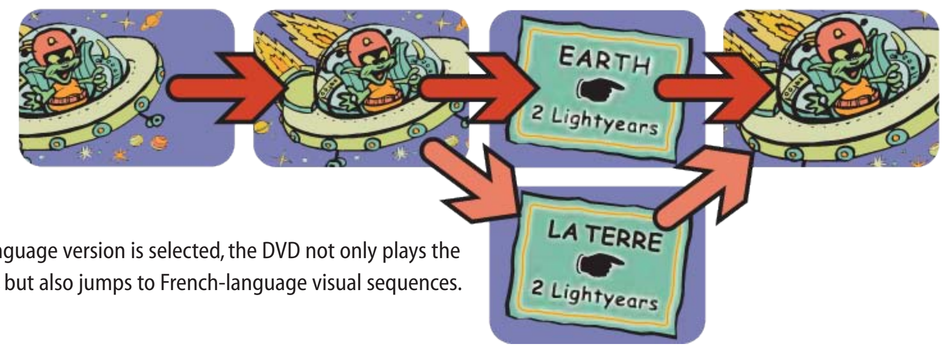
Seamless branching

DVD-Video makes it possible for the viewer to be given some choices in how the video program unfolds. The possibilities are limited only by available content and the imagination of the DVD author.* For example, the viewer might be given choices to skip or include certain scenes, experience an alternate ending, view the director's cut, share a specific character's point of view, and so on. Once selected by the viewer, these choices are presented "seamlessly," that is, without a break in the perceived flow of the program. This seamless branching, aka seamless playback, aka multistory capability, is a big improvement over the branching functionality in earlier digital video formats such as laserdisc and VCD, where jumping to another part of the program meant a break in the playback. Several levels of branching can be offered to the viewer—for example, long- or short-version of chase scene, with or without gory ending. A random branching option can also be offered to keep the experience fresh upon each subsequent viewing.

Some selections enabled by seamless branching functionality result in an alternate presentation being played without the viewer even realizing such a choice was made. For example, if an alternate language soundtrack is selected, scenes in which written words appear—on signage, for example—might be replaced with matching language versions.

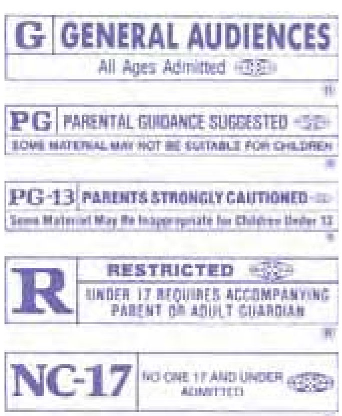
An example of seamless branching

* Current technology may present limitations to a DVD author's creativity, however. Because seamless branching is very complex to plan and prepare, this functionality has not yet been offered within any commercial DVD authoring applications of which the authors of this Primer are aware.



If the French-language version is selected, the DVD not only plays the French-dubbed soundtrack, but also jumps to French-language visual sequences.

Rating system used in the United States

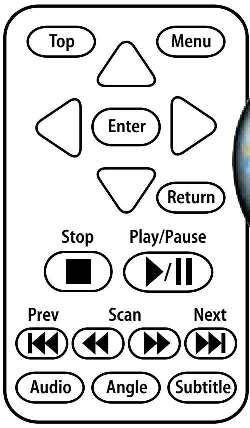


Rating systems vary from country to country

Parental management

Different DVD players have different mechanisms for gaining access to a special parental control menu screen that enables parents to set the player to a specific rating level, using password-protection. Three different implementations of parental management are possible:

- **Lockout**—If a disc with a rating above the established level is inserted in the player, it will not play.
- **Censorship**—If the content has been rated on a scene by scene basis, and those ratings are included in the encoding, and chapter points are set so that multistory functionality can be employed, the player can map the rating against the content and skip over those scenes that are not acceptable. While the playback will be seamless, the story line may suffer gaps in continuity.
- **Multirated content**—DVD-Video content can also be authored so that a different version of the movie—one that is acceptable to the established parental control level—will play back seamlessly by using branching to jump to alternate scenes. While this feature is noteworthy for its ideals, the reality is that very, very few DVDs offer content variations for less mature audiences. The added production expenses are prohibitive, including shooting extra footage, recording additional audio, editing the new sequences and submitting them for rating approvals, then setting up branch points, synchronizing the soundtrack across the jumps, and so forth. Furthermore, packaging standards have not yet been established for DVDs with multirated content, so many video store chains refuse to carry them.



Typical layout of a DVD player remote control device

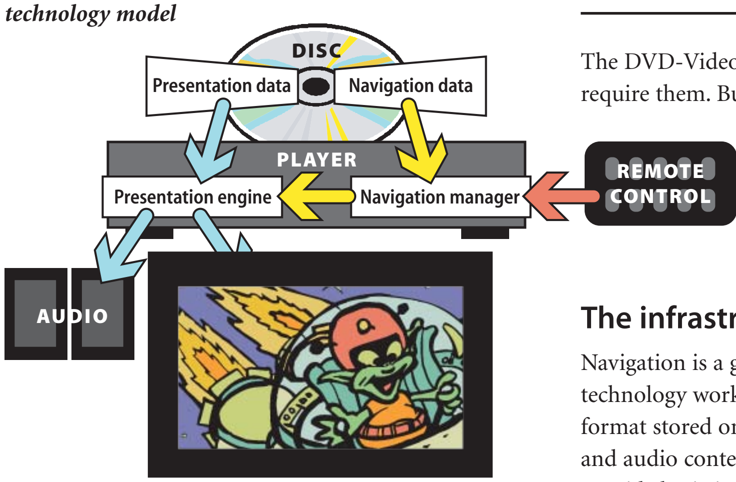
One form of the Windows Media® Player controller for Microsoft® Windows® XP

DVD player controllers (both physical and virtual), in addition to the Select button and the Up, Down, Left, and Right buttons that facilitate menu navigation, sometimes have buttons that let the user play, pause, and usually stop the video; play the video forward or backward at different rates; step through the video frame-by-frame; skip over chapters or jump to the beginning of the title; jump to the title menu or root menu; control audio volume; and choose language, subtitle, or camera angle options.

The "Top" button (which may alternatively be labled "Title," "Guide," "Info," or "Setup") takes the viewer to the very top of the content hierarchy—to the most primary table of contents menu, which is known as the "title menu" or "top menu." The "Menu" button invokes a jump to the most appropriate menu, based on the current state of the content display. The "Return" button executes a "Go up" command, jumping to the next higher level of the menu hierarchy.

Some software player controllers (like the one pictured above), to minimize screen real estate, dispense with buttons that might be redundant to mouse selection controls. Many software players are offered in a variety of configurations, some designed so that the viewer can make them invisible when the video is playing.

Navigation/presentation technology model



MENUS AND NAVIGATION

The DVD-Video specification accommodates on-screen menus; it does not require them. But, without menus, DVD is really nothing more than a storage and playback medium. Menus support the interactive features that make DVD such an appealing delivery vehicle for video. Most viewers expect at least one menu that lets them jump directly to the specific program content they want to view.

The infrastructure of DVD navigation

Navigation is a good example of how the various components of DVD technology work together to deliver an interactive experience. The DVD-Video format stored on the DVD disc contains ***presentation data*** (video, still image, and audio content) and ***navigation data*** (information and commands that provide basic interactivity). The DVD player includes a ***presentation engine*** that uses the presentation data stream from the disc to control the content, and a ***navigation manager*** that uses the navigation data stream from the disc to provide a user interface, including menus, and to control branching and other features supporting interactivity.

Adobe delivers all the software you need to create dynamic DVD menus: Adobe Illustrator and Photoshop for designing backgrounds and graphic elements such as buttons, Adobe After Effects® for developing motion graphics for motion menus, and Adobe Encore DVD for putting your menus together with creative authoring tools for professional DVD production.

What is a menu?

A menu is a user interface (UI) that allows the viewer to navigate the DVD content. The graphical user interface (GUI) part of a menu typically consists of:

- a background that is either a still image or motion video (animation or live action)—and sometimes there's background audio, as well
- informational and sometimes instructional text
- buttons in the form of graphics, still photos, or thumbnail-size motion video that link to points in the video content on the DVD or to other menus

If the background or the buttons incorporate motion video or animation, the menu qualifies as a ***motion menu.*** Many entry-level DVD authoring applications do not support motion menus.

A typical DVD chapter menu

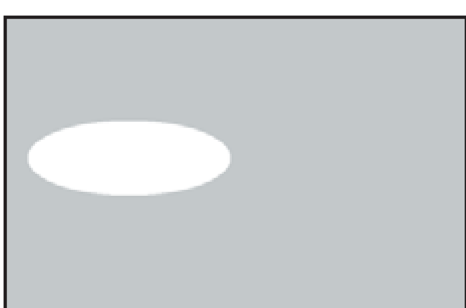
On the menu above, "The Bride" button is selected. If activated, playback will jump to "The Bride" content.

Button highlighting, as in this example, is typically done with a subpicture overlay. In this case, the subpicture overlay highlights the selection by simply placing a 40% opacity white oval over the selected button. Shown below are the components of this menu.

Background graphic

Buttons

Subpicture overlay (40% opacity white oval)



The user moves between buttons on the menu by pressing the up, down, left, or right buttons on the player's remote control (either a physical device if the player is a set-top box or a virtual controller if using a computer). A button is selected when the user moves to it and it is highlighted in the GUI; the user presses the "Select" button on the controller to activate the highlighted choice. Note that if the DVD is being played on a computer, in addition to the controls simulated by the player interface, a mouseover usually indicates a selection, causing the button to be highlighted, with a click or hit on the "Return" key resulting in activation.

Subpictures, as you have learned, may be used to provide visual feedback—that is, to highlight menu choices—when buttons are selected *(see example in sidebar)* and then when they are activated. Subpictures are the most common and most efficient way to highlight menus, because the 24-bit color background graphic remains the same, while only the RLE-encloded 4-bit subpictures change.

Action buttons (aka action menus) are another method that can be used to provide visual feedback (not to be confused with motion menus). A highlighted action button is really a jump to an entirely different 24-bit menu graphic —sometimes with motion. While this approach enables a full palette of colors to be used (as contrasted to the limitations of using subpictures) for highlighting and can be used for more complex motion highlighting with dynamic effects, it is more difficult to implement, the feedback may be quite slow on some players, a mouseover on a computer player will usually not cause the highlight effect, and it eats up far more bandwidth.

What can menus and buttons do?

Many menus simply facilitate choices between titles or chapters on the DVD. Some menus let the user choose the way in which the content will be presented—for example, with which type of audio, in which language, with or without subtitles or captions and, if multistory options are available, which scenes will be included. A menu can masquerade as a quiz—the answer selected, once activated, will determine the next jump. Choose correctly and you've chosen to play a still or video sequence that congratulates you on your aptitude; choose incorrectly and you'll view content that may suggest you try again, or will provide more information. Unless the quiz is really a link to a more nimble application made available via Web-enhancement, it's simply another type of interactive menu.

Each button must be programmed to perform a desired function—in most cases, to jump to a specific point in the video content, or to another menu. So there needs to be a system for identifying desired points in the video content, as well as recognizing the menus and subpictures that need to be displayed upon command—a road-map, of sorts.

Content hierarchy—the DVD road-map

The video content saved in the DVD-Video format and stored on the disc can be parsed much like a map. In other words, it can be broken down into hierarchical units—like a country may be divided into states that are comprised of counties in which there are cities and towns each made up of neighborhoods which, in turn, can be separated into blocks that can ultimately be dissected into parcels or lots. Further, the dividing lines between these map units are indicated by specific conventions we recognize—solid or broken lines of varying weights and colors.

We also understand that the map hierarchy is flexible—there are countries that do not have the equivalent of both states and counties; there are towns too small to bother dividing into neighborhoods. Just as with maps, it helps to understand

The efficient asset management system in Adobe Encore DVD provides a unique way of displaying menus, buttons, and chapters that lets you track your project's structure with ease. For flexible menu routing, use the simple, intuitive interface to link buttons to any destination in your project.

the nomenclature used to describe DVD-Video content, and the hierarchy in which it fits, to develop navigational tools—that is, menus and buttons. And, just as with maps, the DVD-Video hierarchy is flexible, so it can be quite confusing to the newcomer. Entry-level and even quite advanced DVD-authoring tools will walk you through the process of creating menus and buttons that function. So you can make DVDs without really understanding the hierarchy, but it may save you frustration and let you do more, if you have at least a familiarity with the basics.

The terminology *is* confusing. But language is often confounding—consider, for example, the difference between a child's toy "block" and a city "block." When it comes to DVD, consumers usually think of a "title" as a complete, packaged product including one or more discs—what a retailer would count as a SKU (stock keeping unit)—such as: "Star Trek, The Motion Picture" or "Star Trek II, The Wrath of Khan (Director's Edition)" or "Star Trek, The Motion Pictures Collection." As you'll read below, "title" has a slightly different meaning in the DVD content hierarchy. Similarly, we usually think of a "program" as a complete show—like a TV show or other stand-alone production. Like "title," the term "program," too, has a different meaning in the DVD nomenclature.

