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# Magneto-optical Disk as a CD-ROM Development Tool

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## Introduction

Computer-based training (CBT) programs are becoming more sophisticated. They are no longer electronic papers, but are large multi-media systems which incorporate computer-generated graphics and digital audio as well as text. The numerous computer-generated graphics, large audio files, and complex hyper-text structures place a great demand on the computer system's binary storage capacity (disk space). If the use of interactive video is prohibitive because of cost or other restraints, a compact disk read-only memory (CD-ROM) delivery system is a viable delivery system.

Because CD-ROM is a read-only system, the development and delivery systems must be different. There are several alternatives for the development system, including a very large hard-disk and a magneto-optical disk drive. Recently a CBT package for radiation protection workers (RPTs) that was developed at Los Alamos National Laboratory (LANL) was delivered on CD-ROM. A magneto-optical drive was used for the development system.

This paper will discuss some reasons for selecting a CD-ROM delivery system and the use of magneto-optical disk drive as the development system.

## CD-ROM For Delivery of CBT

While the laser videodisc is usually thought of as the vehicle for interactive multimedia, the CD-ROM is quickly beginning to be an option for multimedia delivery (Salpeter, 1991). While compact disk technology is probably best known for its impact on the music world, the same technology has been used to store information for computer programs since 1984 (Salpeter, 1991). There are many reasons why the CD-ROM should be considered as a delivery system for CBT. It has the advantage of a digital information storage which allows the easy transfer of data from one computer to another via a network or a modem. Furthermore, with a storage capacity of approximately 600 megabytes, it is equivalent to over 1,500 floppies (Bitter, 1988). The large storage capability of the CD-ROM makes it an ideal storage device for large reference files such as training manuals, glossaries, encyclopedias, etc., computer-generated graphics, and digital audio. The large capacity frees the instructional designer to be more creative in the use of varied instructional strategies and materials. The CD-ROM development is no more difficult than the development of any other CBT program and is priced to make more complex learning environments affordable.

### Selection of a CD-ROM Delivery System

In the last five years the cost of a CD-ROM delivery system has substantially decreased, so that it is now within the reach of most training organizations. There are several considerations when estimating the cost of the delivery system. The selection of the delivery platform should be based on cost, availability, and performance considerations. A bare bones 80386 PC system, which costs less than $1,200, was determined to be the appropriate platform for

the RPT-Trainer. To allow the program to run as smoothly as possible, it is important to allow the CD-ROM to transfer data at its maximum capacity. The faster the data can be transferred from the MS-DOS buffers to the memory, the faster the data can be transferred from the CD-ROM. When a machine less capable than the 80386 was used, the graphics and screen changes were jerky and disconnected.

At this time full motion video is not available on the CD-ROM; therefore, if the CBT is not a text only package, it is important to have the best color graphics display. With the cost/performance ratio between Video Graphics Array (VGA) and older color standards comparable, the use of VGA, which allows the use of both graphics and scanned images, is recommended.

To take advantage of the digital storage ability of the CD-ROM, digital audio should be used. A digital audio system includes the cost of the audio board and the speakers. The audio board which we used was about $400. Other boards and playback systems are advertised for less. Thus, the cost of digital audio boards is decreasing.

The selection of a CD-ROM player is dependent upon the system used. At this time, Apple, Commodore, and IBM have different platform standards. If the delivery system is IBM compatible based, the CD-ROM player selected should conform to the ISO 9960 standard which was adopted by the International Standards Organization (ISO) to define a CD-ROM directory structure. The actual cost of the player is between $400 and $800. Thus, if the CD-ROM player is added to the basic delivery system of a 80386 PC with a VGA monitor, mouse and audio board, the total cost ranges from $3,000 to $4,000. The addition of a CD-ROM player has minimal impact on the delivery cost.

### Selection of a CD-ROM Development System

Of course, the selection of a development system depends on the delivery system selected. The development system specifications are those of the delivery system with the addition of a read/write medium. Because the development of a training package is often an iterative process incorporating many changes, the development system needs to easily accommodate the changes. Because CD-ROM is a read-only device, multiple masterings during CBT development would be prohibitively expensive (approximately $1,500 a master). Therefore, hardware with read/write capabilities which mimic the CD-ROM is required. There are several different types of hardware devices available, including removable hard disk, fixed hard disk and magneto-optical removal disk. Listed below is the cost per megabyte (Dataware, Inc., 1989):

| | |
|---|---|
| removable hard disk | $15 |
| fixed hard disk | $10 |
| magneto-optical removal disk | $10 |

Since the costs are virtually the same, the decision must be based on other considerations. The performance of the development system should mimic the performance of the delivery system as closely as possible.

