

# A DVD Primer

DVD has become an increasingly popular way to store and playback videos. This disk based video storage has the same advantages over video tape that an audio CD has over an audio cassette tape. Video rental stores, once stocked exclusively with VHS tapes, now have growing DVD sections. As the price of DVD players comes down the future of DVD seems bright.

## Basic Definitions

**DVD** is an optical disk storage technology. It can store high quality video, high quality audio and computer data. The DVD is the acronym for Digital Versatile Disk. You may have heard DVD referred to as Digital Video Disk. Because the disks can be used to store data as well as video the more general term is the currently accepted term.

**DVD-Video**, often simply called DVD, defines how video programs are stored on the DVD disk and played on a DVD-Video player or DVD-ROM drive in a computer.

When you hear the term "**DVD-ROM**" it may refer to either DVD-ROM drives or DVD-ROM disks. DVD-ROM drives are the DVD disk drives that can be installed in computers to read DVD disks. DVD-ROM drives can also read CD-ROMs. DVD-ROM disks (instead of drives) refer to manufactured DVD-ROM disks. These are the disks that you buy with the video/audio/data already recorded on the disk.

(Note: ROM = Read Only Memory, or a permanently recorded storage medium that can be read, but can only be recorded to one time, during manufacture.)

**DVD Players** are the specialized stand alone machines that are used to play DVD disks. So far there have been 3 major revisions, or 3 generations. Sometimes a disk that cannot play on an older machine can be played on a 3<sup>rd</sup> generation DVD Player.

While CD-ROM disks can be read by DVD-ROM drives and DVD players, some brands of CD-R disks (the blank CDs that can be written to by a CD burner) **cannot** be read by some DVD Players or DVD-ROM drives. This is because the dye used by some CD-Rs may be "invisible" to the DVD laser wavelength. Some DVD Players have a "dual laser" or "dual optics" feature to allow the DVD Player to read CD-R disks.

A **DVD disk** is exactly the same physical size as a CD. As well as DVD-ROM disks DVD disks include several types of disks that can be recorded (or burned) such as DVD-R, DVD-RAM, DVD-RW and DVD+RW.

## DVD Production

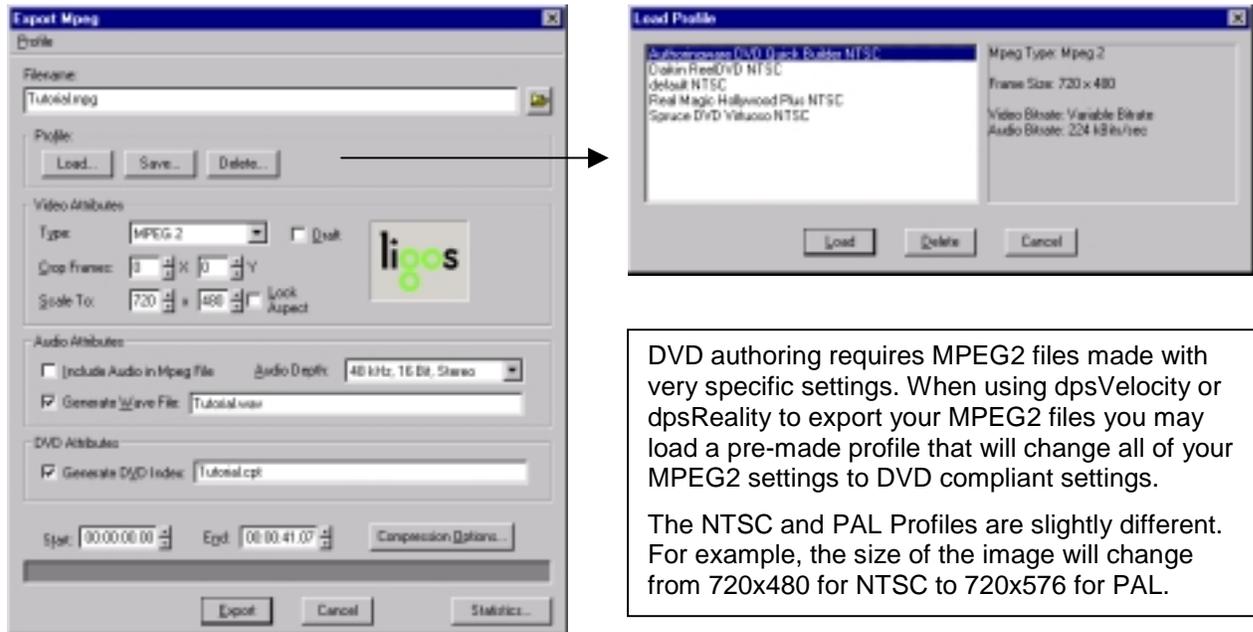
There are 4 major steps in DVD Production:

- 1) Encoding the content to MPEG2 video files and digital audio files
- 2) Authoring (navigation design, layout and testing)
- 3) Premastering (creating a disk image)
- 4) Duplication (under 50 copies using DVD-R disks) or Replication (mass production at a DVD manufacturing plant)

## DVD Video Files – MPEG2

If you want to record video onto a DVD disk you will have to create MPEG2 files that meet the DVD video requirements. These are fairly exact requirements.