Typical map hierarchy

country* > *state* > *county* > *city/town* > *neighborhood* > *block* > *lot *(smallest addressable unit)*

Typical DVD hierarchy

volume* > *zone* > *space* > *domain* > *video title set* > *program chain* > *part of title* > *program* > *cell *(smallest addressable unit)*

DVD hierarchy may seem to parallel video content hierarchy, but it isn't quite so simple...

Video Content Hierarchy	Comparable DVD Content Hierarchy	Maximum
Movie, Project, or Program	Title (TT)	99 per disc
Chapter	Part of Title (PTT) *or* Program Chain (PGC)	999 per title
Scene	Video Object Set (VOBS) *or* Program (PG)	99 per PGC
Clip	Cell	N/A

You're already familiar with the nomenclature of the video hierarchy—from largest to smallest unit: *movie* > *chapter* > *scene* > *clip* > *frame* > *pixel*. The DVD content hierarchy may sometimes seem to parallel the video hierarchy, but there won't always be a direct correspondence. In some hierarchical structures—such as weights and measures—there are clear, consistent size relationships between units—2 cups to a pint, 2 pints to a quart, 4 quarts to a gallon, and so on. But in video and DVD—and, for that matter, in the *country* > *state* > *county* > *city* hierarchy we've used as an analogy—the unit relationships are not defined by size or quantity—a state can have any number of counties and be almost any size; a clip can be comprised of any number of frames. Some of the larger units in the DVD content hierarchy have a capacity limit for smaller units (for example, a disc can have no more than 99 titles) but, by and large, unit boundaries can be defined by the video editor or DVD author.

There are two interrelated sides to the hierarchy:

- ► The ***navigation (or control) data*** is the logic that determines the order and conditions of the content playback.
- ► The ***presentation (or object) data*** is comprised of the actual video, audio, and still image content including menu backgrounds and subpictures.

The object data is combined into multiplexed streams called ***Video Objects (VOB)***. Video Objects are stored in logical "containers" called ***Video Object Sets (VOBS)***. Which Video Object is played back, and when, is determined by a set of instructions referred to as a ***Program Chain (PGC)***, another logical container.

But let's start at the very top of the DVD hierarchy, and work our way down through the DVD nomenclature, taking a look at how the logical and presentation hierarchy is intertwined.

The top level of organization on a DVD disc is called a ***volume***. A single-sided DVD contains a single volume; a double-sided disc has two volumes—one for each side. The UDF file system employed by DVD breaks the volume down into zones. In this case, there are two zones: a DVD-Video zone and a DVD-Others zone. All of the video-related content and navigational data—everything that can be played back by a set-top DVD player—is in the DVD-Video zone, while the DVD-Others zone contains any non-DVD-Video data, such as desktop computer applications (which will be ignored by a set-top DVD player).

Zones are comprised of ***spaces***; spaces are groups of ***domains***—spaces and domains are fairly abstract logical constructs that we needn't delve into here.

The first part of the DVD-Video zone you may want to be aware of is the ***Video Manager (VMG)***, a special type of ***Video Title Set (VTS)***. The Video Manager contains any ***first play*** material, such as an introductory sequence, as well as the main table-of-contents menu for the entire volume. This is the "top" menu that is invoked when the "Top" button on the remote control is

WHAT'S ON THE MENU?

Because there are no details in the DVD-Video specification for menu hierarchies, the manner in which menus are presented to the end-user is up to the DVD developer. A disc may have no menus or hundreds of menus. But there are six basic types of menus, as outlined below. And, guess what? The nomenclature is confusing! So what else is new?

Top menu

- ***Technical name: Video Manager Menu (VMGM)***
- ***Accessed by pressing "Top" button on controller***

The top menu is at the top of the menu food chain. Technically, it is called the ***Video Manager Menu (VMGM)*** because it resides within the Video Manager (VMG). There is only one top menu per volume (that is, only one for each side of a disc). There may be different language versions of the top menu—the version displayed depends on the preferences set in the DVD player. The top menu is typically displayed automatically when the disc is first inserted in the player—sometimes appearing after other first-play material. The top menu can also be invoked when the "Top" button on the controller is pressed. The "Top" button may alternatively be labeled as "Title," "Guide," "Info," or "Setup." The top menu is sometimes called the "title menu," but that can be misleading if there are multiple titles within the volume, in which case each title might have its own menu which, by rights should be called "title menus" but which would truly be root menus *(see below)*. Confused? That's okay... You're not alone.

Root menu

- ***Technical name: Video Title Set Menu (VTSM)***
- ***Accessed by pressing "Menu" button on controller***

A Video Title Set (VTS) can have a root menu area, technically called a ***Video Title Set Menu (VTSM).*** Pressing the "Menu" button on the controller displays the menu that has been designated as the root for the currently active title (often a chapter menu).

Submenus

The four other kinds of menus are submenus of root menus, residing in the same Video Title Set. Many players do not provide buttons for displaying these submenus, and those that do rely on the DVD developer to have programmed the appropriate interactivity. Some players provide a "Return," "Back," or "Go Up" button that may, if the menus are programmed to take advantage of it, jump back to the parent menu. Note that submenus can have submenus of their own. The names of the four submenu types are practically self-explanatory (for a change!)

- **Chapter menu** ***(part-of-title or PTT menu):*** Button activation results in jump to specified PTT (chapter) or PG (scene) marker.
- **Audio menu:** Lets viewer select audio stream (such as type of audio, language option, or narration option).
- **Angle menu:** Lets viewer select camera angle or other alternate video stream.
- **Subpicture menu:** Usually lets viewer select a subtitle option.

pushed. There can be only one Video Manager per volume and, consequently, only one top menu (although the top menu can be stored in different languages and the preferences that have been set for the DVD player will determine which is displayed).

The Video Manager may be followed by 1 or up to 99 other Video Title Sets, which fill most of the DVD. A Video Title Set is composed of one or more ***Titles (TTs)*** (aka Video Titles (VTTs)) and a ***VTS Menu (VTSM)***, which is classified as a ***root menu***. The root menu for the Video Title Set currently being played appears when the Menu button on the remote control is pushed.

Many DVDs have only one Video Title Set. But, because all of the video content in a given Video Title Set must be in the same aspect ratio, a DVD that offers multiple aspect ratios (for example, standard and widescreen) must have multiple Video Title Sets.

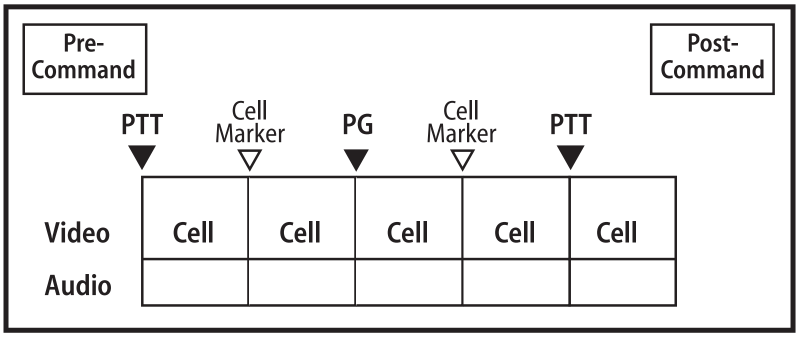
A ***Title (TT)*** is the largest unit of presentation data, or content, on a DVD—usually an entire movie, TV program, or other presentation. If a disc includes four episodes of a TV series, each episode might be presented as a title. A disc that offers a feature film, a theatrical trailer, and a supplement might be divided into three titles: *The Movie, The Trailer,* and *The Making of.* There can be up to 99 titles per volume.

Optionally, a title may be broken down into ***Part of Titles (PTTs)*** and/or ***Programs (PGs)***, which may reflect chapters or scenes, and which may be correlated to menus. Titles, parts of titles, and programs are comprised of ***cells***. The cell is the smallest addressable unit of presentation data in the DVD hierarchy. But don't try to equate a cell with a frame or even with a certain number of frames—a cell may be as small as an MPEG Group of Pictures (GOP)—that is, no more than 18 frames NTSC/15 frames PAL and a fraction of a second—or as large as an entire movie—that is, hours-long. If we go back to our map analogy, think of a cell as a town—it may be as small as a single square block or as large as Los Angeles; it may only be a small portion of a state or it may (if we allow the District of Columbia as a state) comprise its entirety, as does Washington, DC.

The presentation data referenced by a Title may include a single cell or multiple cells; it may be composed of cells organized into programs or directly into part of titles; or it may be made up of cells that are organized into programs that are further organized into part of titles. The breakdown is relevant only to the level of menu navigation that can be implemented. In any case, the presentation (or object) data is contained in logical units called ***Video Object Sets (VOBSs)***. A Video Object Set is made up of one or more Video Objects. A ***Video Object (VOB)*** includes presentation data—video, audio, subpictures, and navigation data—that is multiplexed into a stream. Because the data is multiplexed, it can be separated into its constituent parts and called upon as needed.

The Video Object can be considered the basic presentation-data building block of DVD-Video, while the ***Program Chain (PGC)*** is the fundamental logical unit. Each Program Chain is a set of instructions telling the DVD player which VOBs should be referenced, under which conditions, and in what order. A DVD-Video title can, simply, be seen as a collection of Program Chains (instructions) and the Video Objects (assets) to which they refer. Different Program Chains can reference the same VOBs, selecting different sets of cells and audio streams to create variations of the content—such as, versions with different ratings.

The anatomy of a Program Chain (PGC)



The Program Chain is the fundamental logical unit of DVD-Video. Specific video cells, audio streams, menus, and subpictures to be played back are pulled from referenced Video Objects (VOBs). Each Program Chain is made up of a pre-command, a list of content residing in associated VOBs, and a post-command. The pre-command contains the instructions for playing the content. It is followed by the list of which VOB content will be played—much like an Edit Decision List (EDL) in a nonlinear editing system. The post-command contains instructions for what to do after the list of content has been played—usually to link to another PGC or jump to a menu.

WHAT COULD YOU DO WITH WEB DVD?

What you can do with Web DVD is limited only by your imagination and your ability to work with the technology. Here are a few examples of what you might do with Web DVD:

- Offer a choice of "surf or show"—a menu appears when you insert the DVD, offering options to either connect to a Web site or work with the disc alone
- Add Web links to menus or to the video itself that appear as buttons when jumps to relevant Web content would supplement the DVD experience
- Provide a separate window, synchronized to the video, that provides information from the Web during viewing
- Incorporate an HTML-based interface to control DVD playback, either in a window or in full-screen mode
- Enchance the Web experience by substituting high-quality DVD content played from a local drive in place of lower-quality streaming Web content
- Update the DVD experience by inserting or adding new or time-sensitive information from the Web that supersedes content on the DVD.
- Encourage audience interaction related to the DVD content between multiple viewers by providing a window that facilitates online "chat."

WEB ENHANCEMENT

The Web offers instant access to a world of content, as well as the capacity for two-way communication and interactivity that far surpasses the current capability of DVD-Video. But the Internet is constrained by bandwidth restrictions that keep the notion of streaming high-quality video-on-demand a future promise. Even with DSL, it would take 24 hours to download a DVD-quality movie; perhaps less time with cable modem, depending on how many other people in the neighborhood were placing high-bandwidth demands on the shared network at the same time.

DVDs deliver high-quality video immediately, but only provide the content that can be fit onto the disc itself. DVDs cannot be continually updated like Web sites, nor can they deliver the level of interactivity made possible by the Web.

Greater than the sum of its parts

Combining the best of both the Web and DVD enhances the viewer's experience, and it opens up possibilities for connecting marketers with consumers, students with teachers, and community members with each other as they share a high-quality video experience. The technique of combining DVD and the Web is known by several names: enhanced DVD, connected DVD, online DVD, Internet DVD, and WebDVD, among others.

