Technical Report Documentation Page

1. Report No. HPR/ VA 91-R25	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle An Investigation of the Feasibility of Interactive Videodisc as a Training Mode for VDOT		5. Report Date June 1991
		6. Performing Organization Code
7. Author(s) Peggi E. Hunter Michael A. Perfater		8. Performing Organization Report No.
9. Performing Organization Name and Address Virginia Transportation Research Council Box 3817 University Station Charlottesville, VA 22903		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

      This report addresses the potential application of interactive videodisc (IVD) technology in the Virginia Department of Transportation (VDOT). The research re- vealed that IVD is a growing force as a training vehicle in several industries and institutions and pointed tomultiple training possibilities for VDOT. Responses to an IVD user survey sent to 58 state and federal transportation agencies showed that IVD is also garnering the interest and support of several agencies. However, IVD requires a large, up-front monetary investment, and initial costs need to be well substantiated before investment. By coupling an examination of IVD hardware components and their costs with several criteria that justify in implementation of IVD, this report gives guidelines along with recommendations for further consideration of the adoption of IVD for VDOT training. In addition, this report provides an evaluation of two FHWA-developed IVD training programs (Pavement Structure Repair Techniques and Work Zone Traffic Control), and it is recommended that VDOT conduct a pilot study of the former program.

17. Key Words interactive video, videodisc, video, training, computer-based training, IVD	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 60	22. Price

Form DOT F 1700.7 (8-72)   Reproduction of completed page authorized

2042

FINAL REPORT

AN INVESTIGATION OF THE FEASIBILITY OF INTERACTIVE VIDEODISC AS A TRAINING MODE FOR VDOT

Peggi E. Hunter
Graduate Research Scientist Assistant

and

Michael A. Perfater
Research Scientist

(The opinions, findings, and conclusions expressed in this
report are those of the authors and not necessarily
those of the sponsoring agencies.)

◆

ADMINISTRATION & FINANCE RESEARCH ADVISORY COMMITTEE

J. W. ATWELL, Co-Chairman, Director of Finance, VDOT

A. W. COATES, JR., Co-Chairman, Asst. Commissioner, VDOT

M. A. PERFATER, Executive Secretary, Research Scientist, VTRC

F. C. ALTIZER, Salem Resident Engineer, VDOT

A. V. BAILEY, II, Fairfax Resident Engineer, VDOT

A. C. BAIRD, Administrative Services Officer, VDOT

R. J. BOYD, JR., Human Resources Administrator, VDOT

R. G. CORDER, Rail & Public Transportation Administrator, VDOT

J. L. CORLEY, Bristol District Administrator, VDOT

T. F. FARLEY, Culpeper District Administrator, VDOT

C. D. GARVER, JR., Northern Va. District Administrator, VDOT

J. S. GIVENS, Asst. Budget Officer, VDOT

J. GROUNDS, Financial Manager, Federal Highway Administration

M. S. HOLLIS, Urban Engineer, VDOT

L. D. JONES, Management Services Administrator, VDOT

E. T. ROBB, Asst. Environmental Quality Engineer, VDOT

A. S. SABO, Internal Audit Manager, VDOT

C. S. SORRELL, Richmond District Administrator, VDOT

P. C. TARDY, Information Systems Manager, VDOT

M. L. TISCHER, Policy Office Administrator, VDOT

S. A. WAYMACK, Right-of-Way Engineer, VDOT

G. A. WHIRLEY, Fiscal Manager, VDOT

TABLE OF CONTENTS

ABSTRACT

This report addresses the potential application of interactive videodisc (IVD) technology in the Virginia Department of Transportation (VDOT). The research revealed that IVD is a growing force as a training vehicle in several industries and institutions and pointed to multiple training possibilities for VDOT. Responses to an IVD user survey sent to 58 state and federal transportation agencies showed that IVD is garnering the interest and support of several. However, IVD requires a large, up-front monetary investment, and initial costs need to be well substantiated before investment. By coupling an examination of IVD hardware components and their costs with several criteria that justify the implementation of IVD, this report gives guidelines along with recommendations for further consideration of the adoption of IVD for VDOT training. In addition, this report provides an evaluation of two FHWA-developed IVD training programs (*Pavement Structure Repair Techniques* and *Work Zone Traffic Control*) and recommends that VDOT conduct a pilot study of the former.
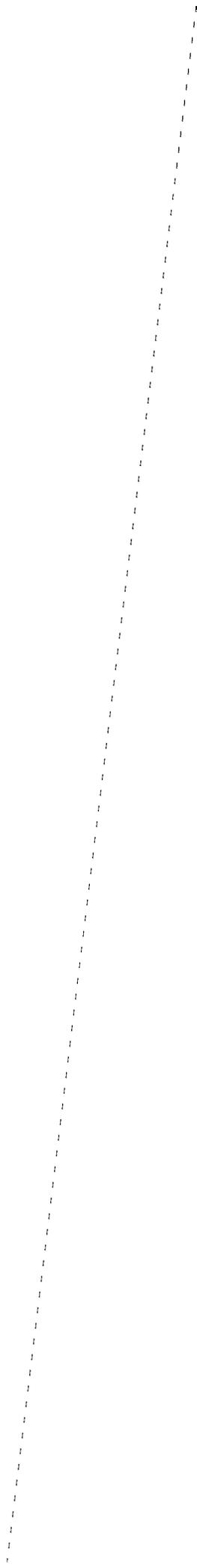
FINAL REPORT

AN INVESTIGATION OF THE FEASIBILITY OF INTERACTIVE VIDEODISC AS A TRAINING MODE FOR VDOT

Peggi E. Hunter
Graduate Research Scientist Assistant

and

Michael A. Perfater
Research Scientist

INTRODUCTION

Cardiovascular pulmonary resuscitation, automobile diagnostic repair, how to "drive" around a difficult city, and word processing programs—all are being taught with the latest in interactive videodisc (IVD) technology. During the last decade, development of IVD as a training medium has proceeded rapidly, in terms of both the quality of equipment and the availability of appropriate instructional software that meets a variety of needs. Much of the success associated with IVD programs is attributed to the active, realistic, and cost-effective learning experiences that the merging of video and computer technology allows. IVD allows the selection and sequence of images to be determined by the user's response to the material. The excellent graphics capabilities and visual impact of video can be retained along with the outstanding versatility and responsiveness of a computer. The resulting experience is both realistic and individualized to the needs of the learner.

Although IVD technology has existed for some time, it was only with the advent of faster and less expensive computer and video hardware and software that it became a potentially cost-effective training alternative for budget-conscious public agencies. Given VDOT's commitment to training and video production and application, and IVD's potential to meet a variety of training needs, an investigation of IVD as a training medium appeared timely.

PURPOSE AND SCOPE

This study investigated the use of IVD as a mode of training for VDOT. The researchers sought to provide management with information to make decisions as to whether IVD is a viable, cost-effective means for delivering employee training

and education in VDOT and to determine the feasibility with which the technology could be adopted. To accomplish these purposes, the following tasks were undertaken:

1. identification of how IVD is used in industry, government, and other state transportation agencies

2. identification and evaluation of existing IVD programs that might be appropriate for use by VDOT

3. identification of criteria that justify the development and need for IVD programs

4. determination of the hardware that is necessary to employ IVD programs and an assessment of how best to use hardware that is already in place

5. determination of the resources that would be required should VDOT choose to produce or purchase IVD programs.

The report concludes with recommendations based on the research findings and in light of technological trends that are emerging in the industry and the literature.

METHODOLOGY

1. An extensive literature review was conducted to ascertain up-to-date activities in IVD training and education and to provide the reader with an overview of the medium.

2. Three professional national conferences were attended in order to obtain information on and gain exposure to state-of-the-art IVD hardware and interact with a variety of training applications in various industrial contexts. The three conferences attended were Interactive Healthcare 90 (Washington, DC); the Society for Applied Learning Technology's Twelfth Annual Conference: Interactive Videodisc in Education and Training (Washington, DC); and the Professional Development Seminar '90, sponsored by the Association for Educational Communications and Technology and the University of Georgia (Athens, Georgia).

3. A user survey was sent to 58 state transportation agencies and the Federal Highway Administration (FHWA) to determine whether they have adopted or intend to adopt IVD technology for training.

4. Highway maintenance personnel, trainers, and researchers from the Virginia Transportation Research Council (VTRC) were asked to operate and evaluate two IVD programs developed by the FHWA: *Pavement Structure Repair Techniques* and *Work Zone Traffic Control*. Information was solicited from several VDOT staff on the programs' technical proficiency, instructional design, content accuracy, and general effectiveness as instructional tools.

5. Several major IVD production facilities were contacted in order to gather state-of-the-art hardware information, including costs and configurations.

OVERVIEW OF THE IVD MEDIUM

Definitions of IVD

There are varying degrees and opinions as to what constitutes true interactive video. Some experts define IVD in terms of its technical capabilities, and others define it by the emphasis placed on the computer and video roles or according to the purpose of the particular program.

Maclean (1985) stressed the technical and computer aspects of the medium: "Interactive video involves the control of a video format by a computer or microprocessor" (p. 9). Salpeter (1986) believed that, because a computer alone can be programmed to accept and control interactivity, the medium becomes an IVD medium only when a videodisc adds the capability to include photographs, video sequences, and two audio tracks. Conversely, others claim that interactive video instruction differs from computer-assisted instruction (CAI) by more than just the video imaging. For example, Iuppa (1984) defined interactive video as "any *video system* in which the sequence and selection of messages is determined by the user's response to the material [emphasis added]" (p. 5). He pointed out the key phrase "video system" to distinguish interactive video from what is really CAI accompanied by video footage or images. It is typical for programs with more computer dominance to be labelled as CAI and for those with more video control to be considered as IVD.

Taking a different approach, Floyd and Floyd (1982) believed that viewer participation was the critical factor that defined an IVD program. They defined IVD as "any video program in which the sequence and selection of messages are determined by the user's response to the material" (p. 2) and emphasized the interactivity of the medium. Souter (1988) followed this vein of thinking but gave a more comprehensive definition:

> Interactivity occurs when the videodisc, its player and a microcomputer are brought together in such a way that the viewer can ask questions, be offered choices and, in general, manipulate both text and video images. The process allows the user to determine the sequence of information through response to the program material (p. xii).

Christie (1989) stated that a program is not truly interactive video unless it meets the individual needs of the user and that "it is misleading to suggest that interactive video means simply the 8-inch and 12-inch disc variety that perform simple branching, quizzes and scorekeeping" (p. 18).

Further complicating the potpourri of definitions, terms such as *laser disc, optical disc, digitized videodisc,* and *compact disc interactive* are found throughout

3

the literature and are often used interchangeably. Although most of these terms do refer to interactive video programs, an understanding of the functions of the technology can help reduce confusion. These functions include hardware and software sophistication, ease of use, and levels and types of programming.

For the purposes of this report, the definition of IVD includes *any program that makes use of a laser videodisc, a computer, and an interface (an internal or external device that connects the computer to the disc player) and requires user input to propel the program along.* To further the reader's understanding of IVD, an explanation of the technical aspects of video laser technology, its general function, and the three levels of applications follows. A glossary of terms is given in Appendix A.

Technical Information

Disc Composition

An optical, or video, laser disc is a very thin sheet of metal imbedded between two sheets of clear plastic that is "read" by a laser beam inside a special disc player. The videodisc can be either 8 or 12 inches in diameter. Most videodisc programs use 12-inch discs, comparable in size to a standard LP record. The disc contains information stored in the form of tiny pits that have been burned in by a low-power laser beam. Each pit measures about 0.4 micron across and 0.1 micron deep, and there are approximately 14 billion pits recorded on one side of a 12-inch disc. These pits are arranged in a spiral. One ring of the spiral is called a track, and one side of a disc has 54,000 tracks. Each track holds one frame of visual information. If played as a slide or freeze frame, one side of a disc could hold about 54,000 of these solitary, still video images. (To put this into perspective, consider how many slide carousels would be needed to hold 54,000 slides!) Motion video, however, uses more disc space than still frames; thus its playing time is limited by the disc storage capacity. Recorded at 30 standard images per second, a disc accommodates either 20 to 30 minutes or 50 to 60 minutes of motion video play per side, depending on the type of disc.