If you are using a dpsReality or dpsVelocity Timeline to create your MPEG2 files you will find that some MPEG2 profiles have been created for you that already meet the DVD video requirements. Do not alter these pre-made profiles unless you thoroughly understand the DVD MPEG2 video requirements.



DVD-Video may have up to 8 audio tracks (streams). Each track can be in one of 3 formats: Dolby Digital (AC-3), MPEG1 Layer 2 audio (MPA or MP2), or PCM (WAV). The audio must be sampled at 48 kHz (as opposed to the 44.1 kHz for an audio CD) with a minimum of 16 bits/sample. (Note: You cannot use MP3 files when authoring a DVD.)

The DVD specifications (adhered to by DVD Players) requires a maximum bit rate of 10.08 Mb/s for DVD Video disks. This is the maximum bit rate for the video, the audio, and the subpicture stream. The maximum video bit rate is 9.8 Mb/s, but normally a video bit rate of 6 Mb/s will appear lossless. For just the video and the audio streams the recommended maximum bit rate is 9 Mb/s. For example, if you encode your video at 6000 Kbits/sec and your audio at 1540 Kbits/sec (an uncompressed WAV file) your combined bit rate will be 7540 Kbits/sec. If you add more audio streams (up to a maximum of 8 audio streams) your combined data rate will be the video data rate plus the audio bit rates of **all** of the audio streams (not just the video and the single audio stream that will be playing at one time).

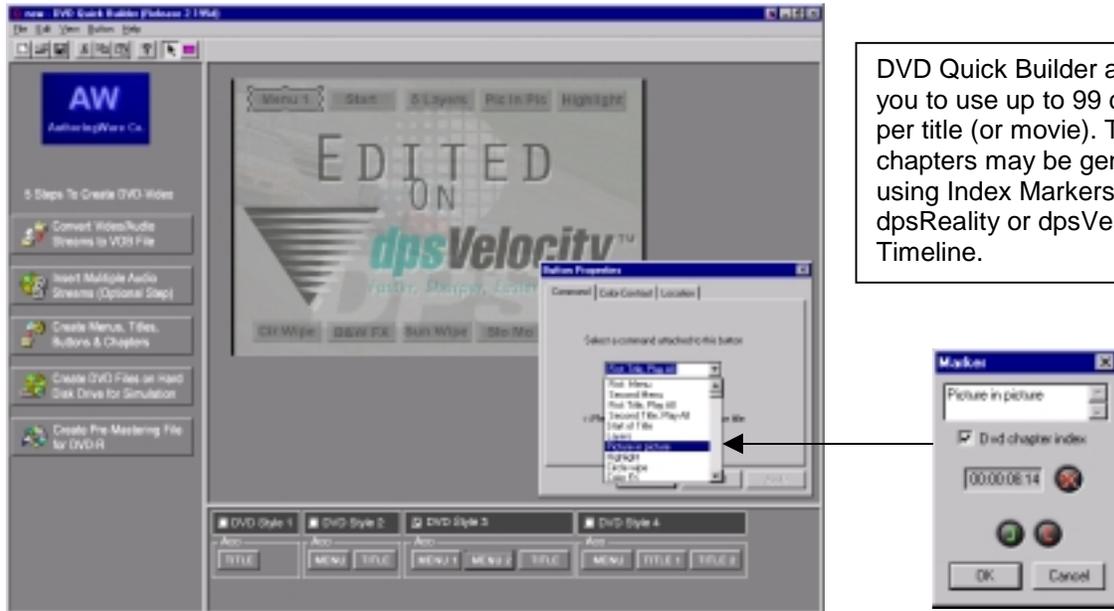
## DVD Navigation

The most simple type of DVD Video disk has a single movie (or title). When you place the DVD disk in the DVD Player the movie starts playing. Disk playback can be controlled using the usual transport controls found on the DVD Player's remote control.

Many DVDs have a **menu** to provide the viewer with content selection and feature control options. Each menu has a background graphic and buttons (or hotspots).