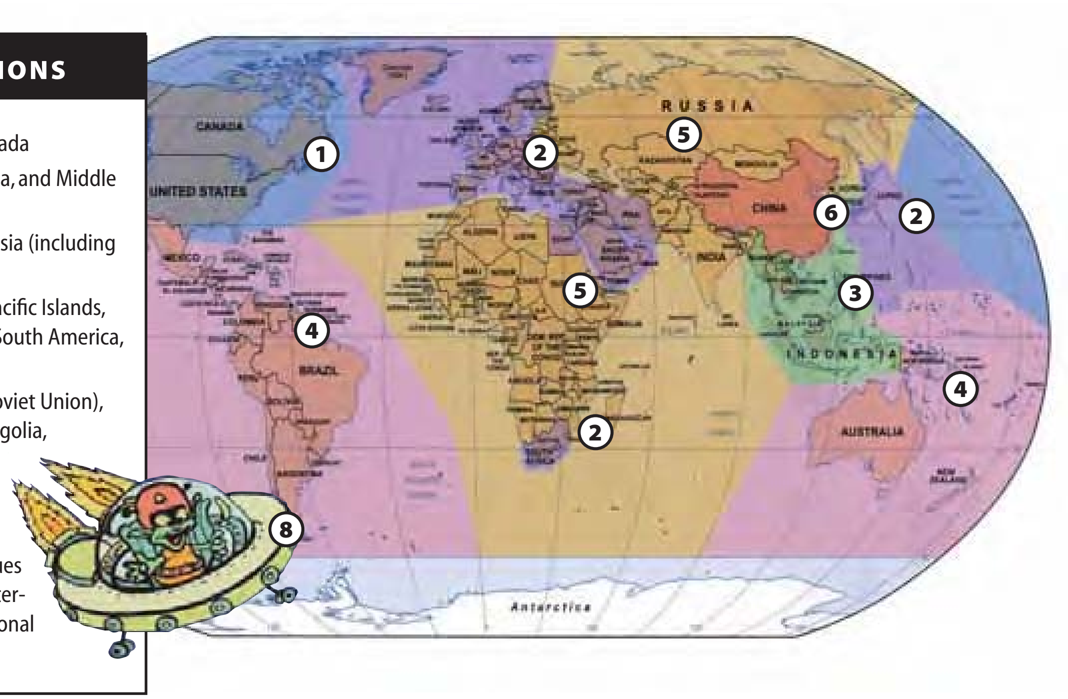
You pop the latest DVD blockbuster movie into your DVD player and see previews of other titles, just like you would at the theater. But with each preview, you are given the opportunity to order the DVD of the movie being advertised—either for purchase or for rent. But why stop with movies? The heroine in the feature has a fabulous wardrobe, and you can order any of her outfits online. Or maybe you're watching an instructional DVD on your favorite recreational activity—golf, tennis, skiing, fishing. With Web DVD, you can go online to access current catalogs selling the equipment shown in the video, to make reservations for your next vacation, or to chat with a community of like-minded enthusiasts. It's not too difficult to come up with similar scenarios for distance learning and all kinds of business applications.

Convergence is coming to a living room near you

Obviously, the use of Web-enhanced DVDs requires a DVD player built into or hooked up to a computer that is, in turn, connected to the Internet. More and more computers are being sold with built-in DVD players as standard equipment. But watching movies is, for the most part, a sit-back-in-the-easy-chair-in-the-living-room experience, and most home theater set-ups don't include a computer. So the audience for Web-enhanced DVD movies is still limited. The near-term applications of Web-enhanced DVD are more likely to be found in education and training, and in the business-to-business arena, rather than in consumer entertainment and marketing. But it won't be very long before all of our living rooms are wired, and we'll be watching movies and other programming fed through either computers or set-top boxes that are as "smart" as computers.

THE DVD REGIONS

1. U.S.A., U.S. Territories, Canada
2. Japan, Europe, South Africa, and Middle East (including Egypt)
3. Southeast Asia and East Asia (including Hong Kong)
4. Australia, New Zealand, Pacific Islands, Central America, Mexico, South America, and the Caribbean
5. Eastern Europe (former Soviet Union), Indian subcontinent, Mongolia, Africa, and North Korea
6. China
7. Reserved
8. Special international venues (airplanes, cruise ships, intergalactic and interdimensional vehicles, and elsewhere)



REGION CODING

What is Region Coding and why does DVD have it?

The motion picture industry has a powerful voice in the DVD Forum, and that's why the controversial ***Region Coding*** feature—also known as country coding, zone lock and, in computer drives, ***Regional Playback Control (RPC)*** —was included in DVD technology. Region Coding works like this: If you purchase a DVD player in Canada, it will not play back most prerecorded DVDs purchased in France, or Tahiti, or in any region other than Region 1, which includes Canada, the U.S.A., and U.S. Territories.

The code itself takes up just one byte on the DVD. It is designed to search for a matching bit of code in the DVD player's firmware. If the proper code is not found, the DVD will simply not play. However, a disc without a Region Code—also known as an "all-region" disc—will play on any compatible DVD player or drive, anywhere. And there are "multiregion" players available. In fact, NASA has purchased and used them on multinational space shuttle flights. But some DVDs from major motion picture studios use a system known as RCE (Region Coding Enhancement), won't play in multiregion players.

Region Coding is a "feature," not a requirement

The producer of a DVD—whether a major motion picture studio or *you*—is *not* required to include Region Coding. Why would it possibly be a desirable feature? Because movie studios want to control the timing of DVD releases in different geographic markets, because movies aren't always released everywhere in the world simultaneously. What's more, the movie moguls want to sell exclusive rights for DVDs to different foreign distributors in discrete geographic markets. The practice of Region Coding is quite controversial. Those opposed to Region Coding suggest that it may be a violation of fair trade practices. In a recent court case, the Australian Competition and Consumer Commission (ACCC) argued that the practical effect of Region Coding was that consumers who purchased DVD players in Australia are prevented from playing films procured overseas and, because overseas markets give Australian consumers access to a wider range of film titles with special features not available locally, the practice amounts to the creation and maintenance of artificial barriers to trade.

Can Region Coding be modified to permit multiregion playback?

Yes. Special command sequences from the remote control allow some players to switch regions or play all regions. Some players can be physically modified to play all regions; however this practice will usually void the warranty and may be prohibited by law in some jurisdictions. Contact the manufacturer to determine if the player will permit multiregion playback or may be modified to do so.

CONTENT PROTECTION

Content Protection, like Region Coding, is not a requirement, but an optional feature of DVD. It's not very difficult to understand why content developers and copyright holders want Content Protection. So who *doesn't* want it, and why? The opponents of Content Protection claim that its ramifications violate our rights to benefit from open technology and to freely distribute and share information. There are complex issues involved in the Content Protection debate—issues involving not only content rights, but also the capabilities (or potential lack of them) built into the DVD recording technology available to the general public. Most of us hope that DVD will be able to avoid the pitfalls of DAT and MiniDisc, neither of which ever fully realized its potential, largely because of interference from powerful special interests.

We are not going to get into the Content Protection debate, in these pages; but, if you are interested in the future of the DVD medium, you may want to learn more about the issues. Just enter '"Content Protection" and "DVD" in any Web search engine and you'll net a wide variety of opinions and information. What we *will* try to do, instead, is provide you with an awareness of the basic technologies currently in use—an exercise that will consist largely of sorting out a boatload of abbreviations and acronyms. This part of the Primer is worth reading if you want to better understand the technology that makes it difficult (although, apparently, never impossible for clever hackers) to copy commercial DVDs, or if you plan to produce content for commercial DVDs yourself.

CPS and CPSA

Content Protection System (CPS) is the generic term for a technology designed to protect content from being misused or misappropriated—that is, altered, copied, or displayed in any unauthorized manner.

Content Protection System Architecture (CPSA) is an overall framework for DVD technology, related to controlling access to content recorded on DVD discs. Comprised primarily of watermarking and encryption technologies and policies, CPSA includes protection measures for both digital and analog outputs. CPSA was developed jointly by IBM, Intel, Matsushita, and Toshiba, forming an alliance known as the 4C Group, in cooperation with the Content Protection Technical Working Group (CPTWG), a somewhat broader consortium of consumer electronics and computer companies, as well as content producers. CPSA was designed to encompass the major Content Protection technologies currently in use, to accommodate the integration of emergent technologies, and to ensure consistency with and avoid duplication of Content Protection technologies being developed by the Secure Digital Music Initiative (SDMI).

CMI and CCI

Content Management Information (CMI) is the specific logic, or set of rules, governing protected content. Region Coding is one form of CMI. Simply stated, CMI is just digital code, recorded with the content and other data on a DVD disc, that may modify the behavior of the DVD device in which it is played and may restrict copying of content from protected discs. CMI often modifies playback or restricts recording attempts, regardless of whether the attempt is made by digital or analog means.

Copy Control Information (CCI) is the logic governing if and how content may be copied, and usually comprises a portion of the CMI.

Watermarking and encryption

Digital watermarking has been in use for some years, in efforts to protect still images from being used or altered without permission. Typically, the watermarking of still images is quite obvious, often in the form of a logomark or emblem that partially obscures the image, and clearly identifies it as protected. Conversely, when it comes to video and audio content, watermarking refers to technologies that embed CMI in content, in such a way as to be imperceptible to the audience. And unlike the watermarking used to protect still images, video and audio watermarking does not, in and of itself, serve to protect the content. The watermark simply triggers the playback device to respond in accordance with the CMI, so long as that playback device is compliant with the system being employed—that is, a noncompliant device will generally not play back watermarked content. The watermark triggers the device to decrypt encrypted content in accordance with the CMI. Watermarking and encryption/decryption technology systems are typically made available to content producers and device manufacturers under license; the license contract specifies the CMI protocols. Ready for a really silly acronym? Watermarking technologies are standardized by an organization called the Watermarking Review Panel (WaRP).

APS, aka analog CPS, aka copyguard; aka Macrovision

Adobe Encore DVD offers support for standard Content Protection formats: Macrovision, CGMS, and CSS

An ***Analog Protection System (APS)***, also known as an analog ***CPS (Content Protection System)***, prevents **analog** copies from being made from DVDs (that is, prevents the copying of DVD content onto analog videotape). The most widely used APS was developed by a company called Macrovision and is generally referred to by its trade name. A Macrovision circuit is built into just about every DVD player available, as well as into computer video cards with S-video outputs. Macrovision-protected discs include trigger bits, encoded in the recorded data, that trigger the Macrovision circuit in the player or video card to send out ***AGC (Automatic Gain Control)*** pulses to the video outputs. AGC pulses, which interrupt the vertical interval in the television display, usually do not affect playback on standard TVs but, because they do affect the AGC circuitry in VCRs, show up as noise, interference, or other undesirable artifacts on analog videotape copies. Macrovision also uses an additional protection scheme called ***Colorstripe,*** which adds a rapidly modulated ***colorburst*** signal that results in lines or stripes appearing across the picture when analog videotape copies of material protected in this manner are viewed. Because the DVD producer pays Macrovision royalties (typically several cents per disc produced) based on how much protection is incorporated into the content, and because Macrovision protection can be applied selectively, not *all* the content on a Macrovision-protected disc may actually *be* protected. Because both of the Macrovision techniques—AGC Pulsing and Colorstripe—hinge on interrupting the analog video signal, Macrovision can be used to protect only video, not audio, content. There are some inexpensive devices available that defeat Macrovision, but only a few can be used to circumvent the Colorstripe scheme.

CGMS and SCMS

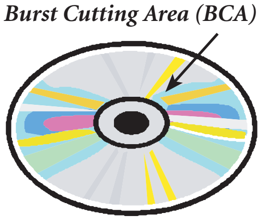
Copy Guard Management System (CGMS) is a ***Serial Copy Management System (SCMS)***. The CGMS code embedded in the outgoing video signal is based on one of three rules: copy freely, copy never, or copy once. The "copy once" rule allows a first-generation copy to be made, but disallows copies of copies.

CSS

Content Scrambling System (CSS) is a Content Protection solution developed primarily by Matsushita and Toshiba. It was designed to prevent the direct digital copying of video files from DVD discs, which could result in virtually perfect clones. With its reliance on matching up a pair of so-called "keys" to authenticate both the disc and the device as duly licensed, before allowing an encrypted MPEG-2 file to be descrambled and played back, it almost sounds like the plot of a "Dungeons & Dragons" style videogame or adventure movie—don't try this at home without your decoder ring! Here's how it works: 400 (give or take a few) "master keys" are stored in the lead-in area on every CSS-encrypted DVD disc. Each licensed hardware (device) manufacturer is given what amounts to a "keyhole" (in the form of computer code), matching one of the 400 master keys, and this "key" code is included in the device's firmware. There is no charge for a CSS license, but it is difficult to obtain one, and the license is extremely restrictive requiring, among other covenants, that Region Coding be employed. If the hardware license is revoked, the matching key is simply not included on any future CSS-encrypted DVDs. In order to play a CSS-encrypted disc, the device—be it a DVD-Video player or a computer drive, must include a licensed CSS decryption module with a valid key code. When a CSS-encrypted DVD is played in a CSS-enabled device, the plot thickens... in addition to decrypting the scrambled MPEG-2 file to actually play the video, the CSS decryption algorithm exchanges keys with the device to generate an incremental encryption code that prevents the further exchange of disc keys and device keys that would be needed to decrypt data from the disc. Confused? We were meant to be—the CSS algorithm and keys were intended to be a closely-kept secret. However, these days you can truly learn every secret—on the Internet. **DeCSS** is a "hack" that was posted on the Internet in October 1999, cracking the CSS algorithm and spawning a remarkable rat's nest of legal controversies. The original flavor of DeCSS enabled the playback of CSS-encrypted DVDs on computers running the Linux operating system (which had been excluded from CSS because of its "open source" approach); another flavor "does" Windows. No longer a deep, dark secret, you can now purchase a T-shirt with the DeCSS source coded printed on it (at ***www.copyleft.net***), or learn more about the DeCSS polemic at ***www.opendvd.org***

CPRM and CPPM

Burst Cutting Area (BCA)



Content Protection for Recordable Media (CPRM) has stirred up a lot of controversy because it is a technique that can be applied to a spectrum of storage media, including personal computer hard drives, where issues related to data recovery and privacy have been cause for concern. As it relates to DVD, CPRM involves a unique code, physically etched into the ***Burst Cutting Area (BCA)*** of every blank disc. When the disc is played, a CPRM-enabled playback device reads the code from the BCA and uses it to generate a key to decrypt the content for playback. But if the encrypted digital content is copied to other media, it will not be able to be decrypted because the code that generates the key will be missing or different. Every DVD recorder shipped after 1999 supports CPRM.