Disc Types

There are two types of videodiscs in each of the two sizes. One type is optimal for image storage, and the other is necessary for interactivity. In the 12-inch format, discs contain 54,000 tracks, but they differ in the way they are "read" by a disc player laser beam. The constant linear velocity (CLV) disc is the longer playing disc (60 minutes) and is sometimes called an "extended play" disc. Technically speaking, the rotations per minute (rpms) are such that the laser beam reads the signals (pits) at a constant rate, which permits up to 60 minutes of playing time per side. However, the CLV disc does not allow for user interaction. The constant angular velocity (CAV) disc is the "standard play" disc and is the type required if programs are to be interactive. The CAV disc plays precisely one frame of video per

revolution, with no change in the rpms. Even though the CAV disc allows interactive features that the CLV does not, such as freeze-frame, random access, and slow motion (which have obvious advantages for an interactive program), the CAV disc is limited to 30 minutes of motion video per side.

Disc Mastering

Disc production, or mastering, begins with an edited, 1-inch, master video-tape. The production facility uses the tape to make a release, or "working," master tape, which contains all of the program's visual, audio, and digital data and has been encoded with laser formatting, such as frame numbers, chapters, and picture stops. Once the master tape is reviewed and approved, it is used to produce an unalterable master disc. The disc mastering process includes chemical, recording, and stamping procedures that ultimately yield two thin reflective metal discs. These metal discs are then fused together and covered with a protective coating to form the "master disc" (Staples, 1989). The master disc is used to produce duplicate copies that are later played on laser disc players. These videodiscs are virtually indestructible, in part because the laser beam that reads them never actually touches the pitted information. The cost of mastering a videodisc ranges from $1,500 to $3,000 per side. Duplication costs range from $8 to $25 per disc, depending on the type and number of duplications.

Levels of Interactivity

The phrase *levels of interactivity* refers to a hierarchical classification of IVD programs. There are three levels of programs that increase in their interaction capabilities. Although the levels are primarily classified by the degree of interactivity, classification criteria also include disc type, hardware capabilities, and program purposes.

Level 1

Level 1 (also referred to as level 0 in earlier literature) is the least complex and most familiar to the public consumer. All extended play (CLV) discs are limited to level 1 play and are typically viewed in a sequential, playback manner. Entertainment video movies that have been recorded on CLV discs are a common example of level 1 programs. Standard play (CAV) discs played at level 1 might include units of instructional material that are viewed in sequential, linear segments or large quantities of stored video information (e.g., highway videologging) that require random and/or rapid access.

The hardware for level 1 programs consists of a laser disc player, a television receiver and, usually, a remote control (see Figure 1A). Controls on both the player and the remote control device allow playback, limited random access and memory, forward or backward scanning, and the use of dual audio channels that can be used
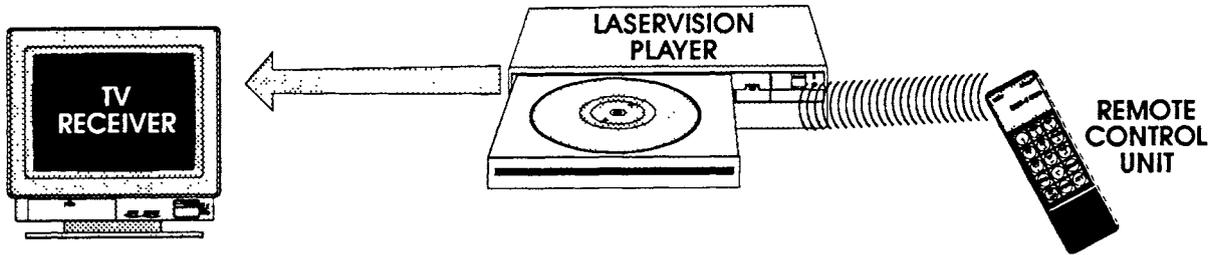
5

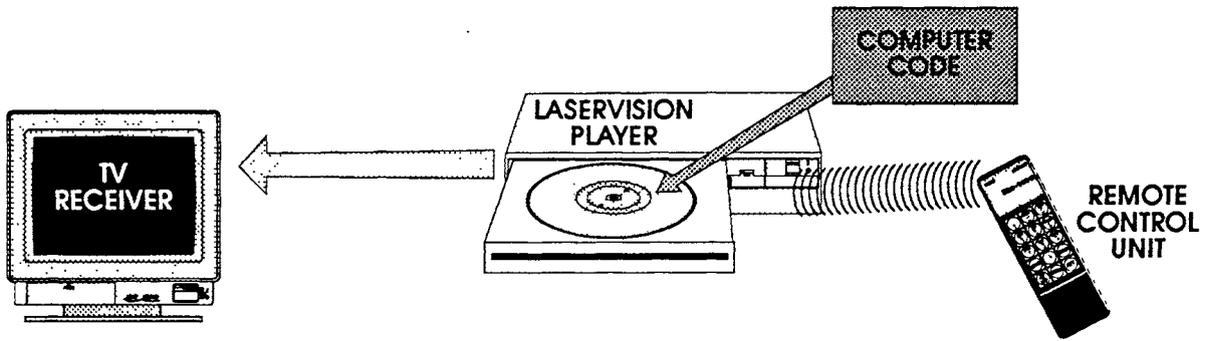Figure 1A. Components of a level 1 hardware system.

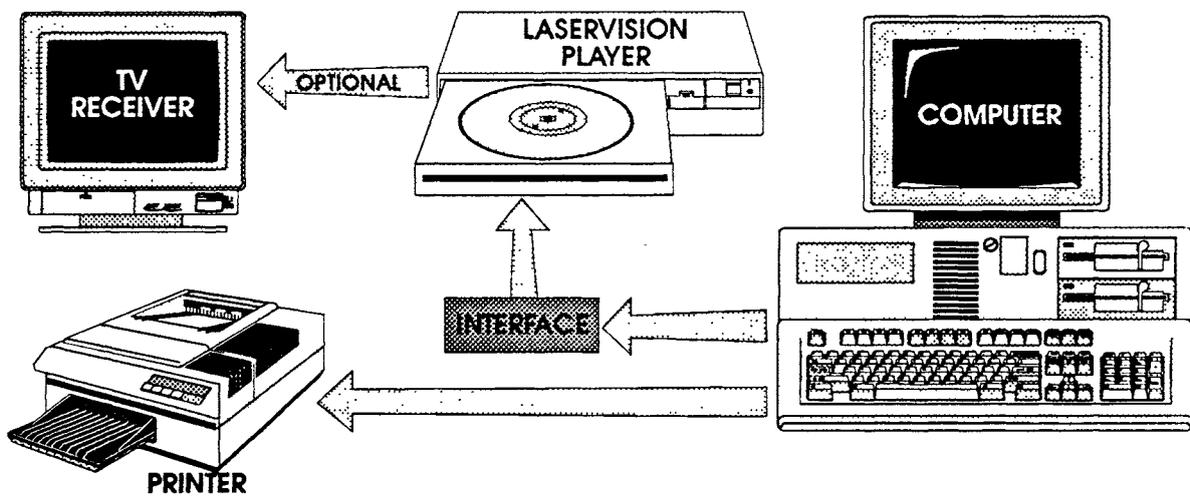Figure 1B. Components of a level 2 hardware system.

Figure 1C. Components of a level 3 hardware system.

for stereo sound or two audio tracks (Souter, 1988; Uhlig & Feldman, 1985). There are neither programming nor viewer interaction capabilities at level 1.

The advantages of level 1 programs include a high-quality picture, instant visual images for enhancing live presentations, tremendous image storage capacity, and rapid scanning to enable quick access to desired portions of video (Pioneer Communications, n.d.). Level 1 applications, for example, allow a user to skip from the outermost to the innermost track on a disc, usually in less than 1 second. Further, in comparison to videotape, the videodisc suffers no wear, has very low duplicating costs if reproduced in large quantities, and has much greater storage density (Iuppa, 1984).

Level 2

Level 2 programs and hardware subsume all of the capabilities of level 1 and have enough additional features to provide for interactivity. Level 2 is the simplest level of interactive programming and does not require an external computer (see Figure 1B). Instead, microprocessors and small memory buffers are built into the videodisc players to control and follow a limited amount of flow (e.g., one chapter to another) and branching (e.g., if-then program commands that direct the videodisc according to user input). This type of programming can be done in different ways. One way is for a programmer or user to enter the computer code for specific functions into the player through a remote control or keypad. A second method is for the programmer to store a digital code on one of the two available audio tracks when the disc is mastered. The second method yields faster loading and response time from the computer, but it prohibits use of the second audio channel for audio music or secondary narration. With either method, the player can be "told," or programmed, to play certain sequences in a given order, do simple answer analysis, and branch according to particular user responses.

The primary advantages of level 2 programs have to do with their implementation and cost. First, the interactivity capability at level 2 makes it viable for many presentation, sales, and instructional applications. Level 2 programs are often used in what are called "point-of-purchase" sales wherein customers select a product from a menu on the screen, view a video segment about the product, encounter another menu to find out more information, and sometimes even place an order. Level 2 programs can run alone in a kiosk and, when programmed to play continually, can attract shoppers throughout the day. In addition, selected images from any place on a disc can be sequenced to enhance visually the content of verbal or computer presentations, or instruction can be "jazzed up" with complementary videodisc images and audio tracks. Second, since level 2 programs do not require an external computer, a single system is much less expensive than one required for level 3 programs, which will be discussed next.

Level 3

The most sophisticated interactive applications are found at this level. Level 3 subsumes the program and hardware capabilities of levels 1 and 2; in addition,

7

through the control of an external computer, level 3 has programming capabilities that provide for varied types of interactive instruction (see Figure 1C). "The ability to merge video with computer graphics makes it possible to use the best features of each medium at the same time" (Smith, Jones, & Waugh, 1986, p. 117).

Features of Level 3 Interactivity

External computer control provides the videodisc designer with a rich variety of graphics and display options for visual presentations. In one program, the television monitor can display video images only, display all computer-generated graphics and text, superimpose text over video, or display a "window" of video images surrounded by a computer-generated display (Smith et al., 1986). The presence of the computer provides for various methods for facilitating interactivity, including the use of touchscreen, keypad, mouse, and/or joystick input devices. With touchscreen, there are "hot buttons" on the screen that, when touched, branch the user to a specific part of the videodisc program. Touchscreen is the most user-friendly of the input options because no keyboard skills or peripheral devices are necessary and both hands are kept free. The keypad or keyboard device is also frequently used to communicate with the video program. Keypad input typically involves use of the same key strokes or letters repeatedly (e.g., *Y* for *Yes*, *N* for *No*) so as to simplify operation for users without keyboarding skills. The mouse and joystick are also common input devices that are typically used with Macintosh programs and video simulation games, respectively. The joystick is especially desirable for programs that require a user to move a cursor or other icon (e.g., a vehicle) across the screen.

Because level 3 systems have at least one videodisc player attached to an external computer, they can use programs stored both on the external computer and on the videodisc. The computer program can interface with the programming information stored on the videodisc to communicate and convey millions of bytes worth of information (as compared to thousands of bytes at level 2). The memory capacity of an external computer is the key to level 3 programming since it greatly exceeds that of the level 2 internal memory buffers.

The hardware requirements for level 3 programs include all those for levels 1 and 2 (television monitor, disc player, input device) plus an external computer and a computer-to-player interface, or decoder device. (A red, green, blue [RGB] monitor may also be required.) The type of computer can range from a microprocessor (personal computer [PC]) to a large mainframe system, depending on the requirements of the IVD program software. Through the program's software, the computer facilitates rapid movement among the videodisc, stored information, and computer memory (Kalowski & Woldman, 1986). The use of an external computer also allows less stable program information to be stored on an erasable disk, which can be easily tailored or changed, instead of on the unalterable videodisc (Snyder & Webster, 1987).

