

Multimedia Production: A Set of Three Reports

- Casual Multimedia Production
- Videodisc Basics
- Videodisc Production of the "Visual Almanac"

The Multimedia Lab
Apple Computer, Inc.

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Preface

These highly interrelated reports provide the reader with an overview of some multimedia production issues relevant to the preparation of audio and video materials for a Macintosh-HyperCard-videodisc multimedia environment.

Casual Multimedia Production describes the laboratory configuration that we use in our Multimedia Lab for prototyping multimedia presentations and for creating personal multimedia communications that do not require professional-quality production values (things such as lectures and in-house presentations). We find this configuration to be quite flexible, and a good first version of the type of "Information Lab" that we hope will start to spring up in universities, schools, and offices, providing people with the basic tools for participation in the "Information Age."

Videodisc Basics provides the reader with access to the basic vocabulary relevant to videodiscs, a vocabulary that can be useful to a content expert or a producer working with video professionals. We have found this report useful in-house to acquaint our multimedia professionals (who come from a wide range of computer, film, graphics, and education backgrounds) with the details of videodisc production.

Videodisc Production of the "Visual Almanac " describes the production techniques used in one case study, a project done in our Apple Multimedia Lab. It gives the reader a general sense of the trade-offs confronted in a production project.

We hope that these reports will acquaint you with the broad issues involved in multimedia production so that you can then begin conversations and further research on your own projects.

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Casual Multimedia Production

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November 1988

[1]This paper was produced as part of the work of LUAU, the Lucasfilm Apple Umbrella Collaboration.

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Abstract

This report describes how prototype design work is done in the Apple Multimedia Lab. It discusses the processes that are involved in storing images and sounds from a range of media onto a videodisc for access by a Macintosh®-controlled videodisc player. It also describes the specific equipment used in the Multimedia Lab, with approximate prices given for reference purposes. The paper is designed to help you create your own multimedia prototype lab to support the development of design examples leading to products or single presentation projects.

Introduction

One of the exciting opportunities provided by interactive multimedia is the possibility for individuals to create their own projects that integrate video, sound, still images, and graphics, under computer control. Simple tools can support the production of multimedia programs and the modification and extension of these programs by users. At the Apple Multimedia Lab, we have developed techniques and a laboratory that allow us to quickly create and modify interactive multimedia design examples.

Creating "Design Examples"

We have found it useful to create "design examples" as a way to begin our work. A design example is an interactive multimedia prototype that addresses a specific design and/or pedagogical challenge. The intent in developing design examples is to quickly test ideas by building a working prototype that we can extend easily as we learn more.

Design examples represent a first stage in a product-development process, a "blueprint" for product planning. They provide the opportunity to check content and interface ideas before a major commitment of resources is made. They are often developed to the point where they're robust enough to be tested with potential users to learn what is working well and what needs to be modified.

Design examples are quite different from multimedia products designed for wide distribution. For one thing, design examples often require presenters, either because the material or interconnections are incomplete or because they are designed to be used as part of a lecture or demonstration. Products are usually designed to be used without a lot of additional support. Prototypes are usually considerably smaller than products, with only some of the components developed fully. Design examples usually do not have print documentation and they tend to be both more complicated and less integrated compared with finished products, because they are continually evolving with the addition of new ideas.

We start our work with design examples for the following reasons:

1. Often we don't know the exact form a fully developed product will take. The design example allows us to try out several ideas and to build from one idea into another.

2. At this time, there is no standard interface design that can be used across different projects. Therefore, in most cases the interface as well as the content and design has to be developed.

3. Working with design examples phase lets us identify interesting source materials and learn what can be done with them before we commit to the configuration of a final product. The source material can influence the design and the design can suggest the need for additional material.

4. Full-scale multimedia production can be expensive. Design examples let us see if our ideas are working before significant costs are incurred.

5. Well-developed design examples can be tested in real settings. This allows for the design to be modified before production begins.

In addition to using design examples as prototypes for products, we have discovered that this same prototyping process can be used to quickly create single copies of multimedia programs as a lecture aid or as support for a presentation. We have found it possible to build a rich interactive program that can serve a number of needs by incorporating a series of images, sounds, and graphics that can be accessed in different ways at different times by modifying the HyperCard® software. With this approach, a customized presentation can be made very quickly. In these cases, the prototype becomes the ultimate product.

We need flexible tools and equipment to create these design examples. The core of our prototyping configuration includes Apple® Macintosh computers, HyperCard software, and computer-controlled videodisc players. We intentionally use HyperCard and other software materials, such as MacroMind's VideoWorksII and Authorware's Course of Action that make it easy to build and modify materials.

