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DVD Software Support for Compaq Portables

Abstract: Beginning in 3Q98, Compaq began shipping DVD drives for use with the Armada and Prosignia family of portable computers. This relatively new drive technology represents a significant increase in capacity over read-only CD-ROM media. Increased capacity provides new applications impractical with CD-ROM drives, most notably, playing DVD Hollywood movie titles.

The purpose of this White Paper is to introduce the DVD movie playback software for use on select Armada and Prosignia portables equipped with a DVD drive. Compaq has enhanced the installation process of MediaMatics™ DVD Express software to combine all the latest drivers and supporting utilities necessary to provide a seamless playback solution on our various Armada and Prosignia platforms. This document will summarize those supported platforms, review the software solution's feature set, and provide additional information on how the software will be distributed.

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DVD Software Support for Compaq Portables
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Overview

DVD, which stands for Digital Versatile Disc, is the next generation of optical disc storage technology. It's essentially a bigger, faster CD that can hold video as well as audio and computer data. DVD aims to encompass home entertainment, computers, and business information with a single digital format, eventually replacing audio CD, videotape, laserdisc, CD-ROM, and perhaps even video game cartridges. DVD has widespread support from all major electronics companies, all major computer hardware companies, and most major movie and music studios.

NOTE:

DVD Express is only supported under Microsoft Windows 95 OSR-2 or Windows 98. Windows NT 4.0 is not supported, as this operating system does not include the native components necessary to support DVD. Playback of other multimedia video formats such as AVI and MPEG1 are supported under Windows NT 4.0 on Compaq Armada and Prosignia portables.

To meet customer requirements for a complete Digital Versatile Disk (DVD) solution, Compaq has chosen to augment the Armada and Prosignia family of notebook computers with DVD Express, a software playback solution. This industry leading software has been optimized for playback of MPEG2 (Motion Picture Experts Group specifications) encoded video clips as well as encrypted Hollywood DVD movie titles. Decoding digital MPEG2 video is accomplished through software only, eliminating the need for more expensive hardware. Although the software will function on Intel 233-266MHz Pentium II based notebooks, playback quality is reduced since loss of video frames (video images look as though they're skipping sections of the movie) during playback may occur. Software playback performance on platforms faster than Intel's 300MHz PII processors may sustain 30 fps (Frames Per Second) on certain titles which approaches the quality of most hardware playback solutions.

DVD Express offers:

- **A High performance software DVD player for the PC that:**
 - Supports DVD, MPEG-1, MPEG-2 and VideoCD formats
 - DirectShow® compatible
 - Contents Scramble System (CSS) enabled for Hollywood movie playback
 - Decodes -
 - MPEG-1 and MPEG-2 video streams
 - Sub-picture streams
 - AC-3 (Dolby Digital®), MPEG-1, MPEG-2, MPEG-3, and normal CD audio
 - Dolby Level C Certified
 - True consumer-quality audio and video playback
 - Significantly reduces cost of enabling PCs with DVD capability by avoiding the purchase of additional hardware components
 - Backwards compatible to MCI (older MPEG2 formatted content) command set
 - Optimized for MMX®-based processors

Regional Playback Considerations

Playback of Hollywood DVD movie titles involves decoding MPEG2 video, digital AC3 audio and decryption of CSS protected content. CSS (sometimes called copy guard) is the name given to the content protection scheme adopted by the motion picture industry to satisfy a need to protect against unlawful content duplication. DVD Express is able to read movie content encrypted using CSS, which obligates Compaq, as a licensor of CSS technology, to satisfy legal obligations embodied in the CSS license agreement.

Windows 98 the user will be prompted to make this selection when first attempting to play a regionalized DVD movie title. Under Windows 95, the DVD Express software will store this choice. Under Windows 98, DVD Express will rely on native capabilities of the operating system to manage regionalization. In either case, once the choice is made *it cannot be changed*.

As Compaq rolls out newer RPC2 DVD players, these drives will be capable of storing the region code in the drive's firmware. The intent at this point is for regionalization to behave the same as it currently does under Windows 95 and Windows 98. The user will be allowed to make up to five choices when attempting to play regionalized movies. The difference is that the software will work with the drive firmware to maintain the choice and not the DVD drive. The impact to the user will be that in order to play regionalized content the region code maintained by the software and the DVD drive hardware must match the region of the DVD movie in order for it to play correctly.