The interface, or decoder device, allows the computer to relay necessary information to the videodisc player in a language the player understands. This works in the following way: The computer receives the user's input through, for example, the

computer's mouse, and the input is picked up by the interface. The interface then translates and parlays the user input to the laser disc player, which then retrieves the appropriate video response. All of this happens in a matter of seconds or less. As an added dimension, a printer can be attached to the video system, enabling a user or supervisor to receive a printout of program feedback or test results. This is particularly useful if the videodisc program includes quizzes or a final test.

Types of Level 3 Interactivity

The three types of broad instructional programming categories for IVD program applications are *didactic, simulation,* and *problem solving.*

Didactic instructional programming resembles the standard classroom format of lecture, review, and evaluation. A typical didactic program presents an instructional unit or a lesson in the form of video clips, still frames (with computer graphics and text), and audio; asks the learner to do a few practice items or applications; and then administers a test. Test questions are either "true-false" or multiple choice and have only one correct response, and a program usually gives instant feedback on user responses. If an incorrect answer is given, the viewer is looped back through a relevant instructional segment for review. When the correct answer is given, the program provides verbal reinforcement.

Simulation involves fairly complex programming. The simulation program is designed to create a mock on-the-job scenario or learning situation, and instruction can be delivered in either a didactic or problem-solving format or can include elements of both. There is a great deal of freedom to maneuver in a simulation program, and users are offered a variety of choices on how to respond and what to view. Simulation may be the best choice when training calls for the use of equipment (or locations) that is expensive, dangerous, or unavailable. Examples of simulation videodisc programs might include a tour of the Louvre museum, learning to fly a military aircraft, or navigating through tumultuous seas.

Problem solving is the highest level of IVD instruction because the learner is able to perform or "do something" with information and knowledge he or she has acquired through the IVD program. For example, an interactive flight simulation that used problem solving as an instructional strategy would let the learner "fly" the plane, making aircraft and piloting decisions and experiencing the results of the decisions with simulated outcomes. Because there are many possible input responses that any one user might make, the development of the IVD programs used in simulation problem-solving applications is complex and time-consuming. Simulated problem solving does afford learners opportunities that actual classroom situations do not, chiefly because students can test their performance skills and not just their knowledge. All problem-solving instruction does not have a simulation format, however. A problem-solving format can be used to have learners demonstrate what they have learned didactically or apply information to a unique situation. For example, an IVD program could teach students to solve complicated calculus problems for bridge engineering by having them work step by step through the algorithms before depicting visual consequences (e.g., the road and bridge are misaligned by 10 feet) and providing a mathematical analysis of the results.

9

PROGRAM APPLICATIONS OF THE IVD MEDIUM

"The success of interactive video does not lie in the capabilities of the system, but in its applications. This is the challenge that interactive video designers must meet" (Iuppa, 1984, p. 119). The onus of IVD's success rests on the quality of the program applications that continue to be developed. Before investing in IVD hardware for their training needs, consumers should be aware of the availability of IVD program applications in their own field, and particularly in fields where programs are more limited.

The military, the healthcare industry, and education are the biggest investors in IVD. In all three, a variety of primarily level 3 program applications are used for instructive and training purposes, as well as for both technical and nontechnical skills. A look into the use of IVD in these three fields shows the great potential this medium can have in any given field.

Military Applications

The military has a large stake in the IVD industry, partly because of the medium's cost-effectiveness. The costs associated with operating and expending military weapons, aircraft, and technology for the sake of training are so exorbitant that an investment of $40,000 to $100,000 in highly sophisticated IVD production is extremely cost-effective. Even the replacement of a technical repair manual with IVD instruction saves training time and money for the military:

> In order to come to grips with a World War II fighter plane, mainte-
> nance people had to cope with a manual some 1,000 pages in length.
> The manual for a modern jet fighter such as the F-18 runs more than
> 500,000 pages. The cost of [training through the use of] interactive
> learning systems is quickly amortized in such circumstances (Souter,
> 1988, p. 68).

Consider the consequences should a young air force cadet miss his or her first landing attempt on an aircraft carrier or drop bombs on a wrong target. With IVD, the potentially devastating results of trainee errors can simply be cleaned off the video screen and the student can easily access remedial programs for retraining.

The U.S. Army began using IVD in the mid-1980s when it established a long-range training program system called Electronic Information Delivery System (EIDS). The Army developed its own authoring language system so that it could produce IVD course software specific to its own needs. Level 3 programs are developed with this authoring software to teach hard and soft skills. These programs include instructional strategies from the more simple didactic teaching strategy to the most complex flight simulators.

Healthcare Applications

The healthcare industry is perhaps the largest user of interactive video technology. One source of available proprietary and commercial videodisc programs lists close to 500 entries for the health sciences that cover such areas as continuing education, nursing, health promotion, staff training, and patient education (Stewart Publishing, 1989). Program applications have been developed for levels 1, 2, and 3. Applications range from IVD informational data bases to real-time simulation.

Informational Programs

An example of an informational program developed by GBD Corporation compresses still and motion images of biological organs onto a CD-ROM. The goal of the program was to create more than 200 images and 56 minutes of moving video in cross-sectional anatomy, showing such organs as the heart or kidneys at work. The program allows a user to "quickly select a cross-section from a graphical menu and to view it in color. Using a mouse, the user can point to any feature in the image and have the computer display a label for it" (Gallaher, 1990). A second example is a level 1 disc data base that contains more than 9,000 childbirth images (Emerging Technology Consultants). The images document childbirth from prenatal through postpartum care, capturing both the physiological and emotional dimensions of the process. The disc can be used to accompany medical lectures or for consumer information.

Didactic Programs

Intravenous Therapy (FITNE) is an example of a clinical skills tutorial designed to give in-depth, comprehensive instruction in administering and discontinuing intravenous (IV) infusions. The program is divided into six units of instruction on IV therapy techniques and uses demonstration and periodic content quizzes. The learner can view the techniques, be tested on his or her cognitive mastery of the steps, and, upon mastery, practice performing the procedures using the video as a guide or reference. The program is not designed to give the learner simulated on-screen practice of IV therapy but to accompany and guide hands-on practice in a clinical setting.

Bereavement Counselling: Theoretical and Clinical Perspectives (Lambretcht) is an example of a two-disc didactic program designed to teach content-specific communication skills to bereavement counselors. The first disc presents documentation and factual information on related topics, such as funeral arrangements, death-related legalities, and how different cultures and religions deal with death. The second disc demonstrates six support strategies, showing how each is implemented across a clinical case study. The disc includes a counselling situation "simulation" during which users make intervention decisions based on what they have previously learned, but users do not experience simulated outcomes as a result of their decisions. The targeted audience of users and trainees includes nurses, physicians, social workers, and funeral directors.

Simulation Programs

The advantages of using simulation in the healthcare field are obvious. Cost-effectiveness can be realized in terms of equipment, materials, and human lives. Healthcare practitioners can substitute expensive equipment and materials with an IVD simulation as they learn new skills. More important, practitioners can learn and practice with IVD before trying out their skills on humans, whose lives might otherwise be at risk. Two very popular medical simulations are *Emergency* (Emerging Technology Consultants) and *The CPR/ACLS Learning System* (Actronics and the American Heart Association).

Emergency is a "real time" simulation, meaning that each user makes life or death emergency room treatment decisions under the pressures and constraints of a time clock and then experiences realistic outcomes of those decisions. Students interact with the patients and medical emergencies in the program just as they would in an actual emergency. The primary goal of the program is to eliminate emergency care treatment errors.

The CPR/ACLS Learning System is widely known in the medical field for its ingenuity and award-winning application of IVD learning. It is used to train and certify users in basic and advanced cardiac life support by combining multiple methods of instruction. The CPR course uses electronically sensitive dummies to give immediate feedback on hands-on maneuvers, such as chest compressions, ventilations, and hand placement. Students receive on-the-spot feedback from their "victims," as well as feedback from the computer as to how to improve their performance.

Education Applications

Most of the IVD program development in general education has been concentrated in elementary and higher education. At the elementary level, Apple Computer, Inc., and film and television producers, such as Walt Disney Productions, have worked conjunctively to build interactive prototypes. In university settings, major corporations have worked with business and engineering schools to develop IVD teaching modules and experimental applications (Iuppa & Anderson, 1988). In addition, many education facilities, such as university schools of education, develop programs in-house. Education IVD programs are developed for use as a total learning system or as a component of a multimedia unit or presentation.

Informational Programs

Images of Antiquity (Ponessa Productions) is an example of a level 1 disc containing 42,000 historical images that date from 2800 B.C. to 1000 A.D. The disc is indexed according to rulers, architecture, geography, and specific sites (such as the Wailing Wall). It is most useful as an ancillary source for instruction, enabling teachers to key in and call up images in seconds.

Didactic Programs

Laser Learning (Hoffman Educational Systems) is an example of an 18-disc set created for language arts instruction. The program concentrates on comprehension and vocabulary skills for grades 4 through 10. Each disc contains teacher-directed instruction; practice, reinforcement, and application exercises; mastery tests; and record-keeping capabilities. This type of package is what is referred to as a total learning system.

Applied Industrial Mathematics (Industrial Training Corporation) is an example of an 8-disc program that trains adult students to perform basic mathematic algorithms in an industrial context and offers advanced math concepts (e.g., fractions, algebra) as they relate to industry. The discs provide 16 to 32 hours of demonstration and practice sessions that are intended to help learners achieve proficiency in industrial mathematics.

Simulation Programs

Chemistry I and II (GPN) is an example of a simulation program that includes both evaluation and problem-solving tasks. For example, in one of the lessons, students are provided, via the computer and video screens, all of the equipment and materials needed to perform titration experiments. This use of IVD is premier since it gives students full manipulative control over the videodisc program. Another lesson on the disc, although more didactic, presents a number of chemical reactions and asks students to determine which chemicals were combined to create these reactions. The opportunity for students to interact one on one with chemical compounds and chemistry equipment while *safely* watching the results of their experiments illustrates a powerful use of the IVD medium.

A number of other academic disciplines employ IVD technology. Disciplines such as music, social studies, physical and biological sciences, and foreign languages all have programs designed to teach basic to advanced skills, often from primary school–aged through college-level and adult students. The Harvard School of Law, for example, has produced level 3 discs that simulate courtroom litigation. A program entitled *The Alberta Disc* (Access Network) includes information, drill and practice, and simulation exercises on the tourism geography of Alberta, Canada. This program is being used by high school geography students and travel agents. An excellent example of a successful level 2 program is one that teaches sign language by using IVD's video capability for demonstration and computer capability for drill and practice.

Industrial Applications

David Hon, the creator of the aforementioned CPR program, designed a second widely acclaimed IVD program entitled *Arc Welding*, which instructs welding students on the basics of the trade, including how to perform a weld. Souter (1988) described the design and interactivity of the welding simulation:

Using an analogy of heat to light, Hon turned the video screen to a horizontal position and provided the student with a "welding torch" that produced a perfect weld across the monitor—if the student did everything right. The "torch" is actually a light pen with two adjustments on it—one representing acetylene, the other oxygen. The student's choice must correspond with the program's expectations for the plates pictured on the horizontal screen. If the light is held too far away or too close—according to the mixture—the weld would be faulty and the student would be branched to a remedial part of the program, which describes the proper way to overcome the particular difficulty. If everything is right, the moving torch produces a perfect weld between the two plates (p. 67).

IVD application has also found its way into the automotive industry. The Ford Motor Company has installed IVD systems to train mechanics to repair carburetors. In one such program, a light pen becomes either a screwdriver or vacuum gauge, both of which the mechanic uses to tune the simulated engine. The audio track plays engine sounds that would correspond to the mechanic's adjustments. The program praises the user for a correctly tuned engine but returns him or her to the carburetor to try again in the event of an incorrectly tuned engine (Souter, 1988). For Ford, IVD's accessibility and cost-effectiveness make it superior to other types of training. Training can be done on location at the garage, which cuts the costs students would incur by travelling to a central training facility and productivity losses that would result from the travel time and class attendance.