Content Protection for Prerecorded Media (CPPM) is designed specifically for DVD-Audio content. It is based on CSS but uses a different algorithm developed after the appearance of DeCSS.

DCPS, DTCP, and HDCP

Now that you've learned about CSS, the complex Content Protection systems being developed in its wake won't sound quite so cloak and dagger. Devised specifically for the next generation of digital TVs and VCRs, these systems include all manner of clandestine key exchanges and encryption/decryption schemes.

Digital Copy Protection Systems (DCPS) enable the exchange of data between digital components via lossless, digital connections such as IEEE 1394 (aka, Firewire or i.Link), without permitting perfect digital copies to be created. Several proposals have been submitted to the Consumer Electronics Association (CEA) from various combinations of major consumer electronics players. These proposals call for devices enabled by digital keys or physical "smart cards" for renewable security. Such devices exchange keys and authentication certificates to establish a secure channel whereby other connected but unauthenticated devices cannot access the signal. The DVD player itself encrypts the video signal as it sends it to the receiving device, which must decrypt—unauthenticated devices cannot do so. All the proposed techniques flag content with CGMS-style "copy freely," "copy never," or "copy once" coding. Players that can authenticate that they are "playback-only" devices are allowed access to all protected content. Recorders can only receive data flagged as copyable and, as a copy is made, must change the flag to "no more copies" if the source is marked "copy once." Devices that utilize DCPS are beginning to appear on the market. You will start to see DVD players and discs, as well as digital TVs, VCRs, and computer drives that include DCPS protocols, such as ***Digital Transmission Content Protection (DTCP)***, the "5C" DCPS, so-called for the five companies involved in its development: Intel, Sony, Hitachi, Matsushita, and Toshiba.

High-bandwidth Digital Content Protection (HDCP), developed by Intel, is specifically for use with components connected with the new digital video monitor interfaces, such as the **Digital Video Interface** (**DVI**), designed to replace the analog VGA standard. Many of the new HDTVs are expected to have DVI compatibility. Like other DCPS, HDCP utilizes a complex set of coded keys for device authentication. Upon authentication, the HDCP protocol encrypts each and every pixel as it is transferred across DVI from the DVD player to the digital display. Any unauthorized device that attempts to play back HDCP-protected content will transfer only random noise to the display.

HOW DO I MAKE DVDs?

Because this Primer isn't a "how-to," you won't find step-by-step instructions in this section. What you will find here are basics to familiarize you with the tools and the process, whether you are actually making your own DVDs or engaged in working on DVD projects in some other capacity. In broad strokes, there are two principal stages to making DVDs: **authoring** and replication. For DVD-Video, authoring comprises the process of planning, designing, assembling, and formatting content. Depending upon the software being used and individual interpretation, authoring may also be seen to include encoding or transcoding video and audio, as well as developing menus. When the authoring process has been completed, the replication process begins. In the professional production environment, the replication process consists of more than simply burning discs—it also includes premastering, proofing, QA, physical formatting (during which Content Protection and Region Coding may be incorporated), and glass mastering—all before a sizeable run of DVD-Video discs can be produced, packaged, and distributed.

WHAT TOOLS DO I NEED?

Much of the hardware and software you need is the same as for producing any other video-based production: tools to create, capture, and edit video. In addition, you'll need DVD-authoring software, as well as a device for recording the final content you've prepared in the DVD-Video format, either directly onto DVDs for playback or replication, or onto the half-inch digital linear tape (DLT) typically used in preparation for mass reproduction. (Note that most replicators will also accept single-layer DVD-R for replication, but not when copy protection is to be included).

Hardware

The speed, power, and capacity of many desktop and even laptop systems, today, make it possible to go from DV to DVD with a fairly minimal hardware investment, either by using the system you already own, or by enhancing it somewhat. The decisions you make regarding the best computer (workstation) to choose, whether you should add a video card to your system, what kind of offline storage is best, and what type of recording device(s) you need, can be guided by answering the following questions:

► ***What kind of video will you be incorporating into your productions?***
Simple, straightforward editing of DV takes less processing power (that is, MHz) and less random access memory (RAM) than applying complex visual effects or compositing uncompressed footage. Check the system requirements on your video editing software for guidelines. But because these system requirements are usually established using a "clean" computer, in the real world, you're likely to want more than what is recommended. While you may be able to struggle along with 256 MB of RAM, you'll probably be happier with at least 512 MB. And it's always a good idea to hedge your bets—make sure you can add more RAM down the road. Many professionals opt for 2 GB of RAM.

► ***How time-critical will your productions be?***
Are your productions deadline-driven? Do you need or want real-time capabilities—and, therefore possibly a real-time video card—for video capture, processing and previews, or transcoding for export? A video card relieves your CPU of much of the processing load, letting you work more efficiently.

► ***How much video will you be working with?***
There's no getting around the fact that digitized video requires a lot of storage. Uncompressed, a single video frame is approximately 1 MB and, therefore, at the NTSC frame-rate of 29.97 fps, 1.5 GB is required for just one minute of video. An hour-long program can consume 90 GB of storage, without even considering all the raw footage that went into it—often five times the amount of the actual product (450 GB), or, for high-end productions as much as 20-50 times (1,800-4,500 GB). To figure the amount of storage you need for DV video (compressed 5:1), you can calculate based on approximately 216 MB for each minute of stored video. Or, looking at it from the opposite direction, each 1 GB of storage holds about 4 minutes and 45 seconds of video. For an hour of DV, therefore, you would need a 13 GB disk.

Let's say that you're an event videographer planning on shooting DV and creating DVDs for your clients. To figure out how much storage you would need to make a one-hour DVD, here's how you might do the math:

Start with what you need for your finished production—two hours of DV footage	26.0 GB

Add a conservative amount for unused footage—at least twice the finished amount	52.0 GB
Figure in some additional graphics—titles, for example—and audio tracks	2.0 GB
You'll need space for the MPEG-2 files you export for your DVD	4.7 GB
Minimum storage space needed	84.7 GB

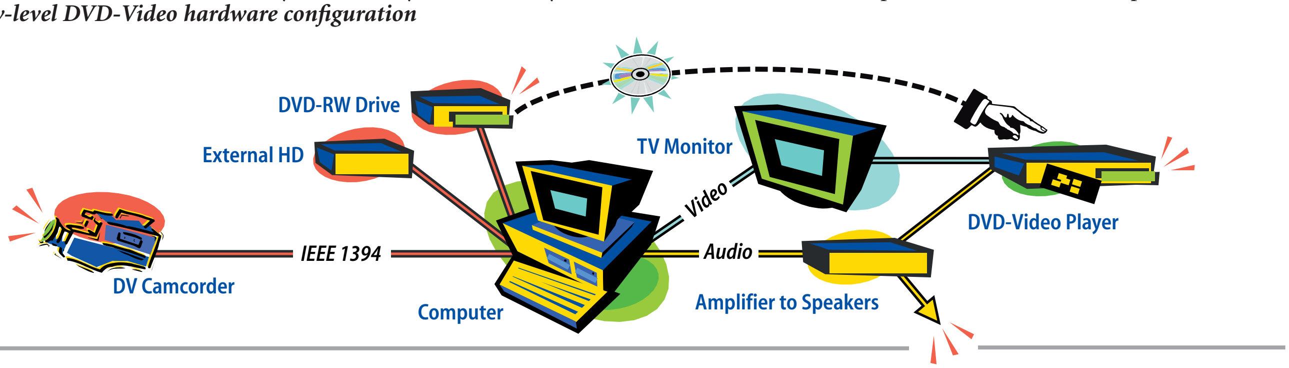
So you're probably going to need offline storage—a large-capacity external hard drive or two, at the very least; a RAID array or storage area network (SAN), if you're running a professional operation.

When you consider an offline storage subsystem, capacity isn't the only thing you must bear in mind—transfer rate is important, as well. The data comprising each frame of video needs to be transferred to and from the processor at the video frame rate—29.97 frames per second for NTSC—no matter how large or small the frames might be (that is, how much data comprises them). The transfer rate for DV is typically 3.6 MB per second. If you are compositing multiple video streams in real time, that rate must be multiplied for every stream being concurrently processed. And the video must move at a steady, sustained pace, too. If the transfer rate falls below what's required, frames may be dropped, resulting in poor quality video. Because faster disk subsystems typically cost more, you'll want to configure your system with disks and interfaces that are fast enough to not drop frames, but not so fast that you're paying a premium for speed you don't need.

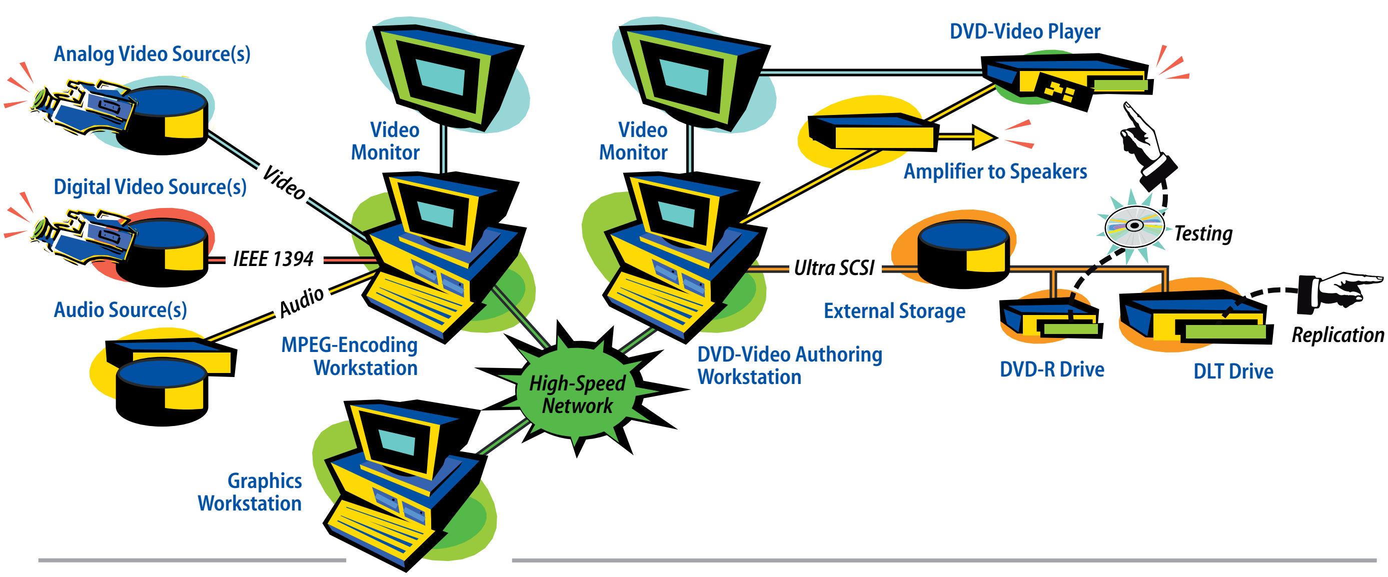
► ***How will you distribute your finished video?***

If you need only to burn a very small number of final DVDs for personal use, a consumer/prosumer

Entry-level DVD-Video hardware configuration



Mid-range DVD-Video hardware configuration

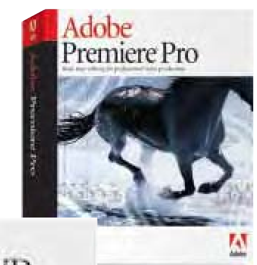


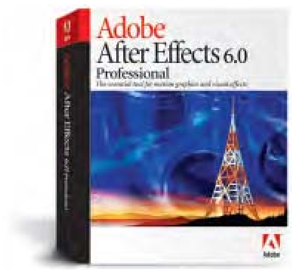
DVD writer is all that you need. If you have broader distribution plans, you may also need a DLT drive for recording to DLT, the medium often preferred by DVD-replication facilities.

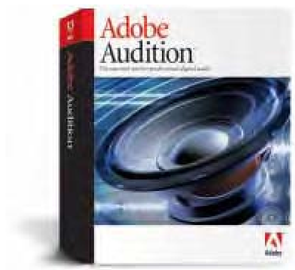
Software

Adobe delivers the leading-edge software you need to produce professional-quality results for film, video, and DVD. This comprehensive video production toolset is well integrated, streamlining your workflow to give you more time to be creative and to maximize your productivity. Adobe products have a familiar interface that will get you up to speed quickly, while letting you customize them to meet your particular workflow needs.