DVD-Video content is broken into “**movies**” (sometimes referred to as titles or, for audio DVDs, albums) and “**starting points in movies**” (chapters or songs). Sometimes the entire DVD is referred to as a “DVD title”.

**Movies** are normally created from a single **VOB file** (video object file). The VOB file is normally created from an MPEG1 or MPEG2 file and 1 to 8 audio files. Some DVD authoring software allows you to use chapters in your movie for navigation to a specific starting place. For example, DVD Quick Builder (from AuthoringWare) allows you to use up to 99 chapters per title (or movie). Note: chapters are starting places only. You cannot mark the “end of a chapter”.



Alternately, with some DVD authoring tools, movies may be made up of “cells” linked together by one or more “program chains” (PGC). A PGC can be on of three types: sequential play, random play (may repeat), or shuffle play (random order but no repeats). Individual cells may be used by more than one PGC, which is how parental management and seamless branching are accomplished: different PGCs define different sequences through mostly the same material.

**DVD Remote Controls:** All DVD remote controls have 4 arrow keys to allow the viewer to select onscreen buttons, plus a select (or activate) key, numeric keys, a menu key and a return key. DVD Remote controls may include a variety of other functions, such as next, previous, search to part of title (chapter) and select audio track (using one of 8 languages).

## DVD versus CD

DVD and CD disks are physically exactly the same size. However, that is where the similarity ends. CDs can often be played in DVD drives, but DVDs cannot be played in CD drives.

DVD drives use a laser with a smaller wavelength. A DVD laser uses 650 nm or 635 nm wavelength while a CD laser uses a 780 nm wavelength. A DVD packs the data closer together (smaller track pitch and shortest pit length). It also spins faster. A 1x CD-ROM can deliver up to 1.168 Mb/secs while a 1x DVD can deliver up to 10.6 Mb/secs. A CD-R has a data capacity of 650 Mbytes. A DVD-R has a data capacity of 4.38 GB. A DVD-ROM disk can hold up to 15.9 GB.

## **DVD Drive speed**

The DVD specifications (adhered to by DVD Players) requires a maximum bit rate of 10.08 Mb/s for DVD Video disks. This is the maximum bit rate for video plus audio plus subpicture. The maximum video bit rate is 9.8 Mb/s, but normally a video bit rate of 6 Mb/s will appear lossless.

A 1x DVD-ROM drive provides a data transfer rate of 1.321 MB/s (or approximately 11 Mb/s, where 1 Byte = 8 bits). This is roughly equal to a 9x CD-ROM drive (the 1x CD-ROM data transfer rate is 150 KB/s or 0.146 MB/s). DVD-ROM drives are currently available in 2x, 4x, 4.8x, 5x, 6x, 8x, 10x, and 16x speeds.

Note: When playing movies, a fast DVD-ROM drive gains you nothing more than possibly smoother scanning and faster searching. Speeds above 1x do not improve video quality from DVD-Video discs. Higher speeds only make a difference when reading computer data, such as when playing a multimedia game or when using a database.

## **Recordable DVD Disks:** DVD-R (A), DVD-R (G), DVD-RAM, DVD-RW, and DVD+RW

There are currently 5 different types of recordable DVD disks. Unfortunately, none of these formats are fully compatible with each other or with existing DVD-ROM drives and DVD Players.

**DVD-R** disks can record data only once. They can be read by most DVD-ROM drives and DVD players. Pioneer released their 3.95 billion byte DVD-R disks in October 1997 and their newer 4.7 billion byte (or 4.38 GB) DVD-R disks in May 1999. Blank DVD-R disks are currently about \$30 US.

In early 2000 the DVD-R format was split into a DVD-R(A) "authoring" version that uses a 635 nm laser and a DVD-R(G) "general" version that uses a 650 nm laser. This gives the DVD-R(G) version the future ability to write DVD-RAM disks. DVD-R(G) is intended for home use while DVD-R(A) is intended for professional development.

Pioneer is currently the leading supplier of DVD-R drives. These drives can use the Prassi software to burn a DVD-R image to a DVD-R disk.

**DVD-RW** disks can be rewritten about 1000 times. The disks have a capacity of 4.7 billion bytes. Pioneer also developed this format. In 1999 Pioneer released DVD-RW home video recorders in Japan. These recorders use the new DVD-VR (video recording) format, so the disks will not play in existing DVD Players. A new version is expected to be released near the end of 2000 which will use the DVD-Video format and will therefore be compatible with existing DVD Players. Sharp and Zenith are also expected to release DVD-RW recorders near the end of 2000. Blank DVD-RW disks are currently around \$30 US.