Two other examples in vocational training are *Forklift Truck Training* (The Alive Center) and *Rigging and Lifting* (Industrial Training Corporation). In the former program, which has been approved by the National Training Council, employees learn the proper use of the forklift. The program is didactic in that users do not "operate" a forklift to drive the videodisc but rather concentrate on rules and procedures. The latter program trains students to use equipment such as cranes, forklifts, and scaffolding. The program includes instruction on equipment operation from preparing lifts through inspecting equipment.

SURVEY OF IVD USE IN STATE DOTS AND THE FHWA

A survey (Appendix B) was sent to 58 state transportation agencies and the FHWA. The survey solicited information concerning implementation of the IVD medium, knowledge of and sources for available programs, and hardware systems and configurations. An essential premise behind sending the survey was that if several transportation agencies were using or considering using IVD, it was likely that the number of transportation program applications would increase.

Table 1 gives a summary of the survey results. Of the 58 state transportation agencies and the FHWA that were sent surveys, 37 responded. Of those 37, 9 state DOTs and the FHWA are either using or considering using IVD. Eight of the

Table 1

Summary of Responses to IVD User Survey
(37 Respondents)

Agencies using IVD	4
Agencies considering IVD	5
Capacity	
Instructional	8
Image storage	1
Informational	1
Other (photologging)	2
Employee classification	
Highway personnel	6
Professionals	4
Clerical	3
Data Processing	4
Other	2
Types of programs	
Playback	1
Didactic	2
Simulation	1
Problem solving	2
Levels of programs	
Level I	1
Level II	1
Level III	3
Multimedia	1
Sources of programs	
In-house production	2
Outside agency, coproducers	1
Outside agency, vendors	3
Average costs of IVD programs	
Purchase (disc)	$1,700
Rental (disc and software)	$99/mo.
Cost per work station	$13,000
	6,500 *
	7,500

*First year free.

15

9 DOTs are using or looking to use IVD for training. This section discusses the ways in which the states are using or apt to use IVD, possible production resources, IVD hardware, and IVD transportations applications.

Uses of IVD

Instructional

DOTs in Kansas, Montana, Ohio, Oklahoma, and Pennsylvania reported that their use or consideration of IVD is for instructional purposes only. The FHWA and North Carolina DOT indicated that instruction is but one mode for which IVD is used. Two states, Pennsylvania and Ohio, are currently using IVD for training employees in data processing or PC or mainframe computing skills. The FHWA is using instructional training for highway personnel, and Oklahoma is considering doing so. Louisiana is considering using IVD for training with its highway mainte-nance personnel and professional staff, and Kansas and Montana are considering the use of IVD for instruction across categories of employees: highway mainte-nance, professional, and clerical and data processing personnel. Maine did not spec-ify either the capacity in which IVD was being considered or a classification of em-ployees being targeted as users.

Three state DOTs and the FHWA provided information on the types and lev-els of programs they are using or considering using. All four organizations identi-fied instruction as a primary use of IVD, with level 3 programs the most often cited, followed by levels 1 and 2 and a multimedia format that includes IVD as one of sev-eral media. Pennsylvania is using didactic, simulation, and problem-solving pro-grams, and North Carolina is using a "modified program of computer and video with several programs" that includes both playback and problem-solving programs. (It is undetermined just what hardware and software a "modified program" re-quires.) The FHWA is using didactic programs for its highway personnel; Kansas did not specify which type(s) of programs it was considering.

Image Storage

The FHWA was the only agency reporting use of videodisc technology for image storage and retrieval. The FHWA also creates photologs on videodisc for sta-tistical and data collection purposes. Although Connecticut did not indicate the use of IVD technology, Perfater and Harris (1987) documented that Connecticut was us-ing videodisc technology for photologging, or image storage. At that time, the Con-necticut system had been in use for 1 year and was used to "document longitudinal distance, sign inventory, roadside development, surface condition and pavement rat-ings, horizontal curvature, vertical curvature, azimuth grade, cross slope, rough-ness, and side friction" (p. 11). No other agency reported considering the use of IVD for image storage purposes.

Informational Applications

When videodisc is used simply to derive information, either about one lengthy topic or perhaps several subjects (related or unrelated), an application is referred to as informational. There is no interaction via computer. Louisiana is the only state considering IVD use for information retrieval purposes.

Production Resources

Although there is a limited number of respondents currently using IVD, the survey responses indicated that there is at least minimal ongoing IVD production activity in a few transportation agencies. Three state DOTs exclusively use prepackaged IVD programs produced by outside agencies, such as Applied Learning and International Video Corporation. North Carolina has produced its "modified" programs in-house, and the FHWA has used in-house production facilities and co-produced videodiscs with an outside agency.

IVD Hardware

The fact that many IVD hardware configurations are possible is reflected in the fact that four transportation agencies reported using four different hardware systems. The FHWA uses an IBM InfoWindow touchscreen system; one DOT uses an IBM computer monitor with a Panasonic video monitor; another uses an IBM computer monitor, a Pioneer disc player, a Sony video monitor, and a periphery audio decoder; and a third uses an Everex Step 286 PC, a Sony disc player and television monitor, and the InfoWindow Emulation accessory. The IVD industry has hardware compatibility and standardization problems similar to those of the video and film industries: IVD programs designed on and for specific hardware configurations will run only on equipment with those exact hardware specifications. Even within one particular company, such as Apple or IBM, programs cannot be depended on to run interchangeably from system to system. In fact, because certain hardware configurations can play only certain programs, hardware specifications must be considered simultaneously with the selection of prepackaged applications.

IVD Transportation Applications

Survey participants were asked to list IVD programs or upcoming relevant projects of which they were aware and that might have application to VDOT. Six transportation-related programs were listed along with several IVD series for PC applications.

Current Programs

The FHWA has developed two level 3 didactic programs for use with highway personnel: *Work Zone Traffic Control* and *Pavement Structure Repair Techniques.* These programs are evaluated later in this report.

Projected Programs

Freeway incident management (FIM) was identified by the FHWA as a topic that is receiving increased attention by state transportation agencies nationwide and is ripe for training course development. The FHWA Office of Training and Development decided that IVD should be pursued as the medium for this course, especially since IVD is said to be the training mode of the future. The FIM program will be a level 3, didactic training tool. Its target completion date is the summer of 1991, and it is expected to be superior to the two current programs in existence (Paniati, 1990).

AASHTO launched a joint IVD development project with the FHWA and the DOTs in South Dakota, Utah, and Vermont. The primary purpose of the project is to develop what AASHTO calls computer-assisted transportation training (CATT), which is to include IVD technology. AASHTO is convinced of IVD's effectiveness and reports in its project proposal that

> carefully designed computer-interactive videodisc training is effective. That has been proven by the U.S. military and many other users. The technology is available today, the price is reasonable, and hardware requirements are minimal. . . . It is clearly only a matter of time before AASHTO members start to adopt this technology (some may already be doing so). The training advantages these systems offer will not solve all training problems, but they solve many (Yocom, Worrall, & Gingras, 1989, p. 8).

In order to determine priorities and needs for training course development, AASHTO sent a CATT survey to all state transportation agencies. The survey listed 20 potential training topics and the anticipated costs for IVD course development and asked respondents to rank the courses their state might financially support. Respondents were also asked to indicate their interest in conducting an IVD training course pilot study or contributing to course content development. (VDOT is one of the subscribers to the AASHTO project.)

The AASHTO survey determined that, for the 37 DOTs that responded (of 75 surveys sent), the most interest for course development was in bridge inspection, snow and ice control, and concrete surface maintenance. Three such programs will be developed and produced as level 3, didactic training programs. Although each may include simulated procedures and/or case study examples, user responses will not fully drive the videodisc as they do in true simulation programs. The projected completion date for the three programs is 1991.

EVALUATION OF THE FHWA PROGRAMS

At the request of the FHWA, *Pavement Structure Repair Techniques* (PSRT) and *Work Zone Traffic Control* (WZTC) were evaluated at the Research Council. PSRT was further evaluated by three groups of potential users: VDOT highway maintenance operators, district training officers, and two members of the Central Office training staff. Evaluation criteria included (1) technical performance, (2) program design, and (3) content accuracy relative to the practices of VDOT. The PSRT evaluation included the additional criteria of user interaction and user feedback.

The IVD hardware and programs were packaged and sent to VTRC as a complete work station. The video system hardware consisted of a VAC-300 Decoder, a Sony color RGB monitor, a Pioneer LD-V6010A laser disc player, and the necessary cables. The package contained instructions for setting up and using the hardware, but no software documentation or computer specifications. VTRC furnished an IBM PL-AT compatible PC with 640 kilobytes of random access memory (RAM), a 20-megabyte hard disk, and a monochrome monitor. However, difficulty was experienced while trying to get the programs to run properly, and it was finally determined that the computer did not have the necessary math coprocessor and enhanced graphics adapter (EGA) monitor and card. Once these components were acquired, the program evaluation commenced.

PSRT Evaluation

PSRT was codeveloped with the Institute for Transportation Research and Education and the North Carolina DOT. The program has six modules covering the following topics: asphalt chip seals, crack sealing, pothole patching, gravel road maintenance, and shoulder and ditch maintenance. Users select one of the topics from a menu and view informative and demonstrative still frames, motion video, and computer graphics and text as the audio explains the corresponding techniques and procedures. Users interact with each program module by answering multiple-choice questions that follow blocks of instruction. Quiz results can be stored and then printed. The target audience for PSRT is highway personnel, particularly those confined to rural or small urban areas where funding for training programs may be inadequate (Pavement Repair, 1988).

Technical Performance

PSRT has a number of technical problems. For example, users find it difficult to initiate the IVD system and initialize the videodisc player. Throughout the program, menu selections must be entered in the computer repeatedly, the program loops to the wrong place in the program, the audio shuts off inappropriately, the visuals skip or black out in places, and the audio and video tracks do not correspond in one place. Some of these problems are in the program software and could be eliminated, whereas others, such as audio and visual "glitches" or blackouts, are permanently on the disc.

The technical aspects of the aesthetic presentation, such as quality of picture and sound, are satisfactory. The picture resolution for most of the motion and still frames of the video is good, and the computer-generated graphics have very good resolution. The audio is clear and easily understood, and it flows at an even pace. Overall, however, the inferior technical programming of PSRT interferes so much with its use that three of the modules had to be exempted from the field tests of user interaction.

Program Design

PSRT has several noticeable weaknesses:

- The most glaring weaknesses are in the introductory user demonstration and the program's method of review and assessment. The introduction aims to give the users an overview and a demonstration of how the program works, but it fails to do so. The demonstration does not accurately mirror how the program works with respect to its keyboard input and successive looping, reinforcement, and review.

- The review method is simplistic. Review segments are simply "replays" of the original instruction, and there are no meaningful differences between the video segments used for reinforcement and remediation. The result is an indiscriminate application of review that does not depend on the user's response to each question.

- The test questions in the quizzes are limited mostly to literal comprehension and recall questions. This type of question elicits cognitive interaction at a very basic level because no application of the instructional information is necessary in order to answer a question correctly.

- The scope of the potential audiences is narrow. The constant repetition and use of audio to narrate each and every text screen limit the program to low-literacy learners—more advanced learners would likely be frustrated by these features.

Positive aspects of PSRT include its content organization, adherence to good graphics principles, and adequate use of motion video:

- The instructional content is well organized, and the material is presented in discrete procedural steps for the learners without being "choppy." Although some of the segments run a bit too long before any interaction is provided, overall, the segments flow well.

- The computer-generated graphic illustrations are interesting and depict their content clearly and sufficiently. Most of the graphic screens comply with good principles of visual design. For example, the same screen design is used for all of the questions.

- Except for the final module, the instructional units use enough motion video to demonstrate pavement repair and maintenance procedures

adequately, as well as keep the viewer engaged. The pothole patching module is a particularly good example of a combined use of still-frame and moving visual segments.

User Evaluation

Three modules were evaluated by three classifications of highway personnel. These modules (pothole patching, shoulder maintenance, and basic traffic control) were selected because they present a variety of content matter and have the fewest technical problems and interferences.