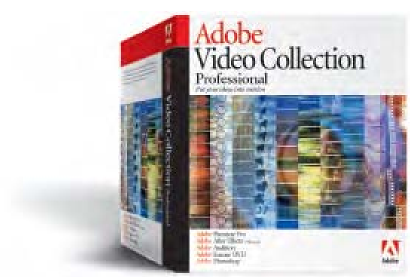
Real-time editing for professional video production: When preparing digital video for distribution via any medium, you'll need nonlinear editing (NLE) software such as Adobe Premiere Pro. Adobe Premiere Pro software elevates digital video editing to a whole new level. This revolutionary editing application delivers a host of real-time video and audio editing tools, an elegantly redesigned user interface and flexible import and export options. Built for the superior performance of Microsoft Windows XP systems, Adobe Premiere Pro provides the power and precision you need to deliver outstanding video productions.







The essential tool for motion graphics and visual effects: Adobe After Effects software sets the pace for motion graphics and visual effects. The latest release delivers dramatic performance gains, an innovative new approach to text animation, integrated vector paint tools with Photoshop-style brushes, all-new motion tracking, Render Automation, advanced keying, and much more. In addition to adding the motion graphics and visual effects that can make the difference between an ordinary video production and an unforgettable viewing experience, Adobe After Effects is the tool of choice for producing animations and richly layered video composites for motion menus.



If you are upgrading any of your Adobe video products, make sure to ask about upgrading to the complete Collection. The Adobe Video Collection offers you an incredible value, with savings of over 50% compared to individually purchased products.

The essential tool for professional digital audio: Adobe Audition turns your PC into a professional multi-track recording studio with the tools to produce high-quality audio, a flexible workflow, and exceptional ease of use. DVD-Video can deliver unprecedented audio quality when the audio assets you incorporate into your DVD production are high-quality to begin with. If you've shied away from engineering your own sound because the available solutions were either too rudimentary or seemed like they'd take a rocket scientist to run, then Adobe Audition™ software will be music to your ears.

The world-standard image editing solution: You'll also need software for creating menu graphics: Adobe Photoshop is the industry standard for developing still graphics, including backgrounds and subpictures for DVD menus.

Creative authoring for professional DVD production: Adobe Encore DVD software gives professional videographers, DVD authors, and independent producers the power to create sophisticated, multi-language DVDs with interactive menus, multiple audio tracks, and subtitle tracks. Adobe Encore DVD provides a comprehensive set of tools for designing professional DVD titles. While DVD authoring may be new to you, many tools in Adobe Encore DVD feature the familiar, award-winning Adobe interface, so your learning experience can be easy and quick. Unparalleled integration with Adobe Premiere Pro, After Effects, and Photoshop optimizes your efficiency. Use the convenient Edit Original command in Adobe Encore DVD to open and adjust your original files in their native applications.

THE DVD WORKFLOW

The Adobe Encore DVD interface

Adobe Encore DVD software takes DVD authoring to a new level of creativity and efficiency. Through its flexible interface and unparalleled integration with Adobe Premiere Pro, Photoshop, and After Effects, Adobe Encore DVD gives professional videographers, DVD authors, and independent producers the power to create sophisticated, multilanguage DVDs with interactive menus, multiple audio tracks, and subtitle tracks. With Adobe Encore, you can produce consistent, high-quality results, and export all recordable DVD formats for the widest degree of playback compatibility. The powerful tools and creative flexibility of Adobe Encore let you meet increasing demand for DVD output, while differentiating your DVD productions.

Adobe Encore DVD includes a variety of predesigned button and menu styles that are easy to customize to create your own look.

Top 10 features in Adobe Encore DVD

- ▶ Automated transcoding converts source files to MPEG-2 video and Dolby® Digital audio formats required for DVD-Video
- ▶ Create/edit menus in Adobe Photoshop, import native PSD files, use Edit Original to make alterations
- ▶ Unparalleled integration with Adobe Premiere Pro and After Effects automatically updates linked files
- ▶ Intelligent image control lets you drag and drop images for buttons or backgrounds, automatically updating linked images
- ▶ Powerful, intuitive navigation controls to program interactivity
- ▶ Integrated text tools based on familiar Adobe applications
- ▶ Dozens of professionally designed, customizable menu templates boost your own creativity
- ▶ Project Preview simulates DVD player functionality
- ▶ Flexible DVD mastering supports all recordable DVD formats
- ▶ Built-in tools for efficient project management

SHOOTING WIDESCREEN DV

Many DV camcorders have a 16:9 switch which, when activated, results in a letter-boxed or an anamorphically stretched image. But there is a "right" way and a "wrong" way to achieve widescreen with a DV camcorder.

The "wrong" way is the result of the camcorder merely lopping off the top and bottom scanlines of the image to achieve a letterboxed effect. If this type of wide-screen image, comprised of only 75% of the available scanlines, is ultimately stretched to fill the 4:3 screen of a standard digital TV (SDTV), the resolution will leave something to be desired. If the image is translated to HDTV or transferred to film, it will look very poor, indeed. The "wrong" way can be easily recognized by looking through the view-finder and flipping the switch: you'll notice that the top and bottom of the image seen in the 4:3 mode are missing from the 16:9 view.

The "right" way is to use a 16:9 CCD. When in 4:3 mode, the camcorder simply ignores the sides of the CCD, reading a 4:3 image from the center section of the chip. In 16:9 mode, the entire chip is engaged. The properly adjusted camcorder ensures that the full complement of scan lines (480 for NTSC; 576 for PAL) is utilized in either mode. The "right" way may be recognized by noting the same vertical information that appears in the 4:3 view is still visible in the 16:9 mode, whether the resulting image is apparently letterboxed by the viewfinder or squashed.

An alternative "right" way is to do what filmmakers have done for years—use an anamorphic lens to squash the picture, which will be digitally stretched upon display. The few anamorphic lenses available for a few digital camcorder models typically cost around $800.

No matter how simple or ambitious your project, the DVD workflow can basically be broken down into seven stages:

1. ***Planning***
2. ***Asset Preparation***
3. ***Authoring***
4. ***Formatting and Layout***
5. ***Emulation***
6. ***Replication***
7. ***Packaging and Delivery***

But there can be as many variations to this process as there are DVD authors, and the steps that comprise these stages may overlap or, depending on the tools being used, may be performed in different stages.

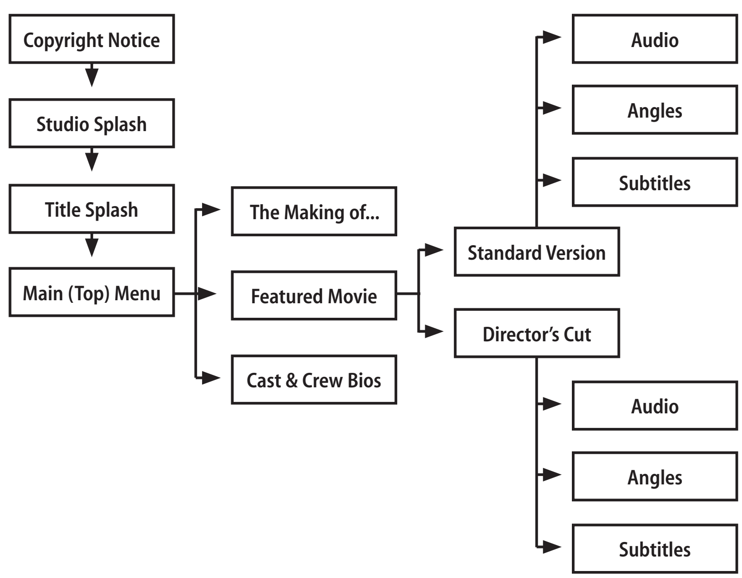
Planning

In the planning stage, you'll define your project, determining what content will be included, as well as how much and what kinds of interactivity will be offered. If you are producing a commercial DVD, you'll develop a schedule and milestones, and prepare or confirm a financial budget. If you are working with others, you'll define roles and responsibilities.

If there will be a significant amount of interactivity, you'll want to create a project flowchart, which is basically a hierarchical representation of functionality that can be used as a blueprint for building the DVD *(see example below)*. It's a good idea to get client approval on the flowchart before moving on to the production phase of a DVD, as changes after production has begun may increase costs and effect deadlines.

Storyboards that pre-visualize the production—primarily showing rough menu layouts and chapter points—may also be developed and may serve as important tools for gaining approvals.

Example DVD project flowchart



BALANCING YOUR BIT BUDGET

Your objective is to balance the amount of content you include versus quality. Start by making a list. In addition to your video assets including multiple angles, list all of your audio streams including multiple languages and audio formats, as well as your graphic assets, including menus, stills, and subpictures.

Both asset size ***and*** data rate must be considered. The combined data rates of concurrent streams cannot exceed the maximum DVD-Video data rate of 10.08 Mbps.

The data rate (in megabits per second) for each asset multiplied by the playing time (in seconds) yields the asset size (in megabits). Asset sizes, when summed, must fit within the selected disc capacity:

	Capacity in GB (gigabytes)	Capacity in Mb (megabits)	Less 4% overhead in Mb (megabits)	Adjusted capacity in Mb (megabits)
DVD-5	4.70	37,600	1,504	36,096
DVD-9	8.54	68,320	2,733	65,587
DVD-10	9.40	75,200	3,008	72,192
DVD-14	13.24	105,920	4,237	101,683
DVD-18	17.08	136,640	5,466	131,174

A spreadsheet with built-in bit budget-balancing formulas is invaluable. You can create your own, but why reinvent the wheel? Jim Taylor's *DVD Demystified* includes (on the accompanying DVD sample disc) just such a tool, designed in Microsoft Excel. Start out by plugging in a desired level of quality. If the spreadsheet shows you have too much data to fit on your disc, you can choose to: a) reduce the amount of content, b) reduce the data rate of all or some of the assets, or c) move up to a disc with greater capacity. Choosing option b—reducing the data rate— effectively amounts to reducing the quality of the video when you encode it.

Some DVD-authoring applications include automatic bit-budgeting tools that perform the calculatations when you arrive at the formatting (layout) stage. But if you wait until that point, you may have to go back and re-encode your video to make it fit. Rather than doing work twice, it makes more sense to budget your bits during the Planning stage of the process. Then, use the built-in calculator in your authoring application as a failsafe.

Bit budgeting is a critical step in the planning stage that ensures all of your content will fit on the DVD. While you want to use up as much space as available to keep your video and audio at the highest quality possible, in planning, it's a good practice to reserve some space for changes or additions as the process unfolds.

Preparation

Preparation means gathering and preparing all of the assets that will be included on your DVD—video, audio, and graphics.

As is so often repeated in regard to any type of video project: Garbage in; garbage out. The ultimate quality of your DVD is largely dependent upon the quality of your source material. Do your best to make sure that you gather the highest quality versions available for all of your assets.

For existing video, digital tape is generally better than analog tape, assuming that the original source was digital. If your content was originally shot as analog footage, you want the closest you can get to first generation because, with every generation copied, analog loses fidelity. Request that any assets provided on videotape include test tones and color bars, so that you can calibrate your playback deck to match the recording deck and, thereby, maintain consistent quality.

Video assets generated in the computer, such as motion graphics and visual effects, should be provided digitally, rather than on tape (either digital or analog)—preferably uncompressed, as AVI, MOV, or OMF files.

If you are shooting new footage for your DVD, preparation includes the traditional preproduction, production, and post-production stages—planning, shooting, capturing, editing, and adding effects, as well as encoding. Because of the possibilities inherent in DVD, it's easy to get carried away, shooting multiple angles and creating branching options or alternate endings. Don't forget that for every additional camera angle you want to include on your DVD, you increase the bits you need to budget for the scene by 100 percent.

After your video has been collected and edited, you may want to preprocess it using filters or Digital Video Noise Reduction (**DVNR**) processors designed to minimize any undesirable video artifacts resulting from MPEG encoding. DVNRs are available in a variety of different forms ranging from hardware to software plug-ins.

Your audio must also be recorded or collected, sweetened as necessary before encoding, and synchronized with your video. For audio assets, the higher the sample rate and the bit depth, the better. The more information you start with, the better your results will be when you downsample and encode.

Menu backgrounds and subpictures must be created, as well. Original menu design requires excellent graphic design skills and a thorough understanding of the limitations of subpictures, which can be a tricky business. So using a DVD authoring application such as Adobe Encore DVD, that comes with customizable menus, can be an excellent idea.

Once your video and audio assets have been collected, edited, and preprocessed, they must be encoded for DVD: video as MPEG-2 and audio in one of the audio formats specified for DVD-video. Encoding can be handled in Adobe Premiere Pro or right within Adobe Encore DVD.

Authoring

If your DVD-authoring software includes MPEG-encoding capabilities, you might save your video and audio encoding for this stage, so long as you are willing to give up some of the fine control you have over the encoding process with more sophisticated encoding solutions. Similarly, if your authoring software provides menu templates, you may create (that is, customize) your menu graphics as part of the authoring stage, as well. Typically, however, the authoring stage involves the following steps:

- **Identifying**, aka importing, the media assets to be incorporated in the DVD project. The actual asset files are not really copied or moved anywhere in this step; rather, their locations within the system are identified and links to those locations are generated.
- **Assembling** the video and audio assets into tracks (also referred to as synchronized presentation groups) and identifying chapter points, titles, and title sets. Most DVD-authoring applications use timelines often with drag-and-drop functionality, to make this step and the next one easier so the author can focus on the creative process.
- **Organizing** the presentation groups to match the project flowchart.
- **Programming** functionality and interactivity. Next, Previous, and GoUp instructions must be programmed that define what will happen when the viewer presses the associated buttons on the player controller. Menus are created by importing background graphics and subpictures into the authoring application and programming the menu buttons to respond to DVD player controls. Menu buttons are then linked to content assets and other menus.
- **Simulating** the final product by testing menus and navigation and checking to be sure that the video and audio work as anticipated. Your DVD-authoring software should let you see how your DVD will look and perform in a player. Some authoring systems will warn you if certain things will cause problems in some players. But this is only the first of several QA steps in the overall process.