**DVD-RAM** disks can be rewritten about 100,000 times and the disks are expected to last at least 30 years. The storage capacity is 4.7 billion bytes per side (with one and two sided disks available). DVD-RAM currently is not compatible with most drives and players. The first DVD-ROM drive to read DVD-RAM disks was released by Panasonic in 1999. Hitachi also released a DVD-ROM drive that can read DVD-RAM disks.

**DVD+RW** is expected to be released in 2001. DVD+RW is supported by Philips, Sony, Hewlett-Packard, and others. It is expected that DVD+RW media will be able to be rewritten about 1000 times.

## **AN IMPORTANT NOTE ON UNITS – GB versus Billion Bytes**

A single layer recordable DVD typically holds 4.7 billion bytes (G bytes), **not** 4.7 gigabytes (GB). It only holds 4.38 gigabytes (GB). A double-sided, dual-layer DVD holds 17 billion bytes, which is only 15.90 GB.

The confusion arises because the SI prefixes kilo, mega and giga normally represent multiples of 1000. However, when used in the computer world to measure bytes these same prefixes generally represent multiples of 1024 (in the binary world,  $2^{10} = 1024$ ). This means that a kilobyte = 1024 bytes, a megabyte = 1,048,576 bytes, and a gigabyte = 1,073,741,824 bytes. So 4,700,000,000 bytes = 4.38 gigabytes.

Unfortunately, most DVD figures are based on multiples of 1000, which means that your computer operating system and your DVD are using the same prefix to mean different things. This is an extremely important distinction to keep in mind when preparing the files for your DVD.

To make things worse, data transfer rates when measured in **bits per second** are almost always multiples of 1000, but when measured in **bytes per second** are sometimes multiples of 1024. For example, a 1x DVD drive transfers data at 11.08 million bits per second (Mbps), which is 1.385 million bytes per second, but only 1.321 MegaBytes per second. The 150 KB/s 1x data rate commonly listed for CD-ROM drives is "true" kilobytes per second (multiple of 1000), since the data rate is actually 153.6 thousand bytes per second.

## **DVD-Video and DVD-Audio files and folders**

DVDs use specialized data files which are normally stored in special folders.

Files:

.IFO (Information)	Menus and other information about the video and audio
.BUP	Backup files
.VOB (Video Object)	MPEG program streams with additional packets containing navigation and search information.
.AOB (for DVD-Audio)	Similar to .VOB files, but for DVD Audio disks

Folders:

VIDEO_TS folder	This folder stores the IFO, VOB and BUP files
AUDIO_TS folder	DVD Audio folder which stores the AOB files

Note: the AUDIO\_TS folder is needed for compatibility with DVD-Video Players.

When you create the DVD files you will usually create the following files in your Video\_TS folder:

Video_ts.ifo and Video_ts.bup	The control data needed to navigate the entire DVD
Vts_01_0.ifo and Vts_01_0.bup	The control data needed to navigate movie 1
Vts_01_0.vob	The video for movie 1, segment 0
Vts_01_1.vob	The video for movie 1, segment 1
etc., up to 9 segments	
Vts_02_0.vob, etc.	The video for movie 2, segment 0
etc., with Vts files for each movie	

If you plan to burn a DVD-R you will usually have to create a DVD-R image file on your hard drive first. Your DVD Authoring program should be able to produce the \*.img or \*.udi file from your Video\_TS and Audio\_TS folders. The \*.img and \*.udi files are identical except for the file extension, so you can rename the file using the other extension should your software require the other file extension.

# **DVD Creation Tips**

## **TIP: DVD-Video Content on a CD-R**

You can burn DVD-Video content on a CD-R or CD-RW disk.

The main advantage of doing this is that you can use an inexpensive recordable CD rather than an expensive DVD-R. Of course, the storage capacity of a CD is much less than that of a DVD, so these “mini DVDs” can only be used for short programs or for testing.

All but the early models of DVD-ROM drives should be able to read CD-Rs. DVD-Video players normally cannot playback DVD-Video content from a CD-R. You must use a DVD-ROM drive to play back these CDs.

To make a CD with DVD-Video content follow your normal DVD authoring procedure until you have created the VIDEO\_TS and AUDIO\_TS folders. Then burn the VIDEO\_TS and AUDIO\_TS folders to the root directory of the CD-R or CD-RW.

## **TIP: Playing Your DVD-R**

If you are having trouble playing your newly burned DVD-R on a DVD Player keep in mind that older DVD Players may not be able to play DVD-R disks. Newer 3<sup>rd</sup> generation DVD Players should have no problem.

With a DVD-ROM drive on a Mac you may need to upgrade your operating system to MacOS 8.6 or higher before you can play a DVD-R disk.