Equipment Operators

Four VDOT equipment operators evaluated the program first. Two of the operators had 4 and 15 years of experience, respectively, with VDOT, and two were relatively new on the job, one with 3 and one with 6 months of job experience. The operators' interaction with PSRT was closely observed, and each was asked a set of questions following each module (see Appendix C). Two and one-half hours was allotted for each operator to complete the three modules, although none needed the full time.

The operators evaluated the modules as follows:

1. *Pothole patching module.* Upon completing the module, the operators generally felt that they could repair a pothole, partly because the program content was presented step by step and partly because the program offered them a good review of procedures with which they were already familiar. The two experienced operators suggested that they had learned less from the module than the two inexperienced workers said they had learned. Three of the four operators felt that the module could have given them all they had needed in the way of training. The fourth operator, experienced, related that although the module was very good at presenting facts, pictures, and explanations, hands-on experience was also a necessary form of training.

2. *Shoulder maintenance module.* All four operators generally felt that this module was as good as the pothole patching module, but two did not feel the program prepared them to perform shoulder work because it did not teach how to operate the machinery.

3. *Traffic control module.* All of the operators agreed that the program content and presentation for the module were helpful and, in fact, better than the on-the-job training they had received.

Regarding their experience in using the IVD medium in general, the operators noted the following:

- They liked receiving feedback on the questions they were asked, and especially the instant feedback for an incorrect response. They felt a mixture

21

of "surprised," "ashamed," and "funny" when the narrator first told them they were wrong, and they appreciated hearing when they were right.

- All believed that the program provided sufficient review, and one operator said that the review helped him learn more. When asked how they would feel if, after a quick introduction, they had been left alone with the system, all but one indicated concern because of their unfamiliarity with the computer and lack of independent work skills.

- All four operators enthusiastically recommended this type of training for their coworkers.

- The operators noted a twofold benefit of IVD interactivity: it keeps their attention and requires no writing.

- Although two of the four operators felt that PSRT would be appropriate for all levels of learners, the remaining two thought it appropriate for only those below the foreman and supervisory levels.

With regard to the program's content accuracy, two of the operators noticed discrepancies between the program's content and VDOT terminology and practices. For example, VDOT does not adhere to all of the procedural steps outlined in the pothole patching module. In the shoulder maintenance module, the term *reshaping shoulders* is used instead of the VDOT term *pulling shoulders*. Further, all of the operators pointed out specific discrepancies in the traffic control module between VDOT procedures and regulations and those in the module.

Following the discussion, the operators completed a PSRT user survey (Appendix D). Survey responses revealed that none had ever used IVD and all understood what the program taught, believed it gave accurate information, and felt it could help them on the job. They all would like to use IVD to learn other job skills and felt that IVD training could at times be superior to other forms of training. Only one of the operators felt that the program was not easy to use, and only one was tentative as to whether this kind of program could save time in learning to do his job. Three operators offered the following comments on the survey:

> This training will help me more on my job. By looking at this video I know more about the menu of jobs than I did not know in the past [sic]. I like the way the video went into detail of the ways to perform a job [high-school education and 3 months experience].

> With equipment operation specifically, hands-on [learning] is best [GED, 4 years experience].

> I don't have any [comments] but I enjoyed it. I also think you learn something new every day [high-school education, learning disabled, 6 months experience].

Trainers

Feedback on PSRT was obtained from two trainers from the Central Office and five of VDOT's nine district training officers. All viewed from one to three of the modules and usually did so in a group of two or three.

During the researchers' discussion with the trainers regarding the IVD medium and PSRT, the following comments emerged:

- There was a consensus that IVD is a fit mode of instruction for reaching VDOT operators and comparable levels of employees.

- The trainers saw IVD as superior to currently employed training methods, particularly given its capability to provide day-to-day training (without having to arrange a class session) and eliminate the chance for personality conflicts between trainers or supervisors and their employees.

- The trainers concurred that the level of interactivity and minimal literacy skills required to interact with PSRT make it especially appropriate for highway maintenance workers.

- The trainers were concerned about the space requirements of an IVD system, pointing to space limitations in their own unit. They suggested that IVD work stations be set up permanently in locations that offer privacy and could serve a large number trainees simultaneously. One trainer, for example, envisioned an IVD learning center where district officers and shop employees could train for such activities as certification and licensing.

- The trainers felt that management support for using IVD as a training option might be difficult to obtain. Two of the trainers said that because some supervisors believe training to be nonproductive, those who could benefit from IVD training are unlikely to be exposed to it even if it were available. The trainers pointed out, however, that locating an IVD work station at or near the residency would enable employees to receive training individually and on a rotating schedule. This type of setup would be advantageous because it would remove only one worker at a time from the job.

- Other trainer comments were that IVD is "a utopia," an effective and "great" technique, and a way to reduce each trainer's workload. One trainer felt that IVD could reduce the 360,000 staff hours spent yearly for training in his district, especially if used for mechanics.

- The trainers commented that IVD would be an excellent tool for teaching secretarial skills and that it offers many options for mechanics, inspectors, and those with low literacy and mathematic skills.

A PSRT user survey (Appendix E) was also completed by each group of trainers. Responses revealed the following:

- Most of the trainers believed that the content of PSRT is accurate and applicable to their needs despite some apparent pavement repair procedural differences. In fact, one trainer believed that the three PSRT modules describe the repair and maintenance procedures quite well.

- All of the trainers felt that highway maintenance personnel could benefit from PSRT.

- The trainers agreed that the program software is easy to use and would be found "friendly" by all levels of users.

- The trainers believed that the program offers an adequate number of interaction opportunities and that the opportunities would enhance learning.

- The program's review feature drew both positive and negative responses from the standpoint of the amount and pace of review in each module. The need for more user control to speed up in or return to parts of the program was expressed, especially since greater user control could overcome the negative aspects of the built-in review function.

- The trainers agreed that IVD is an effective learning tool, could at times be more effective than other training methods, and is particularly applicable for training in the transportation field.

- Additional comments offered by the trainers reaffirmed their view of the potential effectiveness of the IVD. Those comments also criticized the failure of the PSRT program design to allow users to pause, speed up, or review selectively within a module.

WZTC Evaluation

WZTC was written in accordance with the standards set forth in the *Manual of Uniform Traffic Control Devices*. The program begins with brief instruction on how to interact with the IVD system. The instructional content is divided into four self-contained modules, each with a series of lessons. The first module is an introduction to traffic control in a work zone. It provides an overview of sign types, road markings, and available channelizing devices. The second module covers selection and use of traffic control devices and outlines inspection and maintenance procedures. In the third module, users view the implementation of traffic control methods under rural, urban, and detour conditions as sample procedural applications. The fourth module covers the qualifications and procedures that flaggers must meet and follow and demonstrates proper flagging. Each lesson in the four modules concludes with true-false and multiple-choice quiz questions on the information and examples presented in the lesson. Quiz results are stored and can be accessed and printed upon completion of the program. The specific target audience for the program is entry-level engineers, engineering technicians, and construction

supervisors—although the FHWA believes that anyone working in traffic control could benefit from interacting with the program. WZTC was examined at VTRC by the authors and three traffic research engineers.

Technical Performance

Although WZTC contains fewer technical malfunctions than PSRT, many of them are similar to those found in PSRT. For example, it takes at least two attempts for the user to initialize the videodisc player. Also, menu selections that preempt narration must always be entered twice, and there is no way to exit the system without rebooting the computer. Additional problems include a series of graphics that scan across the screen as the program begins and lost audio at the beginning of some of the program segments. Further, the picture resolution and color saturation in certain motion video portions are poor.

Program Design

A number of the weaknesses were found in the WZTC program design:

- The program is overly structured, with the content broken down into too many small, discrete steps. For example, some of the lessons, which are at the third tier in the menu levels, are further divided into very brief "mini lessons." This creates a discontinuous flow from lesson to lesson since the user is constantly choosing from or returning to a lesson or module menu. In fact, the user may be forced to spend more time reading program menus than focusing on the content. The sample applications module provides a good illustration of this weakness. The module has only one lesson, but its main menu is nonetheless subdivided into an additional lesson menu in order to explain to the user which lesson in the module he or she is about to view. Further, when the user finishes the only lesson, the program returns to the module's main menu to explain what lesson has just been completed.

- The numbering and lettering schemes for the menus are confusing, making it difficult for users to keep track of where they are in the modules and overall program.

- The narration is verbose. Much of it is devoted to explaining what will be learned or presented or what has been learned already. Thus, the program is encumbered by too many long "wind ups" and summaries before and after each lesson. Due to design problems in the program's use of review, the narration is also overly repetitive.

- As in PSRT, WZTC's review presentations are no different from either its instructive or reinforcement components. Rather than providing the user with a reiteration of the instructional content, the review segments simply repeat verbatim the instruction that was given just moments before. Also, from the standpoint of program design, there seems to be little difference

between the uses of review and reinforcement. For example, one correctly answered question may result in a simple statement of reinforcement whereas another correct response may result in a more lengthy remedial review. Incorrect responses also yield different lengths of reviews. Thus, by the time a user completes a lesson, it is not uncommon for the same video clips to have been viewed three times and then to appear again at the outset of the subsequent lesson.

- Visually, WZTC suffers from overuse of graphic screens and underuse of motion video. For example, the sample applications module is presented using computer-generated graphics exclusively, rather than integrating motion video where it would have been helpful. In addition, all menus, review outlines, test questions, and much of the instruction are presented via computer-generated graphics. The paucity of motion video in the program makes the choice of IVD for this training material questionable.

- WZTC uses primarily true-false questions to assess learner performance throughout the program. The questions posed ask only that the user recall the informational statements and facts rather than assess his or her ability to apply the information in a particular situation or circumstance. Questions based on literal recall do not maximize the user's learning experience. Further, rather than being grouped at the end of a short unit, to avoid simple parroting of the instruction, test questions are asked immediately following even the shortest segment of instruction. So although test questions elicit user interaction, they do not result in the accurate assessment of knowledge.

- WZTC includes a module with pretest questions that can help determine user gains in and entry level knowledge of the work zone training material. However, users must answer nonapplicable questions in order to finish the pretest rather than being able to bypass them. Additionally, the pretest results are not linked to the actual instruction trainees receive, so that all students are fed the same instructional "diet" regardless of their test results.

The program does contain obvious strengths. Most notable are the program's graphic design work and its use of Preview and Newuser modules. Certain of the computer-generated graphics that are used to illustrate traffic control situations are first rate in both their design and picture quality. The Newuser module is intended for those using WZTC for the first time. It includes a rationale of the program, practice questions, and the pretest. The Preview module contains the program credits and explains the purpose of the program, how to follow the menus, and what to expect from the true-false questions. It instructs new users on how to use the hardware to interact with the program.

Content Accuracy

The three VTRC traffic engineers offered the following comments regarding the program's content accuracy:

- They generally agreed that the content is very basic, although their opinions differed as to whether this is a positive or negative attribute. One engineer saw merit in the simplistic nature of the content because it makes WZTC applicable to lower-level employees. Another expressed concern that the content is too basic and thus does not provide adequate detail to equip trainees to perform the tasks their jobs demand.

- The engineers could not reach a consensus on the goal of the instruction. One engineer thought that the content presented only information but no procedures, and another believed that the content had, at least implicitly, provided sufficient procedural theory to help a trainee understand why procedures are carried out as they are.

- There was a consensus that the content is boring. The engineers agreed that, although the periodic interaction relieved the tedium somewhat, the program content does not provoke a level of interest commensurate with its length. One engineer remarked that a good instructor could cover the same material in one third of the instruction time.

- The engineers did not feel that WZTC is relevant to VDOT since it teaches various standards and practices not applicable to VDOT.

EVALUATION OF IVD FOR TRAINING

Before adopting and investing in IVD technology for training, transportation agencies must evaluate its potential according to their own needs and circumstances. Standard criteria that help agencies determine whether IVD is the most advantageous form of training for their use include training need, content stability, instruction costs, and learner variability.