Supported Platforms

DVD Express software will be distributed with all Armada and Prosignia DVD Drive Option kits and with any Armada and Prosignia notebook equipped with a minimum configuration of an Intel Pentium II 233MHz or faster processor that ships with a DVD drive as part of its shipping configuration. Notebooks that contain Intel 300MHz Pentium II and faster processors and video controllers that include built in motion compensation support provide an optimum platform for software playback that nearly approaches the quality of a hardware solution. Slower platforms, down to the minimum Intel Pentium II 233MHz, can still function with adequate quality, but will suffer minor playback resolution problems. Video playback quality suffers on slower processors, such as "dropped frames" {where the movie will appear to "skip ahead" or "jump" from one section to another (processor is trying to catch up with the playback frame rates)}.

DVD Express is only supported on notebook platforms running Microsoft Windows 95 (OSR2.0 and above) and Windows 98. Microsoft Windows NT 4.0 does not support MPEG2 movie playback at this time. Compaq expects Microsoft Windows 2000 Professional to include the native support required for MPEG2 movie playback.

Additional support details can be found by visiting:

<http://www.compaq.com/products/options/dvd/index.html>

TABLE 2 – SUPPORTED PLATFORMS:

Armada Notebook	Prosignia Notebook	Pentium II 233 MHz	Pentium II 266 MHz	Pentium II 300 MHz	Pentium II 333 MHz	Pentium II 366 MHz
1500c	120	Yes ^{1,2,4}	Yes ²	Yes ³	Not Applicable	Not Applicable
1700	122,140,160 ⁴	Yes ^{1,2}	Yes ²	Yes ³	Yes ³	Yes ³
1750	144, 162	Not Applicable	Not Applicable	Not Applicable	Yes ³	Yes ³
6500	Not Applicable	Not Applicable	Not Applicable	Yes ³	Not Applicable	Yes ³
7400	Not Applicable	Not Applicable	Yes ²	Yes ³	Yes ³	Yes ³
7800	Not Applicable	Not Applicable	Yes ²	Yes ³	Not Applicable	Yes ³

NOTES: 1 STN versions not well suited for multimedia applications. External monitor use recommended.

2 Processor speeds below 300MHz may result in minor playback quality problems (dropped frames).

3 These platforms are likely candidates for full "Designed for Windows" certification.

4 Applicable to and including all Prosignia 120, 140, and 160 series notebooks.

Distribution

All Armada and Prosignia platform users who have purchased a DVD drive option, or system that included a DVD drive, that are using Microsoft Windows 95 or Windows 98, are entitled to one free copy of the DVD Express software. This software is either included in the DVD drive upgrade or notebook box, or can be provided separately upon request.





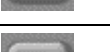
If your notebook includes a DVD drive, and no software was included with your notebook, then you will need to contact Compaq requesting separate software. Notebook platforms that did not include the DVD Express software will be provided with an RTF (Read This First) and BRC (Business Reply Card) that provides instructions necessary for additional fulfillment requests. The BRC should be filled out and returned, if the notebook was purchased in North America or Canada, to request fulfillment kit #388054. All other areas can contact either their local service organizations or Compaq Customer Service Centers to request fulfillment kit #386711. Other geographic regions may use alternative solutions, so please contact your local Compaq agents.

















DVD Express Operational Summary

The DVD Express software will present the user with one of the following interfaces, details of which are below.



TABLE 3 - OPERATIONAL SUMMARY

Feature	Use To...	Icon	Shortcut
Open	Use to open a video or audio file for selection and playback		L
Eject	Use to open the DVD drive for loading or removal of discs		E
DVD Options	Use to display the DVD Express Options menu tabs, which include About, Audio, Video and Parental Control		
Change Camera Angle	Use to change the camera angle of the movie currently being played where the content supports multiple camera angles		V
Change Audio	Changes the audio track currently in play to another track included on the DVD disc		O