Formatting and layout

After you've completed the steps of the authoring process, your DVD authoring software still has more work to do. The various video, audio, and still picture streams will be multiplexed, or "muxed," and, along with the associated navigation, or control, information, will be formatted as special types of data files that are compliant with the DVD-video specification: VOBs (video object files), BUPs (backup files), and IFOs (the information files that tell the player how to access the data stored in the VOB files).

Once formatting is finished, the layout process is performed by the DVD-authoring software, resulting in the creation of a volume image (aka disc image).

Formatting and layout take some time. The amount of time depends on the processing speed and power of the computer being used for authoring, the type of authoring software, and the size and complexity of your DVD content. Most DVD authoring tools can perform formatting and layout in real time, meaning that if the actual playing time of your DVD content will be two hours, then real-time formatting and layout will take two hours. Some DVD authoring tools can also write directly to the DVD disc at the same time.

Emulation

Simulation tests the functionality of components of the DVD, or the DVD project as a whole, from within the DVD-authoring application. ***Emulation*** tests the DVD project outside the authoring tool. Most DVD authors burn a DVD-R for emulation, then test it on as many different hardware players as they can lay their hands on. Emulation may catch problems that go unnoticed in the simulations run during the authoring stage. During emulation, you should check to be sure that: first-play material plays first, video and audio are of the anticipated quality, video and audio are synchronized, menus look and operate as intended, subpictures (that is, subtitles) appear when they are meant to and are clearly readable, closed captions can be decoded by a TV set, parental controls function, DVD-ROM and Web interactivity work, and user operations (that is, the functionality of player controls) behave as expected. For dual-layer DVDs, it is not possible to burn a single DVD-R that includes all the data, so a special software DVD player, based on consumer decoders, can be used to play the material from the disc image rather than from a DVD disc.

Replication

If you are creating just a few, final DVDs, the Replication stage means little more than burning the required number of discs onto DVD-R using a DVD writer. However, if something on the order of a thousand or more DVDs are to be replicated, there are still more steps to go through:

- ► If you will be implementing content protection or region coding, you'll need to flag these options using your authoring tool, and create a new disc image. The actual encryption will be done in the final replication stage, as the replicator will hold the licenses and keys for these processes. (Note that not all DVD authoring applications allow this functionality.)
- ► **Premastering** is the process of writing your final disc image to the digital linear tape (DLT) or DVD-R that will be sent to the replicator. DLT is generally preferred and must be used if Content Protection or Region Coding are to be employed.
- ► **Check discs** are a limited run of proof discs created by the replicator. They should be run through the same rigorous testing process as was performed in the Emulation stage. This is the DVD author's last opportunity for QA before discs are mass produced. Once check discs have been approved, it is the replicator's responsibility to make sure the final fabricated discs match the check discs.
- ► **Physical formatting** converts the disc image provided on the DLT or DVD-R into the bit stream needed by the laser beam recorder (LBR). Among other processes, the data is encrypted for Content Protection and Region Coding, interleaved, and error correction added during physical formatting.
- ► **Glass mastering** is the process of creating a model of the final DVD, which is used for generating **stampers**. A stamper has the inverse of the pits and tracks on the glass master. Stampers wear out fairly quickly during the fabrication process, so multiple stampers may need to be made from the glass master to complete the run.
- ► **Molding, sputtering, bonding,** and **labeling** complete the replication process. Plastic copies of the glass master are made from the stamper, using an injection-molding process. A thin metallic layer is sputtered onto the polycarbonate (plastic) substrate. The two sides of the disc are then bonded together—DVD-5 discs and some DVD-9 discs get bonded to a blank side, while two-sided discs are bonded back to back. For one-sided discs, most of the surface of the back side is available for labeling, in designs that may range from one to full-color. For two-sided discs, the print area is limited to within the burst-cutting area (BCA). Depending on the type of disc and the printing method selected, the disc may be labeled before or after bonding.

Packaging and distribution

DVD discs, once fabricated, are inserted into packages with any printed material that may be designed to house or accompany them. Commercial printers and, especially, packaging specialists can help the designer with keylines or templates to use as guides for packaging graphics. Adobe Illustrator, Photoshop, and InDesign software are often used to develop the artwork for packaging and inserts.

Once packaged, DVDs are then shrink-wrapped, boxed, and shipped.

RESOURCES

HOW TO PURCHASE ADOBE SOFTWARE PRODUCTS

Via Web:
http://www.adobe.com/store

Via Phone:
Call the Adobe Digital Video and Audio Hotline at: **(888) 724-4507**

Education Customers:
Contact an Adobe Authorized Education Reseller at:
http://www.adobe.com/store/general/otherplaces/uscanada/educlist.jhtml

Free Tryouts:
http://www.adobe.com/products/tryadobe/

To find the reseller nearest you, visit:
http://www.adobe.com/store/customerregistration/other_places.jhtml

FOR MORE INFORMATION

A variety of products and information are available that can be helpful to learning and working with digital video and producing DVDs. The following information is provided as a courtesy. Adobe does not endorse third-party products or services. This listing was last updated March 2004.

BOOKS

Adobe Classroom in a Book
published by Peachpit Press
Series of hands-on software training workbooks for Adobe products; includes CD
www.peachpit.com

Visual QuickStart Guides
published by Peachpit Press
Concise, step-by-step instructions to get you up and running quickly, and later provide a great visual reference
www.adobepress.com

Using Encore DVD
by Ralph LaBarge
published by CMP Books
ISBN: 1578202345
Featuring full-color illustrations and graphics, Using Encore DVD gets readers up to speed on features of the application, and teaches the nuances of DVD title design and implementation. Packed with tips and tricks that only a long-standing professional DVD author could impart, this comprehensive, hands-on guide includes sections on adding DVD-ROM content and DVD replication and distribution. The companion DVD illustrates all of the product features and provides sample project templates.

DVD Authoring & Production: An Authoritative Guide to DVD-Video, DVD-ROM, & WebDVD
by Ralph LaBarge
published by CMP Books
ISBN: 1578200822
According to Jim Taylor, "This book takes up where DVD Demystified leaves off, explaining the vital details of designing, producing, and selling a DVD."

DVD Demystified
by Jim Taylor
published by McGraw Hill
ISBN: 0071350268
Essential information on using or producing DVD for home, education, and professional use, with clear explanations of DVD features and technologies and over 200 information-packed charts and figures.

Applying Adobe After Effects Studio Techniques
by Rod Harlan
published by Sams (2000)
ISBN: 0672318563
Step-by-step instructions of popular procedures and effects; includes CD

Creating Motion Graphics with After Effects
by Trish and Chris Meyer
published by CMP Books (2000)
ISBN: 0879306068
Techniques for creating animation, composites, and effects; includes CD

After Effects in Production
by Trish and Chris Meyer
published by CMP Books
ISBN: 1578200776
Companion book to Creating Motion Graphics; includes CD and tutorials

Desktop Digital Video
by Ron Grebler
published by Prompt Publications
ISBN: 0790610957
Examines hardware and software applications, and how to utilize them.

Digital Nonlinear Editing: Editing Film and Video on the Desktop
by Thomas A. Ohanian
published by Butterworth-Heinemann
ISBN: 024080225X
Addresses the latest developments in digital editing for film and video

Digital Video for Dummies
by Martin Doucette
published by: Hungry Minds, Inc.
ISBN: 0764500236
Step-by-step instructions on digital video editing using Premiere Pro

Nonlinear: A Guide to Digital Film and Video Editing
by Michael Rubin
published by Triad Publishing Company
ISBN: 0937404845
Covers topics including SMPTE time-code, component and composite video, the post-production process, online and offline editing, and much more.

TRAINING RESOURCES

ADOBE CERTIFIED EXPERT (ACE) PROGRAM

To become an Adobe Certified Expert, you must pass an Adobe Product Proficiency Exam for the product for which you want to be certified. For more information see the Adobe Web site at:
www.adobe.com/education/educators/ace_program.html

ADOBE CERTIFIED TRAINING PROVIDER (ACTP) PROGRAM

For more information see the Adobe Web site at:
http://partners.adobe.com/asn/partnerfinder/trainingprovider/index.jsp

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Adita Video Inc.
Adobe Premiere Pro training on CD-ROM
www.videoguys.com/adita.html

ElementK
Online training libraries on Adobe products. Learn at your own pace with unlimited subscription access for one full year.
http://adobe.elementk.com/

Mac Academy/Windows Academy
Premiere Pro training on CD-ROM
Phone: 386-677-1918
Fax: 386-677-6717
www.macacademy.com

Total Training Inc.
In-depth training on DVD for both Premiere Pro and After Effects
Toll-free: 888-368-6825
Phone: 760-517-9001
Fax: 760-517-9060
www.totaltraining.com

VideoSyncrasies: The Motion Graphics Problem Solver
Trish and Chris Meyer provide in-depth information about motion graphics and special effects in After Effects
www.desktopimages.com/ae.shtml

VTC: The Virtual Training Company
CD and Web-based training on Premiere Pro and After Effects
www.vtc.com/usa.php

ADDITIONAL LEARNING RESOURCES

Internet Campus
Complete courses in digital video production
www.internetcampus.com

Video University
Complete courses in digital video production
www.videouniversity.com

Short Courses
A course in digital video
www.shortcourses.com/video/index.htm

FREE INFO ON THE WEB

GUIDES, TUTORIALS, AND TIPS

Video Highlights by Total Training:

Adobe After Effects:
www.adobe.com/products/aftereffects/newfeatures.html

Adobe Audition:
www.adobe.com/products/audition/overview.html

Adobe Encore DVD:
www.adobe.com/products/encore/overview.html

Premiere Pro:
www.adobe.com/products/premiere/overview.html

Adobe Digital Video Primer
Download a PDF copy from
www.adobe.com/motion/primers.html

Adobe Streaming Media Primer
Download a PDF copy from
www.adobe.com/motion/primers.html

Master the Art of Digital Video
Download a PDF copy from
www.adobe.com/motion/events/pdfs/dvtour.pdf

Adobe Product Tips
http://studio.adobe.com/tips/main.jsp

Adobe Product Support Announcements
www.adobe.com/support/emaillist.html

Creative Mac
Premiere and After Effects tutorials
www.creativemac.com/HTM/Sections/Tutorials/tutorials.htm

The Mining Company
Overview of desktop video
http://desktopvideo.miningco.com

After Effects Portal
Multipurpose site with tutorials and tips for After Effects
http://msp.sfsu.edu/Instructors/rey/aepage/aeportal.html

After Effects Freemart
After Effects tutorials
www.aefreemart.com

ToolFarm
Tips on using network rendering, 3D channels, and Mesh Warp in After Effects
http://store.yahoo.com/toolfarm/index.html

FlickTips
Tips for low budget video-web production
www.newvenue.com/flicktips

Video Guys
Helpful resource that explains many of the new technologies related to digital video
www.videoguys.com

INFORMATION ABOUT MPEG

- www.mpeg.org/MPEG/
- www.coolstf.com/mpeg/

INFORMATION ABOUT DVD

- www.dvddemystified.com/dvdfaq.html
- www.videoguys.com/DVDhome.html

INFORMATION ABOUT IEEE-1394

- www.oakmusic.com/parkplace/video/techpapers.htm
- www.well.com/user/richardl/theSilverList.html

ONLINE GLOSSARIES

DVD Demystified Glossary
www.dvddemystified.com/glossary.html

PC Technology Guide
www.pctechguide.com

Webopedia
www.webopedia.com

MAGAZINES

AV Video Multimedia Producer
Covers video production, multimedia, and presentation
Phone: 847-559-7314
Fax: 847-291-4816
www.avvideo.com/Htm/homeset2.htm

Broadcast Engineering
Covers broadcast technology
http://industryclick.com/magazine.asp?magazineid=158&SiteID=15

Computer Videomaker
Covers camcorders, computers, tools and techniques for creating video
Toll-free: 800-284-3226
Phone: 530-891-8410
Fax: 530-891-8443
www.videomaker.com

Digital Editor Online
Master the tools needed to make non-linear and digital editing profitable
Phone: 888-261-9926
www.digitaleditor.com

DV (Digital Video Magazine)
Covers mainstream digital video
www.dv.com

eMediaLive
For digital studio professionals who capture, edit, encode, publish, and stream digital content
www.emedialive.com

Film & Video
Covers film and video production
Phone: 847-559-7314
Fax: 847-291-4816
www.filmandvideomagazine.com/Htm/homeset.htm

Millimeter
Resource for technology trends in animation, production and post-production for film, video and streaming
US Toll Free: 866-505-7173
Fax: 402-293-0741
www.millimeter.com

Post Magazine
Resource for video, audio, and film post-production
Toll-free: 888-527-7008
Phone: 218-723-9477
Fax: 218-723-9437
www.postmagazine.com

Videography
Covers the professional video production market
Phone: 323.634.3401
Fax: 323.634.2615
www.videography.com

Video Systems
Covers the video production process from acquisition through presentation
US Toll-free: 866-505-7173
Fax: 402-293-0741
www.videosystems.com

NEWSLETTERS

Adobe.com
Sign up for technical support announcements
www.adobe.com/support/emaillist.html

About.com
Desktop video
www.desktopvideo.about.com/gi/pages/mmail.htm

Digital Media Net
Topics related to digital content creation
www.digitalmedianet.com/newsletters/

DV.com
Digital video industry news
www.dv.com/newsletters/index.jhtml

COMMUNITIES

USERS GROUPS

Adobe User to User Forums
www.adobe.com/support/forums/main.html

DMN Forums
Home of worldwide users groups for Adobe Premiere and Adobe After Effects users
www.dmnforums.com

DVD Forum

International association of hardware manufacturers, software firms and other users of Digital Versatile Discs
www.dvdforum.org

Canopus Users Forums
http://forum.canopus.com/

DV.com Forums
www.dv.com/community/

Creative Cow
Online creative communities of the world including Premiere Pro and After Effects user forums
www.creativecow.net

MAILING LISTS

Use e-mail to exchange information and distribute questions and answers on a particular topic.