Training Need

An agency must first determine whether there is a need for new training materials. A need may be ascertained partly on the basis of an absence of sufficient training materials in a particular subject area (Brandt, 1986). If such training materials are not available, IVD is an option. Freeway incident management is an example of a topic for which no materials or training curricula existed and, after some research, IVD was selected as the best medium for delivery of this training. Second, the IVD option could be used when existing materials are inadequate or are not serving their intended purpose. Although IVD may be an appropriate replacement, those evaluating training should carefully compare the development of new training and the possibility of tailoring existing materials.

Content Stability

When training materials are developed for any relatively expensive medium, they should include content that will remain constant and stable over the life span of the materials. IVD is developmentally the most costly medium available, and the life expectancy of videodiscs is nearly eternal. Content stability is found, for example, in basic mathematics and many fields of science. Programs developed to teach mathematic algorithms and the pull of gravity are not likely to require much change, thus making these subject areas good candidates for videodisc training.

Along with content stability, content consistency is an important factor to consider. As a general rule, in order to achieve cost-effectiveness, the content of an IVD program should not be so specific to one agency or area of training that it limits its possible use in other agencies unless the program is addressing a large number of employees in the agency. Conversely, when there is a need for all trainees to receive the same training over time and across instructors, IVD can provide training materials and presentations that are unaffected by the instructor's practice or mood, the learner's surroundings, and other byproducts of human error.

There appears to be sufficient standardization in transportation subject matter to warrant the development of IVD programs for training purposes. Even with some variability among states, there exists enough of a stable core content to justify the development of IVD training programs without the need for extensive program tailoring. However, Yocom, Worrall, and Gingras (1989) discovered that a minimal amount of tailoring is necessary. "Experience has taught us that trainees in North Dakota do not expect to see Florida beaches or Washington equipment . . . in their training materials" (p. 9). They also reported that it is less expensive for states to share developmental costs and do individual postproduction tailoring than to develop their own programs. Before embarking on an IVD design project, an agency should assess the amount of individualized tailoring that will be necessary, remembering that although the computer software can be modified, rather inexpensively, the cost to alter a videodisc after mastering is considerable.

Instruction Costs

Despite its considerable up-front investment, IVD can be cost-effective by saving the costs of both instructional equipment and instruction time. Although only part of a cost-effectiveness formula, these cost variables are criteria that contribute to the decision of whether or not to use IVD for a particular training package.

Equipment

"When hands-on experience and training would be awkward, inconvenient, dangerous or prohibitively expensive, videodisc systems may be the way to go"

(Minicucci, 1986, p. 26). All of these adjectives can be applied to training that typically involves tampering with, repairing, or learning to operate equipment. The use of the actual equipment during training sessions could be awkward if, for example, there are more students than equipment, thus making it difficult for all to have a hands-on opportunity or to view fully the procedures demonstrated by an instructor. Training on small or expensive equipment is common to this scenario. IVD simulations can cut costs by substituting for actual equipment that is too expensive to risk learning on, too large to carry to training sites, or inconvenient to share with trainers and their students (Brandt, 1986). In addition, Shriver (cited in Brandt, 1986) found that learning time using simulated equipment was less than learning time using real equipment. Finally, because some training equipment is dangerous when improperly handled, such as a welding torch, students can greatly reduce their safety risks by first mastering the use of the equipment through an IVD simulation.

Instruction

Certain types of training are simply more cost-effective when conducted by IVD than by other instructional methods. Three criteria in particular typically contribute to IVD's cost-effectiveness when decisions are being made about the development of training programs.

1. *Instruction time.* For example, when IVD instruction is used in place of a lengthy, complicated technical manual, employees are apt to learn the material more quickly because they interact with it (Nico & Morgan, cited in Brandt, 1986).

2. *Productive time.* A related concern is the amount of time lost or saved from on-the-job productivity while an employee is being trained. Productivity can be lost not only in the time required to learn the material, but also in the time spent travelling to a training site. An agency should endeavor to determine at what point the time saved by reducing travel time and training sessions results in more productivity. If IVD saves time and maintains or improves training standards, it has contributed to a cost-effective method of instruction.

3. *Travel expense.* In many cases, IVD's self-contained and portable instruction features make it less expensive than even well-attended class-room training sessions. If students are attending training sessions from within a large geographical region or instructors are travelling long distances to meet with their classes, funds expended for such travel could total enough to allow the purchase of IVD hardware and programs (Brandt, 1986). Moreover, "learning can take place where classroom training is not possible: at remote locations, at understaffed training centers, or wherever learners have time constraints" (Snyder & Webster, 1987, p. 23).

PSRT is a product of cost-effective thinking. The program was originally designed for small urban or rural areas that did not have their own training programs

or the funds to employ trainers or have employees attend training sessions elsewhere (Pavement Repair, 1988). It is feasible that as many as ten highway personnel could individually complete the PSRT program in less than 2 days by spending an average of 2 hours with it. By having the capability to train one employee at a time, an agency can keep other workers on the job, thereby reducing the loss of productivity and travel associated with several employees attending training courses.

Learner Variability

One of Brandt's (1986) suggestions to agencies evaluating the adoption of IVD was that the target audiences vary in their work experience or entry-level skills. Snyder & Webster (1987) recognized the strength of IVD in addressing this issue:

> [The IVD medium] is self-paced and responsive to individual learning speeds. It presents material at the appropriate level for each individual trainee. It enables the learner to choose what is relevant without going through material that is not wanted or needed and it functions as an infinitely patient tutor (p. 23).

Learner variability extends far beyond work experience and job-related skills. Employees tend to vary in many basic skills, such as reading and mathematics; they may also vary in affective or psychological characteristics, such as attention span, motivation, and learning style preferences. IVD technology is equipped to handle a variety of learner differences. Further, IVD affords adult learners the privacy they may need to work at a slower pace, risk missing an easy question, or choose to review when other learners might not. However, not all prepackaged IVD programs provide for learner variability. For example, IVD's capability to use dual audio tracks to support both a basic and advanced level of narration is not always used in that way; also, all IVD programs do not branch users to places on a videodisc according to individual performance, and fast readers may be forced to suffer through the narration of on-screen text at a reading rate paced for slower readers.

Learner variability is a relevant criterion for VDOT to consider, especially since the education level of its personnel varies from eighth grade to advanced degrees. IVD programs designed or selected for VDOT employees would thus need to reflect this variability in education levels. For example, IVD programs that teach word processing or other computer application software skills must be selected carefully with respect to the VDOT staff's diversity, since software skills are taught to such a wide group of personnel.

EVALUATION OF IVD HARDWARE

Although IVD program applications are said to be the medium's most important component, hardware is the facilitator of the technology. Because the IVD industry has not yet become standardized, there is a maze of hardware configurations. Agencies evaluating IVD as a training option must ensure that the hardware to be purchased is compatible and versatile, as well as affordable.

Hardware Configurations

The components that comprise a functioning hardware system for IVD technology vary according to the level of programming. All IVD programs require at least a computer, a videodisc player, a computer interface device, and a television or video monitor. These pieces of equipment can be purchased prepackaged as a "turnkey" system or piece by piece for assembly into a component system. Although several companies produce state-of-the-art hardware, because VDOT has a heavy investment in IBM and IBM-compatible equipment, only hardware components compatible with IBM were examined. Table 2 presents the average per item costs for basic IVD hardware components.

Table 2

Costs of Basic Hardware System Components

Hardware Component	Average or Range of Cost
EGA card	$80
Math coprocessor	$150
Videodisc player	$2,000–$10,000*
Computer interface device	$2,200
RGB video monitor	$600

*High end represents state-of-the-art equipment.

Computer

At level 3 programming, a computer is needed to control the videodisc player. The computer can generally be of any type, from a PC to a large mainframe computer. (For the purposes of VDOT, a PC can be assumed.) What is important are the

31

capabilities of the computer and how they match up with the IVD programs to be used. Hardware requirements vary, but some IVD software requires that the computer have a huge amount of RAM, a hard disk, a math coprocessor, an enhanced graphics computer monitor and card, or a combination of these features. For example, the computer features needed to configure the IVD system for PSRT and WZTC include a hard disk with at least 10 megabytes of memory, a RAM capacity of 640 kilobytes or more, a math coprocessor, a 3.5-inch or 5.25-inch floppy disk drive, an EGA monitor with an EGA card, a voice card, a genlock card, and two serial ports. An IBM PC/XT or AT or closely compatible PC/MS DOS 3.1 and later versions with all of these features will likely support any of the current or forthcoming FHWA or AASHTO IVD programs. In addition to these transportation programs, many general training skills programs, such as those for word processing or spreadsheets, should operate with this hardware configuration. Since VDOT has already procured IBM-compatible computers for most of its PC applications, hardware costs would be only those associated with acquiring additional features required by each IVD program. Costs vary, but to add some or all of the features to a standard PC system would range from $100 to $1,000 per unit if the PC monitor was already EGA and required only the internal EGA card. However, as IVD applications grow in programming complexity and sophistication, it is reasonable to assume that programs will require further advanced hardware capabilities.

Videodisc Player

IVD software is designed to drive specific videodisc players, or a group of compatible players, by directing the videodisc player to play certain frames or segments on the videodisc or to pause or loop at preplanned places on the disc. Any level 1 or 2 disc player can be directed by the computer—as long as the software drivers "recognize" the player. Pioneer, Sony, and Hitachi make comparable videodisc players at all levels. Most of the differences between the brands and models of players are stylistic. Newer models typically have features the older ones do not, such as decreased search times, digital audio tracks, and open architecture. Selection of a videodisc player needs to be based on the primary software (or authoring language) that will be run, how the medium will be used, and the budget. For example, if the potential exists for program development in-house, a quicker search time would become a more important feature than it would for programs produced by professionals who possess the advanced knowledge and skill to curtail search time in the program and videodisc. Videodisc players for most level 3 play range from $2,000 to $10,000.

The project proposal for the three forthcoming AASHTO IVD programs does not include information on the hardware system that will be required to support them. However, once AASHTO's system or a compatible disc player is identified, it will likely work with all three programs. On the other hand, the FHWA programs were designed using the IBM system "InfoWindow," which is compatible with at least three of Pioneer's models: LD-V6000, 6010A, and 6200. Fortunately, technological advances are making it easy to tailor programs to work on a range of players through interface devices, so if new transportation programs are developed or more

widespread IVD programs are purchased, it is likely that a compatible computer-player system can be configured.

Computer Interface Device

When an IVD system is made up of a mix of proprietary or "mix and match" components rather than a preconfigured turnkey system, an interface device is required to tie the components together. Typically, an interface connects the computer and videodisc player to allow for active communication from the software to the disc, to the user, and back to the software. "The interface accepts specific instructions from the computer program and translates these into functions to be performed by each of the components of the interactive system" (Wilson, 1983, p. 27). The interface device can be a controller card (circuit board) or an external device that is connected through a serial port. There is no universally accepted interface card, or "box," since interfaces are designed to function with specific operating instructions and computers.

Companies often package several versions of the same program for use with different videodisc players, interfaces, and computers. Vendors may carry multiple versions of the more popular training programs, which would eliminate the need for additional interfacing and reconfiguring. However, for limited field-specific subject matter, the choice of hardware components is more restricted and an interface device is likely to be needed. For example, the PSRT and WZTC program systems use the EECO VAC-300 Decoder, which costs about $2,200.

Video Monitor

Finding the right monitor for a composite IVD system is relatively easy. Any make of standard television monitor, including the one from the living room, can be connected to a videodisc player to play the video segments. However, since most current level 3 programs incorporate computer-generated graphics, an RGB monitor is usually necessary. An average-sized (about 13-inch) and average-quality RGB monitor costs at least $600.

Hardware Trends

Rapid development and growth trends are occurring that could advance IVD technology dramatically. New hardware will naturally result in new software potential and could expand the way in which IVD is used in the future. Four trends and their potential effects on hardware configurations and purchases are digital IVD, rewritable discs, barcodes, and mainframe systems.