Feature	Use To...	Icon	Shortcut
Title Menu/Resume	Displays the main title menu for selection of content to be played		T
Change Subtitle	Displays or changes sub-titles viewed onscreen		U
Root Menu/Resume	Displays the DVD root menu for selection of DVD content to play		R
3D Audio	Activates the 3D audio feature for virtual surround sound		A
Play	Begins playback of selected content		Enter
Stop	Stops content playback and returns to the start of the content file		S
Pause	Pauses the content playback and toggles between Play and Pause		P
Fast Forward	Fast forwards content playback at double speed to a selected location		F
Next	Advances the content to the next chapter and resumes playback		>
Previous	Moves content to the previous chapter and resumes playback		<
Rewind	Rewinds the content to a selected location		B
Volume	Increases the volume level when the bar is moved up and decreases when the bar is moved down		+/-
Mute	Mutes the audio track		M
Close	Closes DVD Express		X
Minimize	Minimizes DVD Express		N
Help	Displays the online help file		F1

A Word about DVD-to-GO

In addition to providing DVD Express for select Armada and Prosignia platforms, Compaq has also qualified the DVD-to-Go hardware MPEG2 decode solution (Compaq Part Number 202861-001). The solution includes movie player software and a PCMCIA Card.

The DVD-to-Go Card includes the following key features:

- Hot Plug & Play Interface with Microsoft Windows 95 OSR2 and Windows 98
- MPEG-2 video and Dolby Digital Surround Sound AC-3 audio
- 720 x 480 (16 million colors) video resolution
- Up to 20 megabits per second of sustained video playback
- Multitasking capability
- Backward compatible with video CD and MPEG-1 titles
- Low power usage (1.5 watts) and output (5 volts)

The solution differs from DVD Express in that MPEG2 decode is off loaded to the PC Card, which frees up the processor for other tasks. Off loading MPEG2 decode to the PC Card can improve performance in some cases. More importantly though, DVD-to-Go allows Armada and Prosignia notebooks to play DVD movies where there is no support for a software solution like DVD Express.

DVD Express Software Specifications

Supports multiple graphics controller architectures

- Current video accelerated graphics controllers
- MPEG-2 accelerated graphics controllers:
 - Motion compensation
 - MVCCA™ (patented Mediamatics' motion compensation architecture)
- DirectX interface to graphics controllers
- Outputs data in field and frame modes
- Proprietary de-interlacing algorithms for reduction of motion effect on VGA monitors

Video Decode Filters

- Decodes MPEG-1 and MPEG-2 video streams
- Full compliance with ISO 11172 (MPEG-1), ISO 13818 (MPEG-2), MP@ML (DVD)
- Supports:
 - NTSC and PAL formats
 - Interlaced and progressive frames
 - Closed Caption data
 - Multiple language audio streams

Sub-picture Decode Filters

- Full Sub-picture decoding
 - Text and graphics overlay

Audio Decode Filters

- Decodes AC-3, MPEG-1, MPEG-2 and MPEG-3 audio streams
- Full compliance with ISO-11172, ISO 13818 MPEG audio standards
- Supports MUSICAM, Layer 1 & 2
- Decodes all 5.1 AC-3 audio channels
- Dolby Level C certified
- Sampling rates from 11KHz to 48KHz
- Playback rates up to 48KHz
- Multiple audio streams support (up to 8)
- 2 channel output for:
 - Stereo Speakers
 - Pro-Logic (Dolby® Surround Sound)

- 5.1 channel output for:
 - 6 channel audio cards
 - 4 channel audio cards
- Support for 3-D Audio (from 3rd party)

DirectShow®

- DirectShow® Navigator -
 - Enables the DVD 1.0 standard interactive features such as multiple language control and camera angles.
 - Validates DVD content through a key authentication and exchange system
 - Provides region coding support
- Audio and video filters for Plug-and-Play installation
- Perfect audio/video synchronization
- MCI backward compatibility

GUI (as per table 2)

- User interface for playback of DVDs, VideoCD, and audio CDs
- Friendly look and feel

Splitter

- Available for non-DVD file playback
- Separates program streams into audio, video and sub-picture streams

Content Scrambling System (CSS)

- CSS software support for playback of Hollywood movies or other encrypted content
- Tamper resistant
- Supports six regional codes
- Licensed from IBM Microelectronics

Internationalization

- Currently translated into 16 languages:
 - English, Brazilian Portuguese, Danish, Dutch, Finnish, French, German, Italian, Japanese, Korean, Norwegian, Simplified Chinese, Spanish, Swedish, Thai and Traditional Chinese

Frequently Asked Questions

Am I able to play DVD movies on the slower Armada or Prosignia notebooks?