Yahoo
Premiere Pro and After Effects mailing lists
http://groups.yahoo.com/

DV-L List Server
DV and FireWire technologies
www.dvcentral.org/thelist.html

Vidpro
Discussions for video and television professionals
www.vidpro.org/subscribe.htm

NEWSGROUPS

If you use an internet application that lets you access newsgroups, you can read and respond to postings in the following digital video newsgroups:

- comp.graphics.animation
- rec.video.desktop
- rec.video.production
- rec.video.professional

PROFESSIONAL ASSOCIATIONS

Digital Video Professionals Association
www.dvpa.com

Society of Motion Pictures and Television Engineers
www.smpte.org

Digital Editors
www.digitaleditor.com

CONFERENCES

DV Expo
http://dvexpo.com

NAB (National Association of Broadcasters)
www.nab.org

Siggraph
www.siggraph.org

THIRD-PARTY SOFTWARE AND HARDWARE

PLUG-INS

For Adobe Premiere Pro
For detailed descriptions of third-party plug-ins for Premiere Pro, visit the Premiere Pro page on the Adobe Web site:
www.adobe.com/products/premiere/main.html

For Adobe After Effects
For detailed descriptions of third-party plug-ins for After Effects, visit the After Effects page on the Adobe Web site:
www.adobe.com/products/aftereffects/main.html

CAPTURE CARDS

For a list of video capture cards that Adobe has tested and certified for use with Premiere Pro, visit the Adobe Web site:
www.adobe.com/products/premiere/6cards.html

ENCODING SOFTWARE

Main Concept
One Chagrin Highlands
2000 Auburn Drive
Suite 200
Beachwood, Ohio 44122
Phone: 216-378-7655
Fax: 216-378-7656
www.mainconcept.com

QDesign Corporation
QDesign Music Codec
Phone: 604-451-1527
Fax: 604-451-1529
www.qdesign.com

RealNetworks
Helix Producer
Toll-free: 800-444-8011
Phone: 206-674-2700
www.realnetworks.com/index_rn.html

Microsoft
Windows Media Technologies
www.microsoft.com/windows/
windowsmedia/default.asp

Apple
QuickTime
http://developer.apple.com/
quicktime/

Sorenson Media
Sorenson Video Developer and Basic Edition
Phone: 888-767-3676
Fax: 435-792-1101
www.sorenson.com

Discreet
Cleaner
Phone: 800-869-3504
www.discreet.com

Glossary

Academy Aperture: Standard 4:3 aspect ratio, so-called because it was adopted, in 1927, by the Acadmy of Motion Picture Arts & Sciences as the industry standard.

AC-3: Another name for the ***Dolby Digital*** audio-encoding system, often used in reference to DVD because this is how the technology is referred to in the DVD standards documents.

analog: Refers to video and audio recorded or stored non-digitally. The principal feature of analog representations is that they are continuous. For example, clocks with hands are analog—the hands move continuously around the clock face. As the minute hand goes around, it not only touches the numbers 1 through 12, but also the infinite number of points in between. Similarly, our experience of the world, perceived in sight and sound, can be considered to be analog. We perceive infinitely smooth gradations of light and shadow; infinitely smooth modulations of sound. Traditional (nondigital) video formats such as VHS and Hi-8 are analog.

anamorphic: Refers to an image or to the technique used to create images where the visual information in a widescreen view is horizontally squeezed into the narrower proportion of a standard 4:3 image. For proper viewing, the image is expanded back to its original wide format.

angle: Also known as a *camera angle*, a scene recorded from an alternate viewpoint. When used in DVD-Video, angles offered as alternate video tracks must be of the same duration. Up to nine angles (total) are allowed by the DVD-Video specification.

angle menu: DVD menu used for the selection of alternate angles.

AOB: Audio Object—a DVD audio file.

AOBS: Audio Object Set—a DVD audio file.

artifact: Visible degradations of an image resulting from any of a variety of processes. In digital video, artifacts usually result from color compression and are most noticeable around sharply contrasting color boundaries such as black next to white.

aspect ratio: The ratio of an image's width to its height. For example, a standard video display has an aspect ratio of 4:3.

assets: The video and audio clips, stills, titles, and any other materials that comprise the content of a video or DVD production.

audio sweetening: Processing audio to improve sound quality or to achieve a specific effect.

authoring: For DVD-Video, the process of planning, designing, assembling, and formatting content. The authoring process may, depending upon the software being used and individual interpretation, be seen to included encoding video and audio, as well as creating menus.

autoplay: Describes content that is programmed to commence play-back automatically, upon insertion into DVD players that support automatic playback.

AVI: Defined by Microsoft, "AVI" stands for ***Audio Video Interleave***. AVI is one of the file formats for video on the Microsoft Windows platform.

bandwidth: The data-carrying capacity of a device or network. Bandwidth is the maximum amount of data that can travel a communications path in a given time, usually measured in kilobits per second (Kbps). If you think of the communications path as a pipe, then bandwidth represents the width of the pipe, which determines how much data can flow through it at once. Connections of 56 Kbps or lower (typical dial-up connection rates) are considered low-bandwidth, aka ***narrowband***. High-bandwidth, aka ***broadband*** connections are higher than 56 Kbps (for example, ISDN, DSL, cable modem, T-1).

binary: A type of ***digital*** system used to represent computer code in which numerical places can be held only by 'zero' or 'one' (on or off).

bit: The smallest unit of data used by computer systems. A bit (short for binary digit) has a value of either 0 (nil) or 1. Bits are the "building blocks" of binary data. There are eight bits in one byte.

bit depth (audio): The number of *bits* used to describe each sample.

bit depth (visual): See ***bitmap*** (the two terms are not synonymous, but are more easily explained together).

bitmap: Also known as ***raster***, bitmap data comprises a set of binary values specifying the color of individual ***pixels*** that make up an image. Bitmap data is characterized by ***resolution*** and ***bit depth***. Resolution relates to the detail in an image, and is expressed in dots per inch (dpi) or pixels per inch (ppi). The higher the resolution (that is, the more dots used to describe the image), the more detail possible. Bit depth defines the number of colors the image can display. A high-contrast (no grey tones) black and white image is 1-bit, meaning it can be off or on, black or white. As bit depth increases, more colors become available:

Bit depth	Maximum colors
1	2
2	4
4	16
8	256
16	32,768
24/32	16.7 million

For image detail and quality, bit depth is as important as resolution, because the bit depth determines the colors available in the palette. When fewer colors are available, areas that may have shown a subtle shift of tones and hues are rendered instead as single blocks of solid color, eliminating image detail. Bitmap data is indispensable for continuous tone images, such as scanned or digital photographs, and for anti-aliased images. However, bitmap data is consistently larger than vector data.

Each pixel in a bitmap image has to be defined. A relatively small 150-pixel x 150-pixel graphic requires 22,500 discrete bits of information plus the palette, or color lookup table (CLUT), that is usually included. For more information see the online Adobe Technical Guides at ***http://www.adobe.com/support/techguides/livemotion/lmobjects/page2.html***

Blu-ray Disc: Not yet brought to market, but specified by a group of DVD Forum members known as the Blu-ray Disc Founders, this 27 GB capacity optical disc technology would accommodate high-definition (HD) feature film-length content. Based on a blue-violet laser rather than the currently-standard red laser, Blu-ray Disc would require industry retooling and new players for consumers.

camcorder: A video camera, that is, a device that records continuous pictures and generates a signal for display or recording. To avoid confusion, it is recommended that the term "camcorder" be used rather than "camera"—in contrast, a digital camera records ***still*** images, while a digital camcorder records ***continuous video*** images.

camera angle: See *angle*.

capture: If the source footage is analog, "capture" refers to the act of digitization (conversion to a digital format) to make the video usable on a computer and, usually, the simultaneous application of ***compression*** to reduce the video to a manageable ***data rate*** for processing and storage. If the source video is *DV*, "capture" typically refers to the simple transfer of video from an external device, such as a digital camcorder or tape deck, to a computer hard drive.

capture card: See *video capture card*.

CBR: *Constant bit rate* compression results in a fixed data rate. The amount of compression applied must vary, to produce the selected rate. Poor quality may be seen where complex scenes require greater compression to match the selected data rate. Contrast with *VBR*.

chrominance: The color portion of a video signal.

clip: A digitized portion of video.

codec: Short for *compressor/decompressor*; comprised of algorithms that handle the compression of video to make it easier to work with and store, as well as the decompression of video for playback.

color sampling: A method of *compression* that reduces the amount of color information (***chrominance***) while maintaining the amount of intensity information (***luminance***) in images.

compositing: The process of combining two or more images to yield a resulting, or "composite" image.

compression: Reduction of the amount of digital data used to represent still image, video, audio, or other information to yield efficiencies in storage and transmission.

compression ratio: Degree of reduction of digital data as compared to an uncompressed digital representation of the information.

data rate: Amount of data moved over a period of time, such as 10MB per second. Often used to describe a hard drive's ability to retrieve and deliver information.

digital: In contrast to ***analog***, digital representations consist of values measured at discrete intervals. Digital clocks go from one value to the next without displaying all intermediate values. Computers are digital machines employing a ***binary*** system; that is, at their most basic level they can distinguish between just two values, 0 and 1 (off and on); there is no simple way to represent all the values in between, such as 0.25. All data that a computer processes must be digital, encoded as a series of zeroes and ones. Digital representations are approximations of analog events. They are useful because they are relatively easy to store and manipulate electronically.

Digital Versatile Disc: See *DVD*.

Digital Video Disc: See *DVD*.

digitizing: Act of converting an analog audio or video signal to digital information.

Dolby Digital: Developed by Dolby Laboratories, Dolby Digital has become the most commonly used audio encoding system for DVD-Video. The DVD-Video specification for ***NTSC*** requires at least one audio track in either Dolby Digital or ***PCM***; DVD-Video for ***PAL*** requires at least one Dolby Digital, PCM, or MPEG-2 audio track. Dolby Digital can have from one to five full-range channels, plus an *LFE* (Low Frequency Effects) channel. Full surround-sound Dolby Digital, utilizing all available channels, is often referred to as "5.1 sound." Also see ***AC-3***.

Dolby Pro Logic: Developed by Dolby Laboratories, the decoding process and the circuit used to apply the process of separating discrete audio surround-sound channels from a ***matrix-encoded Dolby Surround*** signal. Note that Dolby Pro Logic **de**codes (extracts channels), while ***Dolby Surround*** **en**codes (combines channels).

Dolby Surround: Multichannel surround-sound audio that has been ***matrix-encoded***—that is, combined—to be carried by and played back on a standard dual-channel stereo system, and the associated encoding technology developed by Dolby Laboratories. Note that Dolby Surround **en**codes (combines channels), while ***Dolby Pro Logic*** **de**codes (extracts channels).

DTS: ***Digital theater sound***, originally developed for use in theaters, is an optional audio format for the DVD-Video specification.

DTV: Digital television.

duration: The length of time a video or audio clip plays—the difference in time between a clip's In point and Out point.

DV: Generally refers to ***digital video***, but current usage suggests a variety of nuances. DV can connote the type of ***compression*** used by DV systems or a format that incorporates DV compression. DV ***camcorders*** employ a DV format; more specifically, a standard consumer DV camcorder uses mini-DV tape, compresses the video using the ***DV25*** standard, and has a port for connecting to a desktop computer. The DV designation is also used to for a special type of tape cartridge used in DV camcorders and DV tape decks.

DVD: Abbreviation for ***Digital Versatile Disc*** (sometimes interpreted as ***Digital Video Disc)***, DVDs look like CDs but have a much higher storage capacity—more than enough for a feature length film that is compressed with ***MPEG-2***. DVDs require special hardware for playback.