Digital IVD

"A key goal of DVI [digital video interactive] is to eliminate the expense, complexity, and awkwardness of a part-analog/part-digital system by storing and

processing everything as digital data" (Glass, 1989, p. 283). IVD programs current-ly use digitized audio in addition to the digital computer-generated graphics, but video is strictly in analog form, which requires more memory and disc space than digitized information. By digitizing (converting and compressing) video information prior to storing it on a disc, vast amounts of visual information and motion video can be stored on a standard-sized CD-ROM (compact disc—read only memory). Digitizing can also enhance audio and computer graphic capabilities. The advan-tages of DVI go beyond storage space. DVI allows highly sophisticated simulation programming that accommodates more user "decisions" and smoother transitions and requires less hardware and circuitry. DVI does require two new microchips that are currently manufactured by only one company, thus diminishing broad mar-keting of DVI systems and keeping prices high. Nonetheless, authoring tools for DVI are already on the market, and the cost of mastering DVI CDs is from $2,000 to $8,000 per master disc. However, applications of DVI are still a few years away.

Rewritable Discs

Several companies are now making "magneto-optic" discs. These discs are coated with magnetic media, which means that the same data that are normally read by a light in the laser videodisc player can be erased by scanning a higher-powered light back over the same track of data. The process reverses the magnetic polarity and leaves a track ready for rewriting. The implications of this technologi-cal advancement are numerous. For example, new disc images could be created from various media sources (e.g., magazines, video, print) or copied from other videodiscs without having to remaster the disc. The hardware for erasing and re-cording on standard discs is now available, albeit still quite expensive at $12,000 to $25,000 per system.

Barcodes

Those black and white striped barcodes that have basically replaced the printed price on many items may begin to turn up in workbooks, textbooks, and cat-alogs and on maps. By scanning a laser light pen over the barcode in a textbook, a programmed videodisc player will respond by searching out and playing certain videodisc frames or segments. For example, Pioneer has developed a barcode sys-tem (LaserBarcode) that has five components: printed material with barcodes, a disc player, a disc, a barcode scanner, and a television monitor. Barcode authoring software and program applications are already on the market. The advantages of barcode technology include its relatively inexpensive hardware, complementary in-teraction of print and video, simple operation, and menu-driven authoring program for making barcodes and writing barcode commands (Pioneer Electronic Corpora-tion, 1989). The cost of barcode system hardware is $750 to $1,050.

Mainframe Systems

Art galleries and museums are the best candidates for "multiuser libraries," or mainframe computer IVD systems (see Figure 2). With this type of system,
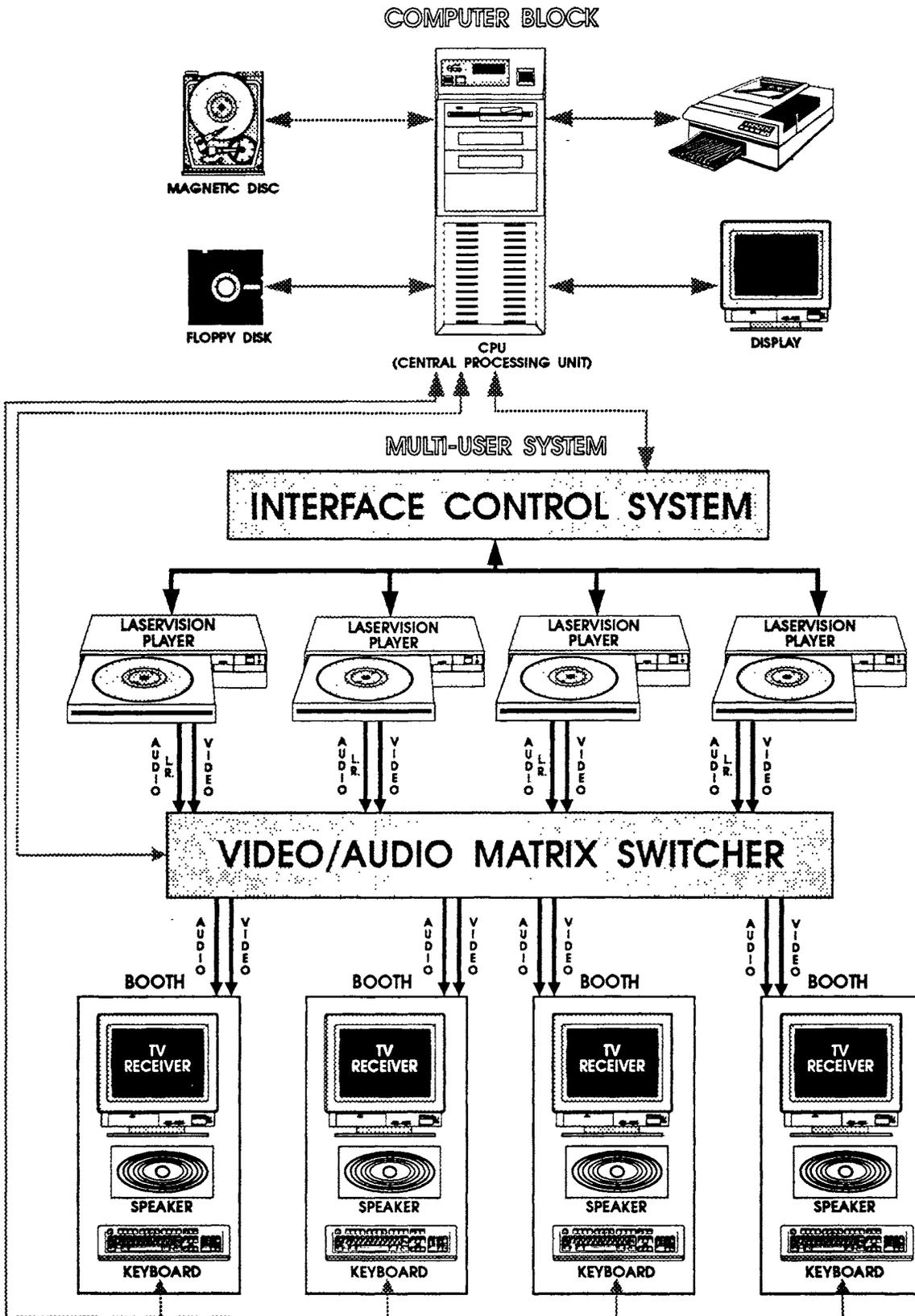
COMPUTER BLOCK

Figure 2. Hardware components of a mainframe IVD system.

several videodisc players are connected to a central computer system and a corresponding number of users can simultaneously access the same or different programs. User access is limited only by the number of discs and viewing stations, and each station requires only an input device and monitor since players are controlled by a matrix switcher via the mainframe computer. Although increased levels of interactivity mean increased technical complexity and cost, this type of system can also work well in an industry that has a high demand for training but limited space and budgets. For a state agency such as VDOT, one or two central locations could house mainframe computer systems and several regional centers could house space-conserving work stations. Mainframe systems reduce hardware costs for a large number of users since individual PCs are not required for each IVD program. Because there are more cost variables for a multiuser system than can be accounted for in this report, further investigation would be required to determine specific cost estimates for using a mainframe system in VDOT.

CONCLUSIONS

1. It is only through available high-caliber videodisc applications that the IVD medium realizes successful implementation. Only a few programs offer the hands-on problem-solving training that trainees get on the job, although there appears to be no limit as to the content or subject matter that can be addressed by the IVD medium. Moreover, IVD provides learners the opportunity to receive safe, personalized, and active training that offers immediate feedback and reinforcement.

2. It appears that a market for IVD is developing in the transportation community. The feasibility for using videodisc technology for image storage has been acknowledged as particularly useful for the process of photologging. Two level 3 training programs are already available for engineers and highway personnel, and four more projects are underway. Both the FHWA and AASHTO have found IVD to be a cost-effective and worthy investment and are leading the way in state-of-the-art training methods and materials development.

3. There are general criteria that are helpful when decisions are being made as to whether IVD is an appropriate and effective medium for training materials:

   - whether or not there is a need for new materials

   - how stable content matter tends to be

   - equipment and instruction costs and cost-effectiveness

   - whether or not the target groups to be trained are heterogeneous.

   However, all other reasons aside, the most critical and persuasive reasons for an organization such as VDOT to consider adopting IVD are probably those that

"point to an economic justification for employing interactive video rather than some other media or combination of media" (Brandt, 1986, p. 32).

4. Hardware purchase decisions are potentially complicated and costly. Although IVD turnkey systems are bought as one integrated package that is interfaced to run supporting videodisc programs, many potential IVD adopters have already invested in computer technology and are faced with the formidable task of creating a piecemeal IVD system that will work for their purposes. Given the many possible equipment configurations, it is important to have a repertoire of potential program applications before purchasing hardware. In that way, hardware specifications are predetermined for the buyer's software needs. The required hardware listed for the current and upcoming FHWA and AASHTO programs may not be compatible with some of the more popular IVD programs. Stabilizing trends might pose a threat to hardware purchases. In a relatively new field of technology, early adoption can be risky. The trends that were discussed should not affect the transportation market as yet, but it is a good idea to look to the future before making hardware system decisions and purchases.

RECOMMENDATIONS

1. *Collaboration with the Information Systems Division.* Personnel from VDOT's Information Systems Division should be involved in any further decisions and efforts concerning IVD, specifically with regard to future software and hardware needs and associated purchase costs as well as for ascertaining the cost-effectiveness of current training programs using computer technologies. Collaborative decisions about IVD program and hardware purchases by trainers and Information Systems personnel would ensure that VDOT was investing in IVD programs that maximized the use of in-house hardware or that could be configured to support existing hardware. Collaborative evaluations of IVD programs by trainers and those with computer programming expertise would yield an accurate assessment of which IVD programs could be purchased on the basis of their being realistic candidates for tailoring or revision in order to meet VDOT's training needs more specifically.

2. *VDOT's pursuit of IVD.* VDOT should continue to investigate the use of IVD as a medium for training by conducting a thorough evaluation of its cost-effectiveness. In order to do this, specific documentation needs to be provided that includes the complete costs of current training programs, including such factors as instructor fees, costs of rental facilities, travel expenses for instructors and students, costs attributable to the loss of employee productivity during training time, and the costs of consumable instructional materials.

3. *Specific IVD program applications.* FHWA's WZTC program should be eliminated from any further consideration. VDOT should, however, consider conducting a pilot study of FHWA's PSRT program in one or two residencies. Given the favorable evaluations of the program by VDOT trainers and operators,

PSRT should be tried as an alternative or adjunct to classroom and on-the-job training. Large investments in hardware or software should not be made until hard data are collected that measure the effectiveness of PSRT within a large population sample of trainees. It is further recommended that VDOT, already a subscriber to AASHTO's IVD development project, become a pilot for one of AASHTO's IVD programs. This involvement would enable VDOT to obtain reliable information about the cost-effectiveness and usefulness of IVD in the training of its employees.

4. *Suggestions for program evaluation:*

- Before purchasing any IVD program, VDOT should conduct a needs analysis with respect to its current method of training, available training materials, and the effectiveness and cost of instruction currently in place. Should IVD remain a viable option, potential programs should be evaluated in terms of how they will address the learning needs of those who will be using it, the number of learners targeted for instruction, the educational quality of the program design, the cost of the investment (including any cost savings that would be realized over time), and the hardware requirements.

- If VDOT decides to invest in IVD instruction, it should consider as many future program needs as possible before deciding on particular hardware configurations. In this way, hardware can be configured to match the greatest number of programs and add the fewest peripheral components. It may, in fact, be prudent for VDOT to lease IVD programs and hardware before making final purchase decisions. Rental arrangements can prevent speculative purchases of both program applications and hardware: programs can appear to be better than they actually are and even vendors are not always sure when programs and hardware configurations will match.

- If VDOT decides that IVD is a superior and feasible mode of training, it should investigate multiuser library systems and rewritable disc technology. It may prove to be more cost-effective for district offices to share a multiuser library rather than individually house several IVD work stations. Depending on how far in the future VDOT were to commit itself to IVD training, rewritable videodiscs may provide additional training benefits (such as custom-tailored video segments) with minimal additional cost.

REFERENCES

Brandt, R. (1986). *Interactive video: When to consider its use* (Report No. ED 272 174). San Jose, CA: San Jose State University.