No, if the notebook processor is an Intel Pentium I generation. Yes, if the notebook processor uses an Intel Pentium II, and includes an optional DVD drive used in conjunction with either the optional DVD-to-Go PC Card from Compaq (Part Number 202861-001) or with DVD Express software, users are able to play DVD movies and other MPEG2 video clips. The DVD-to-Go PC card solution provides hardware assisted MPEG2 decoding (through the PC Card) that guarantees the highest level of movie playback performance regardless of processor. Although DVD Express can be used on 233 MHz processor systems, playback quality is higher if the DVD-to-Go solution is used instead.

How is the DVD region set with DVD Express and can it be changed?

When first attempting to play regionalized movie content with DVD Express the application will prompt the user to select the region. This is a one-time selection and *cannot be changed* once set. The requirement to ensure the application only allow this selection to be made once is a requirement Compaq must satisfy as a licensor of CSS encryption technology used to protect DVD movies. This licensor requirement also restricts distribution via open networks, like the Internet.

Will DVD Express play unencrypted MPEG2 clips?

Yes, DVD Express will play MPEG2 files that have not been encrypted using CSS. The one-time region choice will not impact the ability to play “region-less” content in any way.

Is the Compaq DVD drive compatible with the Armada 7700 & 7300?

Intel Pentium I processor based systems, like the Armada 7700 and 7300 are *too slow* to maintain any appreciable frame rate to support acceptable MPEG-2 playback quality. Only those Armada 7000 notebooks with Intel 233MHz Pentium II processors or better are able to use DVD Express to play MPEG2 movies. For notebooks that do not meet these minimum requirements, Compaq provides the DVD-to-Go PC Card option as an alternative, which is compatible with the entire Armada 7000 family including systems with Intel Pentium I 133MHz processors or better.

Why is DVD Express unavailable on the Compaq website?

CSS licensing prohibits distribution of any product that incorporates CSS technology on any publicly accessible medium such as the web. DVD Express is only available with new DVD drive option kits and select notebooks that ship with a DVD drive as part of their shipping configuration.

What is CSS and why is it important?

CSS stands for Content Scrambling System, a security design used for descrambling and playing encrypted DVD content used by all Hollywood movie studio. Without a CSS solution, PCs cannot play encrypted content such as Hollywood movies. CSS also discourages illegal copying and distribution of DVD content through its MacroVision copy protection features.

How can I improve multitasking performance while playing a DVD movie?

Since DVD Express relies on the processor to decode MPEG2 video clips, using additional hardware to assist with decoding may improve performance. In addition to providing DVD Express, Compaq has qualified the DVD-to-Go PC Card for use with the Armada 1500c, 1700, 1750, 3500, 6500, 7300, 7400, 7700, 7800 and select Prosignia notebooks. DVD-to-Go provides hardware assisted MPEG2 decode that relieves the processor to work on other tasks.

Can I play a DVD movie using DVD Express under Windows NT?

No. DVD Express exploits the DirectX 5.2 API (Application Programming Interface). Since Windows NT 4.0 only supports DirectX 3.0, DVD Express and MPEG2 playback will not work. Microsoft has announced that future revisions of the DirectX feature set will be incorporated into Windows 2000. Other multimedia video file formats such as AVI and MPEG1 are supported under Windows NT 4.0 on Compaq Armada and Prosignia portables.

What problems will exist using software playback versus hardware playback?

Optimum playback quality can only be achieved with a hardware solution like the DVD-to-Go PC Card. Software playback solutions like DVD Express, while economical, only

perform as well as the system resources that are available. Factors such as screen quality, video controller speed, processor speed, and DVD drive firmware and playback speed all drive the video image playback quality. Some STN flat panel screens are not well suited for multimedia applications, so an external monitor is recommended for playback. CPU processor speeds at or above 266MHz are recommended to avoid loss of video image frames.

What is DirectShow and why is it critical for DVD solutions to be DirectShow compatible?

DirectShow is the Microsoft Application Programming Interface (API) that serves as the interface for writing DVD based applications and titles. Having a standard API makes it easier for developers to write their application once and have it work with all DirectShow enabled DVD solutions. Solutions such as DVDEExpress solve this compatibility issue for designers by fully complying with the API.

Why can't I use this software under the retail version of Windows 95?

Neither the DVD express software or the DVD-To-Go hardware solutions will operate correctly under the retail or OSR1 versions of Microsoft Windows 95. The retail and OSR1 versions of the Windows 95 operating system are missing certain key multimedia components, such as Direct-X and DirectShow that provide a sufficient foundation for basic DVD movie decryption. Only by using the preinstalled and enhanced OEM Service Release V2.0 or greater versions (already provided with your Compaq Armada and Prosignia notebook computers) will play DVD content.