DVD Forum: International consortium of consumer electronics, computer, and entertainment industry leaders that established the initial standards for DVD technology.

DVD Multi: A logo program overseen by the DVD Forum that identifies DVD devices (players and writers) that support all three formats: DVD-RAM, DVD-R, and DVD-RW.

DVD-RAM: The first rewritable DVD format introduced; a double-sided disc requiring a special cartridge for handling and recording to avoid damage to the fragile recording surface.

DVD-ROM: A term used to refer to both physical and application layer DVD formats. See pages 5-7 of this Primer for an explanation.

DVD-R/DVD+R: Write-once recordable DVD disc formats, often referred to as "DVD minus R" and "DVD plus R." DVD-R(A), or DVD for Authoring, is used by professionals to generate masters for replication. DVD-R(G), or DVD for General, was developed for the consumer market and incorporates content protection measures that proclude copying of specially-protected entertainment titles.

DVD-RW/DVD+RW: Rewritable DVD disc formats, often referred to as "DVD minus RW" and "plus RW."

DVNR: Available as hardware or software plug-ins, ***Digital Video Noise Reduction*** processors, simply refered to as DVNRs, can be used to minimize any undesireable video artifacts resulting from MPEG encoding.

DVS: *Descriptive Video Services* may be included as an alternate audio track on DVD-Video, augmenting the standard sound track by describing the action so the program can be enjoyed by visually-impaired audiences.

DV25: The most common form of DV ***compression***, using a fixed data rate of 25 megabits/sec.

EDL: *Edit Decision List*—master list of all edit in and out points, plus any transitions, titles, and effects used in a film or video production. The EDL can be input to an edit controller which interprets the list of edits and controls the decks or other gear in the system to recreate the program from master sources.

effect: Alteration of a frame or frames of video to change its appearance.

fields: The sets of upper (odd) and lower (even) lines drawn by the electron gun when illuminating the phosphors on the inside of a standard television screen, thereby resulting in displaying an ***interlaced*** image. In the ***NTSC*** standard, one complete vertical scan of the picture—or ***field***—contains 262.5 lines. Two fields make up a complete television ***frame***—the lines of field 1 are vertically interlaced with field 2 for 525 lines of resolution.

FireWire: Apple Computer trade name for *IEEE 1394.*

FPS: Frames per second; a method for describing ***frame rate***.

frame: A single still image in a sequence of images which, when displayed in rapid succession, creates the illusion of motion—the more frames per second (***FPS***), the smoother the motion appears.

frame rate: The number of images (video frames) shown within a specified time period; often represented as ***FPS*** (frames per second). A complete ***NTSC*** TV picture consisting of two fields, a total scanning of all 525 lines of the raster area, occurs every 1/30 of a second. In countries where ***PAL*** and ***SECAM*** are the video standard, a ***frame*** consists of 625 lines at 25 frames/sec.

fullscreen: Format that utilizes the entire standard ***aspect ratio*** (4:3) television screen by: (a) displaying material shot in ***Academy Aperture***, (b) by lopping off the ends of ***widescreen*** material, or (c) by employing the ***pan-and-scan*** technique to select the optimal 4:3 shots from widescreen.

generation loss: Incremental reduction in image or sound quality due to repeated copying of analog video or audio information and usually caused by ***noise*** introduced during transmission. Generation loss does not occur when copying digital video unless it is repeatedly re-compressed.

headroom: When capturing audio, extra data acquired as a result of capturing at higher quality settings than needed for the final cut. Headroom helps preserve quality when adjusting audio gain or applying certain audio effects.

HD: Abbreviation used to refer to high definition video—that is, video meeting the standards for ***HDTV***.

High Definition Television (HDTV): A monitor or display offering 720p (1280x720 pixels ***progressive***) or 1080i (1920x1080 pixels ***interlaced***) resolution, and capable of displaying a 16:9 image and supplying high-quality, multichannel surround sound; the technology used to create and deliver content meeting HDTV standards.

High Density DVD (HD-DVD): The "next generation" of DVD technology, expected to provide enough storage on a single disc to deliver a feature length film as high definition (HD) quality video. Several proposed specifications, including ***Blu-ray Disc***, are under consideration by industry leaders.

IEEE 1394: The interface standard that enables the direct transfer of DV between devices such as a DV camcorder and a computer; also used to describe the cables and connectors utilizing this standard.

i.LINK: The Sony trade name for *IEEE 1394.*

interframe compression: Reduces the amount of video information by storing only the differences between a frame and those that precede it. *(Also known as temporal compression.)*

interlaced display: System developed for early television and still in use in standard television displays. The electron gun used to illuminate the phosphors coating the inside of the screen alternately draws even, then odd horizontal lines, to compensate for the limited amount of time the phosphors will glow—by the time the even lines are dimming, the odd lines are illuminated. To produce the approximately 30 frames per second of NTSC TV, the screen shows half the lines comprising each frame every 1/60th of a second. We perceive these "interlaced" ***fields*** of lines as complete pictures. But, on larger screens, interlacing can produce a noticeable flicker, as compared to ***progressive*** scanning display.

intraframe compression: Reduces the amount of video information in each frame, on an individual basis. *(Also known as spatial compression.)*

JPEG: File format defined by the ***Joint Photographic Experts Group*** of the International Organization for Standardization (ISO) that sets a standard for compressing still computer images. Because video is a sequence of still computer images played one after another, JPEG compression can be used to compress video (see ***MJPEG***).

keyframe: A frame selected at the beginning or end of a sequence of frames, that is used as a reference for any of a variety of functions. For example, in interframe video compression, keyframes typically store complete information about the image, while the frames in between may store only the differences between two keyframes; or, in applying an effect to a video clip, keyframes may contain values for all the controls in the effect and, when the values are different for the beginning and ending keyframes, the effect will change over time.

land: The flat areas surrounding ***pits*** on the recording surface of an optical disc.

letterbox: When the full width of a widescreen image is preserved on the screen of a standard 4:3 TV, black bars are placed above and below the image to block out the unused portions of the screen so the widescreen image can be viewed as originally intended. DVD-Video players can automatically letterbox a widescreen image for viewing on a 4:3 TV.

LFE: The ***low frequency effects*** channel in 5.1-channel surround sound such as ***Dolby Digital*** or ***DTS*** is used to convincingly reproduce low frequency sounds in the 5-120Hz range, for example an explosion, the roar of a locomotive or jet engine, or the rumble of a spacecraft. While a subwoofer may be used for the .1 channel, it can be played back through any speaker that has adequate dynamic range.

lossless: A process that does not affect signal fidelity; for example the transfer of DV via an IEEE 1394 connection, or a lossless compression scheme such as RLE.

lossy: Generally refers to a compression scheme or other process that strives to maintain as much quality as possible while reducing storage requirement, but does result in some degradation of signal fidelity.

luminance: Brightness portion of a video signal.

markers: Markers are used in the editing process to indicate important points in the Timeline or in individual clips. Markers are for reference only; they do not alter the video program.

matrix encoding: The process of combining multiple audio surround-sound channels into a standard dual-channel stereo signal. Aka ***phase matrix encoding.***

MPEG/MPEG-1/MPEG-2: The Motion Picture Expert Group of the International Organization for Standardization (ISO) has defined multiple standards for compressing audio and video sequences. Setting it apart from ***JPEG*** which compresses individual frames, MPEG compression uses a technique where the ***differences*** in what has changed between one frame and its predecessor are calculated and encoded. MPEG is both a type of ***compression*** and a video ***format.*** MPEG-1 was initially designed to deliver low data rate video through a standard speed CD, and is typically used for Video CDs and Web video delivery. MPEG-2 provides broadcast quality video, and is most often used for ***DVD***. MPEG-1 and MPEG-2 require a special decoder for playback.

MPEG audio: Audio compressed according to the perceptual encoding standard specified by the Motion Pictures Expert Group. MPEG-1 audio provides two channels for stereo playback, which can be in the Dolby Surround format. MPEG-2 audio offers up to 7.1 channels of audio for a true surround experience. MPEG audio is mandatory for DVD-Video in the PAL format.

MPEG video: Video compressed according to the specifications of the Motion Picture Expert Group.

NLE: A ***nonlinear editing*** computer system.

noise: Any signal that is added to the original—that is, any distortion of the pure audio or video signal that would represent the original sounds and images recorded.

nonlinear editing: Random-access editing of video and audio on a computer, allowing for edits to be processed and re-processed at any point in the ***timeline***, at any time. Traditional videotape editors are ***linear*** because they require editing video sequentially, from beginning to end.

NTSC: ***National Television Standards Committee*** standard for color television transmission used in the United States, Japan and elsewhere. NTSC incorporates an ***interlaced*** display with 59.94 ***fields*** per second, 29.97 ***frames per second***.

optical disc: Removable storage medium that is written and read using laser light, for example, CD and DVD discs.

PAL: ***Phase-alternating line*** television standard used in most European and South American countries. PAL uses an ***interlaced*** display with 50 ***fields*** per second, 25 ***frames per second***.

pan-and-scan: A technique for forcing a widescreen image to conform to a different aspect ratio (usually 4:3 for TV) by reframing the image—that is, cropping out parts of the picture. DVD-Video players can automatically create a 4:3 pan-and-scan version from widescreen video by using a horizontal offset encoded with the video.

PCM: The uncompressed representation of audio signals in digital form. PCM stands for ***pulse code modulation*** because it is derived by sampling the analog waveform at regular intervals, quantizing the samples, and generating a series of pulses represented by digital code. PCM is one of the audio formats that may be used to fulfill the requirements of the DVD-Video specification but is rarely used in favor of one of the compressed audio formats, typically ***Dolby Digital.***

phase matrix encoding: See ***matrix encoding.***

pitch: The amount of space between ***tracks*** on an optical disc.

pits: Microscopic depressions in the recording layer of an ***optical disc*** that are "read" by a laser beam in the player and translated into a binary stream which is then decoded for audio/video playback. Contrast with ***land***, the flat areas surrounding pits.

pixel: An abbreviation for ***picture element***. The minimum computer display element, represented as a point with a specified color and intensity level. One way to measure image ***resolution*** is by the number of pixels used to create the image.

post-production: The phase of a film or video project that involves editing and assembling footage and adding effects, graphics, titles, and sound.

preproduction: The planning phase of a film or video project—usually completed prior to commencing production.

previsualization: A method of communicating a project concept by creating storyboards or rough animations or edits.

production: The phase of a film or video project comprised of shooting or recording raw footage.

progressive scanning display: A method for displaying video that shows all the scan lines in one pass, every 1/60th of a second (compare to ***interlaced*** display). Progressive scanning reduces the flicker caused by interlacing on larger size displays, but requires more bandwidth.

resolution: The amount of information in each frame of video, normally represented by the number of horizontal ***pixels*** times the number of vertical pixels (for example 720 x 480). All other things being equal, a higher resolution will result in a better quality image.

RGB: *Red-Green-Blue*—a way of describing images by breaking a color down in terms of the amounts of the three primary colors (in the additive color system) which must be combined to display that color on a computer monitor.

sample rate: In digital audio, the number of samples per second; the higher the number, the better the sound quality.

scope: Short for Cinemascope, the first commercially-successful ***widescreen*** format, scope became the generic term for film either shot or exhibited in any widescreen format.

SDDS: *Sony Dynamic Digital Sound* is an optional audio format for DVD-Video that was original developed for theater surround-sound.

spatial compression: See *intraframe compression.*

subpicture: A bitmap graphic overlay used in DVD-Video to create subtitles, menu highlights, and more.

temporal compression: See *interframe.*

time code: Time reference added to video that allows for extremely accurate editing; may be thought of as the "address" on a tape that pinpoints where the clip begins (in) and ends (out).

timeline: The graphical representation of program duration, on which video, audio and graphics clips are arranged.

track: (*1)* On the recording surface of an optical disc, a single revolution in the continuous spiral along which the ***pits*** are arranged. (*2)* In reference to DVD content, a discrete element such as a video, audio, or still-image stream. For any given sequence, the DVD-Video specification allows up to nine different simultaneous video tracks, or angles; up to eight tracks of digital audio; and up to 32 subpicture tracks.

24-bit color: Type of color representation used by most computers. For each of the red, green, and blue components, 8 bits of information are stored and transmitted—24 bits in total. With these 24 bits of information, over a million different variations of color can be represented.

uncompressed: Digitized video that has no information removed from it. Also called "raw" video.

VBR: *Variable bit rate* compression strives to glean the most efficient utilization of available bandwidthand produce consistent quality by allowing the data rate to vary between selected minimum and maximum rates. Contrast with *CBR*.

video capture card (or **board**)**:** Installed inside a computer, adds the functionality needed to ***digitize*** analog video for use by the computer. Using a hardware or software ***codec***, the capture card also compresses video In and decompresses video Out for display on a television monitor.

widescreen: Any aspect ratio for film and video wider than the standard 4:3 format; previously used to refer to wide-aspect film formats; now typically used to refer to the 16:9 format that has become standard widescreen for DVD because this is the aspect ratio specified for HDTV.