Christie, K. (1989). Interactive illusions. *AVC: Presentation Technology & Applications,* November, 18–21.

Floyd, S., & Floyd, B., eds. (1982). *Handbook of interactive video.* White Plains, NY: Knowledge Industry Publications.

Gallaher, J. K. (1990). *Applying DVI technology to cross-sectional anatomy.* Winston-Salem, NC: GBD Corporation.

Glass, L. B. (1989). Digital video interactive. *BYTE,* May, 283–289.

Iuppa, N. V. (1984). *A practical guide to interactive video design.* White Plains, NY: Knowledge Industry Publications.

Iuppa, N. V., & Anderson, K. (1988). *Advanced interactive video design: New techniques and applications.* White Plains, NY: Knowledge Industry Publications.

Kalowski, P., & Woldman, E. (1986). Interactive video. *Classroom Computer Learning,* November, 27.

Maclean, L. M. (1985). *Seeking information on interactive video: The information sources and strategies used by corporate training developers* (DAI AAC8603789). Unpublished doctoral dissertation, Syracuse University, Syracuse, NY.

Minicucci, R. (1986). Videodiscs in the office: Timely TV tutors. *Today's Office,* May, 25–30.

Paniati, J. (November 1990). Personal telephone conversation with P. Hunter. Charlottesville, VA.

Pavement repair videos in production. (1988). *ITRE Technology Trends,* Summer, 3.

Perfater, M. A., & Harris, G. (1987). *An investigation of the uses of videotape in transportation operations* (FHWA/VA-86/20). Charlottesville: Virginia Transportation Research Council.

Pioneer Communications of America, Inc. (no date). *Laserdisc™ laservision system guidebook.* Upper Saddle River, NJ: Author.

Pioneer Electronic Corporation. (1989). *LaserBarcode system guide book.* Tokyo: Author.

Salpeter, J. (1986). Interactive: The truth behind the promises. *Classroom Computer Learning,* November, 26.

Smith, S. G.; Jones, L. L.; & Waugh, M. L. (1986). Production and evaluation of interactive videodisc lessons in laboratory instruction. *Journal of Computer-Based Instruction, 13*: 117–121.

Snyder, C. E., & Webster, S. L. (1987). Videodiscs and training. *Bulletin of the American Society for Information Science*, Aug./Sept., 22–27.

Souter, G. A. (1988). *The DISConnection: How to interface computers and video.* White Plains, NY: Knowledge Industry Publications.

Staples, T. (1989). *Some notes on videodiscs from the videodisc study group.* Academic Computing Center, University of Virginia, Charlottesville.

Stewart Publishing Company, Inc. (1990). Interactive Healthcare 90. *Conference Agenda.* Alexandria, VA: Author.

Uhlig, G. E., & Feldman, P. (1985). Interactive video. *Education, 10*: 3–8.

Wilson, R. L. (1983). Interactive video: What makes it work? *Performance & Instruction Journal,* November, 26, 27.

Yocom, A.; Worrall, H. W.; & Gingras, G. R. (1989). *A joint development project proposal to the American Association of State Highway and Transportation Officials for computer assisted transportation training.* Unpublished proposal, AASHTO, Washington, DC.

APPENDIX A

Glossary of Terms

Authoring. To write and develop the elements of an interactive videodisc program.

Authoring language. A computer language written specifically for designing interactive video programs.

Branch. To split off from one place or segment to another on a videodisc or within a computer program.

CAI. Computer-aided instruction. The use of a computer program to instruct.

CAV. Constant angular velocity. Videodisc playback in which the disc speed remains at constant rotations per minute.

CD-ROM. Compact disc—read only memory. A small optical disc that holds about 600 megabytes of readable information.

Chapter stop. A code on the videodisc that signals a chapter break in the content and allows access to different portions of the video disc.

CLV. Constant linear velocity. Videodisc playback in which the disc speed varies in rotations per minute from the outer tracks to the inner tracks of the videodisc.

Computer-generated graphics. Visual images that are created by a computer graphics program and usually projected on the video screen.

Decoder. A device that interprets inputs from the computer and determines outputs to the videodisc player.

EGA. Enhanced graphics ability.

Freeze frame. A single frame of motion video that is captured and held in place on the screen.

Interface. A device through which a user relates to the computer program that drives a videodisc.

Kiosk. A stand-alone videodisc display used with or without a computer.

Laser. A beam of light used to write on and read optical discs. An acronym for light amplification by stimulation of emission of radiation.

Linear video. Noninteractive video that plays from beginning to end with no branching, such as a movie.

Master. The first final disc that is used to produce duplicate copies.

Mastering. The process used to make duplicate copies of a master disc.

Menu. A list of user options available for selection.

Menu-driven. A program that is controlled by the user's menu selections.

Random access memory (RAM). A portion of a computer's internal memory available to a user for information storage and retrieval.

RGB. Red-green-blue. Color video output composed of three separate signals for the red, green and blue colors in a picture.

Read only memory (ROM). A portion of a computer's memory available to a user only for information retrieval.

Scan. A method of rapidly browsing a videodisc.

Search. A method of locating a specific frame on a videodisc.

Search time. The time required to locate a specific frame on a videodisc.

Still frame. A single frame of motionless video, such as a slide.

Submenu. A menu below the main menu in a hierarchical design that allows users to make selections without returning to the main menu.

APPENDIX B

Interactive Videodisc Technology Survey

Interactive Video Disc Technology Survey

Please complete the survey questions below.

1. Is your agency currently using or considering using interactive video disc (IVD) technology?

   ☐ Yes — Using   ☐ No *(If "no", please skip to question 11.)*
   ___ Considering

2. In what capacity is IVD being used (or considered)?

   ☐ Instructional   ☐ Informational

   ☐ Image Storage   ☐ Promotional   ☐ Other_____
                                                    please specify

3. If your response to question 2 is "instructional", please check the classification of employees targeted.

   ☐ Highway   ☐ Professionals   ☐ Clerical   ☐ Data processing
      personnel

                                        ☐ Other_____
                                                    please specify

4. What type and level of programs are being used? (Circle all that apply.)

   Type: Playback only   **Level:** Level I (playback)

              Didactic   Level II

              Simulation   Level III

              Problem solving   Level IV (multimedia)

              Other_____
                      please specify

5. What is the source of most of your programs?

   ☐ In-house production   ☐ Outside agency, co-produced for our specific needs

   ☐ Outside agency, pre-packaged software & disc   ☐ Other_____
                                                                please specify

   Please list the name(s) and location(s) of the outside agency(ies) you use most often:

   _____

   _____

   _____

6. Does your agency employ an instructional designer?

   ☐ Yes   ☐ No

                                                        (over)

2O9 What influenced your decision to use IVD?

_____

_____

_____

8. What is the average cost of the IVD programs that you use? (Please specify
    if these costs are rental or purchase amounts.)

    $_____   rental or purchase
          software

    $_____   rental or purchase
            disc

    $_____   rental or purchase
           other

9. Please specify the hardware (Make and Model) your agency uses (or will use) for
    IVD programs. (If IVD use is multi-purpose, specify training hardware.)

    Turnkey   _____

                                    o r

    PC/monitor   _____

    Interface   _____

    Disc player _____

    Video monitor_____

    Other   _____

10. What is the approximate cost per work station (including software and discs)?

    $_____/ work station

11. Can you recommend any IVD programs that might be useful to the VDOT?

    _____

    _____

    _____

12. Please note any upcoming projects/plans that might be of interest to us.

Thank you for your time.

APPENDIX C

**Discussion Questions: Pavement Structure Repair Techniques**

After they viewed the pothole patching module, the users were asked the following questions:

1. Do you feel like you could fill a pothole?

2. How much do you think you learned from the program?

3. What would you want in training that this module does not give you?

4. Have you had training in patching potholes before?

   If so, which form of training . . . did you like best?
                        . . . taught you the most?

   Would you recommend the former type, IVD, or both?

2100
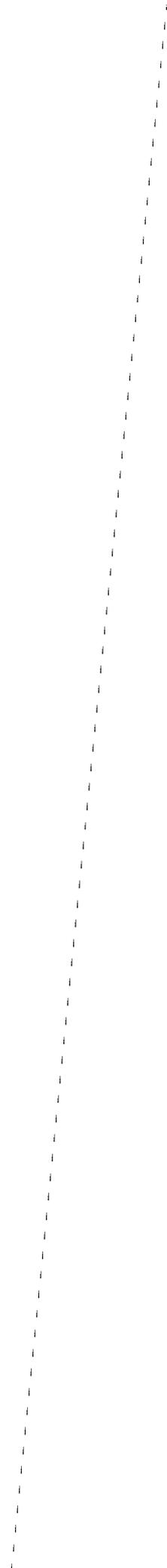
APPENDIX D

Pavement Structure Repair Techniques User Survey: Operators

2102

Pavement Structure Repair Techniques User Survey

Please read over the survey before you use the interactive video program.

Name:_____

Where do you work in VDOT?_____

What is your job?_____

Which programs did you see?. (Circle all those you saw.)

Ex. | ① Pothole Patching | (part) all

Menu

Menu		
1. Pothole Patching	1. part	all
2. Crack Sealing	2. part	all
3. Asphalt Chip Seals	3. part	all
4. Ditch Maintenance	4. part	all
5. Shoulder maintenance	5. part	all
6. Maintenance of Gravel Roads	6. part	all
7. Basic Traffic Control	7. part	all

Please ✓ YES or NO to answer each question.

	YES	NO
Have you ever used IVD (interactive video) before?	☐	☐
Was the program easy to use?	☐	☐
Did you understand what the program taught?	☐	☐
Does the program give the right information for use at VDOT?	☐	☐
Could the use of this program help you on the job?	☐	☐
Could this kind of program save you time in learning to do your job?	☐	☐
Would you like to use this kind of program for other job skills you learn?	☐	☐
Do you feel this way of learning could at times be better than other ways?	☐	☐

Comments:

_____

_____

_____

Thank you for your time.

APPENDIX E

Pavement Structure Repair Techniques User Survey: Trainers

Pavement Structure Repair Techniques: User Survey

Please read over the survey before using the interactive video program.

User Name:_____

District/Division in VDOT:_____

Position/Type of Job:_____

Please indicate which and how much of each program you viewed.
(Circle all that apply.)

Pothole Patching	part	all
Crack Sealing	part	all
Asphalt Chip Seals	part	all
Ditch Maintenance	part	all
Shoulder Maintenance	part	all
Maintenance of Gravel Roads	part	all
Basic Traffic Control	part	all

Please answer all of the questions below.

<u>Program Content</u>   <u>Yes</u> <u>No</u>

Was most of the program content accurate?   ☐ ☐
If not, what was inaccurate?_____

_____

_____

Is the program content applicable for your training needs?   ☐ ☐
If not, why?_____

_____

_____

Who do you think can benefit from this program?

☐ highway   ☐ trainers   ☐ supervisors   ☐ other_____   ☐ no one
   personnel   specify

Comments:_____

_____

_____

_____

<u>Software</u>   <u>Yes</u> <u>No</u>

Was the program easy to use?   ☐   ☐
If not, what about it was "unfriendly?"_____

_____

Do you think all levels of users would find the program easy to use?   ☐   ☐
If not, who would find it difficult and why?_____

_____

Did the program offer enough interaction opportunities?   ☐   ☐
If not, why?_____

_____

Do you feel that the interaction opportunities enhance learning?   ☐   ☐
If not, why?_____

_____

Comments: _____

_____

<u>IVD Medium</u>

Do you feel this method of instruction could be an effective learning tool?   ☐   ☐
If not, please explain why:_____

_____

Do you feel this method could at times be more effective than other methods?   ☐   ☐
Please specifiy:_____

_____

Do you think this method is especially applicable for training in your field?   ☐   ☐
If not, why not?_____

_____

Do you have previous experience with interactive video?   ☐   ☐
If so, how does the PSRT compare with other programs you have seen?

_____

**Please make any additional comments you may have on IVD as a method
of instruction:**

_____

_____

_____

                                              Thank you for your time.