What's the quality of DVD-Video? Why do some demos look so bad?

DVD has the capability to produce near-studio-quality video and better-than-CD-quality audio. DVD is vastly superior to videotape, and can be better than laserdisc. However, quality depends on many production factors. Until compression knowledge and technology improves we may often see DVDs which are inferior to laserdiscs. Also, since large amounts of video have already been encoded for Video-CD using MPEG-1, some early DVDs will use that format (which is no better than VHS) instead of higher-quality MPEG-2.

DVD video is compressed from studio ITU-R 601 format to MPEG-2 format. This is a "lossy" compression, which removes redundant information (such as sections of the picture that don't change), and information that's not readily perceptible by the human eye. The resulting video, especially when it is complex or changing quickly, may sometimes contain "artifacts" such as blockiness or fuzziness. It depends entirely on the quality of compression and how heavily the video is compressed. At average rates of 3.5 Mbps (million bits/second), artifacts may be occasionally noticeable. Higher data rates result in higher quality, with almost no perceptible difference from the original master at rates above 6 Mbps. As MPEG compression technology improves, better quality will be achieved at lower rates.

One of DVD's audio formats is LPCM (linear pulse code modulation) with sampling sizes and rates higher than audio CD. Audio can also be stored as discrete multi-channel surround sound using Dolby Digital or MPEG-2 audio compression. These are similar to the surround sound formats used in theaters but with higher compression. As with video, quality depends very much on how well the encoding was done.

Who can create or produce DVD video content for me?

The following companies are involved today in producing movie or video content onto DVD's.

- [A] Authoring (including compression and mastering).
- [R] Replication (mastering and/or one-offs).
- [S] Uses Sonic Solutions' authoring system.
- [A] All Post (CA), 818-556-5756.
- [AS] CRUSH Digital Video (NY), <mailto:info@CrushDV.com>, 212-965-1501.
- [A] Digital Video Compression Corporation (CA), <http://www.dvcc.com>, 818-777-5185.
- [R] Disc Manufacturing Inc. (CA), 302-479-2525.
- [A] IBM InteractiveMedia (GA), interactive@vnet.ibm.com, 770-835-7193.
- [R] Imation (formerly 3M) (WI), 612-704-4898.
- [AS] Intel (OR), http://developer.intel.com/drg/hybrid_author/devlab.htm, 503-264-3555.
- [R] JVC Disc America (CA), 310-274-2221.
- [AS] KAO Infosystems (CA), www.kaoinfo.com, 510-657-8425.
- [AR] Kao (ON), 800-871-MPEG.
- [R] LaserPacific (CA), <http://www.laserpacific.com>, 213-462-6266.
- [R] Metatec (OH), <http://www.metatec.com>, 614-761-2000.
- [AS] NB Digital Solutions (MD), <http://www.nbeng.com/dvd.htm>
- [R] Nimbus Manufacturing. 804-985-1100.
- [R] Optical Disc Corporation, 310-946-3050. (Makes the LaserWave DirectCut DVD recorder for creating single copies.)
- Pacific Coast Sound Works (CA), 213-655-4771.
- [A] Pacific Ocean Post Sound (CA), audio only, 310-458-9192.
- [R] Pacific Video Resources (CA), <http://www.pvr.inter.net>, 415-864-5679.
- [R] Pioneer Video Manufacturing, Inc., <http://www.pioneerusa.com/replication.html>, 310-518-0710.
- [AS] Rainmaker (BC), 604-874-8700.
- [ARS] Warner Advanced Media Operations, 717-383-3291.
- [A] Zapex

What is meant by AC-3?

This is a sound term used to designate the digital audio coding technique Dolby developed for multichannel applications. The term Dolby Digital is used for movie theaters while AC-3 is used for home video applications.

How does Dolby 5.1 differ from Dolby Surround Pro Logic?

Dolby Digital delivers six totally separate (discrete) channels of sound. Like Dolby Surround Pro Logic, it includes Left, Center and Right channels across the front of the room. Dolby Surround Pro Logic provides a single limited-bandwidth (100 Hz to 7,000 Hz) surround channel which is typically played back in the home through two channels and two speakers.