Once you have used your DVD Authoring software to create the Video\_TS and Audio\_TS folders you will probably want to test your DVD navigation. Note that even though the files you have created are on your hard drive you must still have a DVD-ROM drive installed before you will be able to play back the files. You must also have DVD player software installed. DVD player software is always powered by an MPEG decoder. The decoder can be hardware based, such as the RealMagic Hollywood+ PCI card ([www.sigmadesigns.com/realworld.htm](http://www.sigmadesigns.com/realworld.htm)), or software based, such as DVD Player by Ravisent ([www.ravisent.com](http://www.ravisent.com)) or WinDVD by InterVideo ([www.intervideoinc.com](http://www.intervideoinc.com)).

## **TIP: Selecting Your Text – Font and Size**

When you are creating your menu background you will often want to include text. For example, you will probably want to label the buttons you create so that the viewer knows what each button does. Fonts that look ok on a computer screen may flicker on a video monitor or TV. You should avoid thin text. About 18 point text is the smallest text that you should use. Avoid high contrast between your text color and the background color. Do not use overly saturated colors as they will “bleed” on a TV screen.

## **TIP: Video Safe Area**

Most TV screens do not show an entire video image. The edge of the picture is normally outside the screen. This allows sets that are aligned slightly differently to still show a picture that fills the screen. In order to be sure that the buttons and text on your menus will be visible to all viewers do not place them too close to the edge of the image.

**TIP: Making Bitmaps or “My circles look like ovals” (square pixels vs. rectangular pixels)**

You will often make your Menu backgrounds in a paint program on your computer. If you make a perfect circle on your computer screen, and then you show it on your TV or video monitor, it will look like an oval. That is because the pixels on your computer screen are square, while the pixels on your video monitor or TV are rectangular. In order to avoid this slight distortion you can make your images at 720 x 540, and when the image is complete you can re-size it in your paint program to 720 x 480 (NTSC) or 720 x 576 (PAL). Of course, then your circles will look like ovals on your computer screen, but they will be perfect circles on your TV or video monitor.

**TIP: Calculating File Sizes for DVD**

Before you spend a lot of time authoring your DVD it is very important to calculate your file sizes. Here is a guide to help you with your calculations.

There are two types of DVD-R discs, 4.7 GB and 3.95 GB in capacity. Note that DVD sizes are given in SI units, which means that 4.7 GB = 4,700,000,000 bytes or 4.7 billion bytes. However, your Windows operating system uses the computer convention, where:

1024 bytes = 1 KB and 1024 KB = 1 MB and 1024 MB = 1 GB.

**Your operating system will see a 4.7 GB DVD-R disc as having a capacity of 4,700,000,000 bytes/ (1024 B/KB x 1024 KB/MB x 1024 MB/GB) = 4.38 GB.**

Also note that MPEG2 data rates are often given in Kbits/sec, where 1 Kbyte = 8 Kbits.

Uncompressed audio sampled at 16 bit, 48 kHz, stereo = 187,500 bytes/s = 1,540,000 bits/sec

Typically MPEG1 Layer 2 audio may be compressed to 224 Kbits/sec (approximately 7:1). At a compression of 384 Kbits/sec the audio is compressed at approximately 4:1.

An MPEG2 video bit rate of 6000 Kbits/sec or less generally appears lossless.

At a typical bit rate of 6000 Kbits/sec for video and 1540 Kbits/sec for one stream of uncompressed audio, for a total bit rate of 7540 Kbits/sec:

Number of Minutes	Storage Requirements
10	550 MB Note: The storage capacity of a CD is 650 MB
15	830 MB
30	1.6 GB
45	2.4 GB
60	3.2 GB
75	4.0 GB Note: The storage capacity of a DVD-R is 4.38 GB

Keep in mind that the MPEG2 and audio files must be processed into a VOB file. A typical Video\_TS folder will include .vob, .bup and .ifo files. The main VOB file (or files, if there are 2 or more movies) which includes the MPEG2 video will be the largest file. The other files combined will generally be much smaller (typically only a couple of MBs).

**TIP: Preparing Your Computer’s Hard Drive**

When you are burning a DVD-R it is crucial to maintain the data rate required by the burner. While this data rate is only about 6 – 10 Mbits/sec, a badly fragmented drive may have data flow “hiccups” that can cause the data rate to drop, ruining the DVD-R you are burning. To be safe, always store your final DVD files on a separate hard drive, or a separate partition on a hard drive, that you can re-format prior to creating your final DVD files. That way you can be guaranteed that your data stream will not be interrupted because of a fragmented drive.