### Performance Considerations

When selecting a development system for CBT for CD-ROM delivery, the performance of the CD-ROM needs to be considered. The slower access time and the larger capacity are the two conditions which are unique for the CD-ROM.

### Slow Access Time

The performance characteristics of the training package are defined in terms of the CD-ROM drive performance and the operational characteristics of the software driver interfacing to the CD-ROM drive.

The CD-ROM drive performance characteristics include the data transfer rates and access time. The data transfer rates of the CD-ROM are 150 KB/s sustained and 600 KB/s burst. Access time is 0.8 seconds for a full stroke seek. Seek time is the amount of time necessary to move the mirror of the laser beam to the correct position on the CD-ROM. An average stroke is one-third of a full stroke, thus requiring 0.5 seconds. The typical rotational speeds of CD-ROM are 530 rpm at the innermost track with a constant linear velocity of 1.4 m/s and 200 rpm at the outmost track with a constant linear velocity of 1.2 m/s (Sony Corporation, 1988).

In comparison, a typical hard disk has an access time of about 0.015 seconds, with a maximum track-to-track access time of 0.004 seconds. The data transfer rate from the buffers is up to 6 MB/s (Electronic Engineering Times, 1990). These rates are considerably faster than the CD-ROM. Thus, the hard disk is not a good simulator of the completed CD-ROM product.

With an average seek time of 0.0667 seconds (Relax Technology, 1988), the performance of a magneto-optical disk is closer to that of the CD-ROM than is the hard disk. The data transfer rate (about 690 KB/s) of the magneto-optical disk is faster than the CD-ROM.

### Other Considerations

In addition to the performance of the hard disk and the magneto-optical disk, there are other considerations when selecting a CD-ROM simulator. The capacity of the magneto-optical disk is comparable to the CD-ROM. The magneto-optical disk has two sides; each side has half the capacity of the CD-ROM. Hard discs of comparable capacity are available for about $3,000.

Another important consideration is the media which is sent to the CD-ROM mastering company. The CD-ROM mastering company requires the input media to be a tape cartridge, a magneto-optical disk, a Macintosh compatible hard disk, or a CD-ROM. If a hard disk is used, the data would have to be transferred to magnetic tape before mastering a CD-ROM. This step incurs an added expense for the magnetic tape equipment. If a removable magneto optical disk is used, the cartridge can be sent to the mastering company, eliminating transferring the system to magnetic tape. As a point of comparison, when we compared the cost of the magneto-optical disk with the cost of magnetic tape equipment, the cost was $5,000 versus $30,000. At $5,000 for the magneto-optical disk system, the simulation CD-ROM delivery is affordable.

### Limitations of the Magneto-optical Disk

We used a magneto-optical disk drive to simulated the CD-ROM. While in many ways the magneto optical disk drive was an excellent mimic of the CD ROM, it did have some limitations. The primary limitation was the number of allowable DOS buffers. The magneto-optical disk drive increases the size of each buffer from 512 bytes to 8192 bytes. If the program requires a large number of buffers, there may not be enough memory left to load and execute the program. The RPT-Trainer did not require many buffers; we therefore, reduced the number of buffers in the config.sys file to five.

Another limitation is the inability to use drive assignment statements. The CD-ROM driver does not allow the use of the DOS "subst" and "assign" commands. Therefore, it is necessary to use the magneto-optical disk drive in a single partition mode. Another constraint is, of course, the magneto-optical disk drive must have the same drive letter as the CD-ROM in the delivery system.

### Conclusion

The CD-ROM is a viable alternative for multimedia CBT delivery. Its large capacity allows the user to incorporate scanned images, large computer-generated graphics, and digital audio in a large CBT program. However, because it is a read-only device, there must be a separate delivery and development system. To allow testing, the development system must emulate the CD-ROM as closely as possible and yet be easy to use. The hard disk simulation of the CD-ROM is not recommended for two reasons. First, the performance characteristics of the hard disk and the CD-ROM are significantly different. The CD-ROM is much slower than the hard disk. This makes the package during development appear very different than the delivery package. Second, the data must be transferred to a tape cartridge before mastering. Because the magneto-optical disk drive and the CD-ROM have similar performance characteristics and storage capacity, the magneto-optical disk a good simulator of the CD-ROM. Furthermore, a tape does not have to be produced before the mastering of the CD-ROM.

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