By comparison, Dolby Digital provides separate (discrete) left surround and right surround channels, for more precise localization of sounds and a more convincing, realistic ambience. And, with Dolby Digital, all five main channels are full range (3 Hz to 20,000 Hz). A subwoofer could be added to each channel, if desired. The sixth channel, the Low Frequency Effects Channel, will, at times, contain additional bass information to maximize the impact of scenes such as explosions, crashes, etc. Because this channel has only a limited frequency response (3 Hz to 120 Hz), it is sometimes referred to as the ".1" channel. When added to the 5 full range channels, the Dolby Digital system is sometimes referred to as having "5.1" channels.

What is a DVD-ROM?

A disc that is meant to store vast amounts of data/software/games and be utilized in a computer's DVD drive.

What is a DVD-RAM?

A recordable form of DVD. First of all, the DVD-RAM disc comes sealed in a cartridge to protect it from the wear and tear of handling. DVD-RAM uses a similar phase-change technology to make the disks read/write/erasable, and this backward compatibility means that the drive can read a wide range of existing optical disk formats. The DVD-RAM disc is like a hard drive, just not as fast. Microsoft Windows 95 users can rely on the Universal Disk Format (UDF), which lets you format the entire 2.6GB on each side of the double-sided medium as a single partition (2.3GB formatted), even on Windows 95 systems running with FAT16. Windows 98 users can simply format the disk using FAT32.

This format works out to about a half-cent per megabyte for storage space. DVD-RAM doesn't contain MPEG-2, so a user will need to add a card if they want to watch DVD movies. DVD-RAM drives appeared in June 1998 (about 6 months late) for \$500 to \$800, with blank discs at about \$30 for single-sided and \$45 for double-sided. Disc prices were under \$20 by August 1998. The first DVD-ROM drive that can read DVD-RAM discs is being released by Panasonic in late 1998 (SR-8583, 5x DVD-ROM, 32x CD).

What is a DVD-R, DVD-RW and DVD+RW?

Like DVD-RAM, these are recordable versions of the DVD-ROM. DVD-R can record data once (sequentially only), while DVD-RAM, DVD-RW, and DVD+RW can be rewritten thousands of times. These recordable media are not currently compatible for home video recording though home DVD recorders will eventually become available in future years. The three erasable formats (DVD-RAM, DVD-RW, and DVD+RW) are essentially in competition with each other. The market will determine which of them succeed. At the moment, DVD-RAM has a one-year head start.

DVD-R uses organic dye polymer technology like CD-R and is compatible with almost all DVD drives and players (the Sony DVP-S7000 and DVP-S3000 being notable exceptions).

DVD-RW (formerly DVD-R/W and also briefly known as DVD-ER) is a phase-change erasable format that will be available around the middle of 1999. Developed by Pioneer based on DVD-R, using the similar track pitch, mark length, and rotation control, DVD-RW will be playable in most DVD drives and players. (Some drives and players are confused by DVD-RW media's lower reflectivity into thinking it's a dual-layer disc. Simple firmware upgrades will be required to solve the problem.) DVD-RW uses groove recording with address info on land areas for synchronization at write time (land data is unnecessary during reading). Initial capacity will be 4.7 billion bytes.

DVD+RW: Phase-Change Rewritable, officially called +RW in standards documents, is a competing erasable format announced by Philips, Sony, Hewlett-Packard and others based on DVD and CD-RW technology. DVD+RW drives will read DVD-ROMs and CDs, and probably DVD-Rs and DVD-RWs, but will not be compatible with DVD-RAM discs. Because of reflectivity differences, linking sectors, and defect management, DVD+RW discs can't be read by existing DVD-Video players or DVD-ROM drives, except for the very newest drives from Sony and Philips. The DVD+RW format, which holds 3 billion bytes (2.8 gigabytes) per side, uses phase-change technology with wobbled groove and either CLV format for sequential video access (read at CAV speeds by drive) or CAV format for random access.

Other upcoming potential competitors to recordable DVD include AS-MO (formerly MO7), which holds 5 to 6 billion bytes, and NEC's MMVF (Multimedia Video Format), which holds 5.2 billion bytes and is targeted at home recording. Both are expected to read DVD-ROM but not DVD-RAM or first-generation DVD+RW. MMVF is similar to DVD-RW and DVD+RW, using two bonded 0.6mm phase-change substrates, land and groove recording, and a 640nm laser.