In addition, we use in-house write-once videodisc recorders to get a quick sense of potential "interactions." This prototyping alternative allows us to try out a multitude of options before we freeze the selected imagery and sounds. We also use digitization equipment to quickly add sounds and images to the computer.

Mixing Media Fluidly

The marriage of computers with videodiscs and CD-ROMs provides the possibility of mixing and controlling the presentation of stills, audio, film, video, text, and graphics in a "fluid" fashion. Not only can different media be used easily and conveniently together, but the same medium can also be used in different ways. For example, film and video now can also be used as a sequence of stills, and stills can be animated into a motion sequence. Text and computer graphics can be used to augment film and audio. The sound track of a film can serve as a narration for a series of stills. This ability to effortlessly pass from one medium to another provides a powerful tool for explanation and personal expression.

A major assumption of the Multimedia Lab is that the interactive medium should be available for fluid manipulation and multimedia composition by everyone. The spectrum of interactive media developers therefore includes both low-end users such as teachers, students, and business professionals, and high-end users such as software developers and publishers. At a multimedia workstation, people can construct original interactive presentations by cutting and pasting their own images and sounds with those already provided. In this way, people not only can explore an existing multimedia collection, but they can also share what they have discovered with others by producing media-rich compositions and reports.

Description of the Prototyping Process and Equipment

Creating a design example in our laboratory is a two-step process. First we experiment with specific images, sounds, and computer graphics in an interactive mode. To do this, we make an in-house write-once videodisc that contains the images and audio we want to use. This videodisc is controlled by a Macintosh using HyperCard. We also create HyperCard stacks with the text, graphics, and control structure we need. Additional images and audio are digitized into the computer, where they can be called up by HyperCard as well.

The write-once videodisc and computer combination we use is very useful for initial experiments. But this special videodisc holds only 13 minutes of video and it requires a relatively expensive player which limits its utility outside the laboratory. Therefore, after we learn what we want with our in-house videodisc, we often get a LaserVision-compatible write-once "quick" videodisc made at an out-of-house facility. This disc

holds a half hour of video and will play on any standard LaserVision player. To make this disc, we create a videotape that has all of the images we want to use in the order in which we want them. Further development work on the project is then done with this new videodisc.

The quick disc and accompanying software may be all that is needed for use in some settings. However, if wide distribution is desired (usually more than five copies), a replicate videodisc master can be made and multiple copies of the disc produced.

Video and Audio Production

An initial step in creating a multimedia project is to collect or create the images and sounds to be used. These are then put onto a videodisc or videotape or digitized into the HyperCard program on the computer.

Still Images

Still images often form a significant part of a multimedia project because of the ease with which they can be manipulated using a videodisc system. We use a 35mm single lens reflex (SLR) camera and a copystand to make slides of drawings, objects, and pictures. These slides are transferred to videotape or videodisc in-house using Tamron's Fotovix. The Fotovix creates a medium-quality video image of a slide that is quite acceptable for many uses. Some slide positioning, zooming, and color correction can be done using the Fotovix as well. Because you can use this device in-house where you can control the process, it is very useful for prototype production—especially when you do not have a lot of slides to transfer. Out-of-house slide-transfer services (such as Stokes Slide Service in Austin, Texas, and Image PreMastering in St. Paul, Minnesota) are also available for large projects.

We also use a Sony ProMavica system to create video still images. The Sony ProMavica camera operates like a 35mm SLR camera but produces still images in a video format on a small floppy disk. These images can be put on videotape or write-once videodisc directly using the Sony ProMavica player. The image quality is slightly less than that of a 35mm slide transferred to videotape, but the photographing and transfer process is much faster.

We have also created still images on 16mm film using a camera in time-lapse mode. Inexpensive 16mm cameras (such as a Bolex) can be rented and used as an animation camera (single step) or for time-lapse photography.

Moving Images

We have used a video 8 camcorder to shoot some original video for our design examples. The video 8 format has good quality (as good as VHS) and is very easy to use. The cameras work well in low light conditions and the sound quality is very high. You can also use a VHS camcorder or a 3/4-inch U-matic portable camera and deck for recording.

Otherwise, we use existing film footage in our projects. This film has to be transferred to videotape to be used on a videodisc. We do all of our film-to-video transfers at local video production facilities on high-cost/high-quality transfer systems. The quality of this transfer makes quite a difference to the character of the individual still frames that are critical to our activities. Because of the difference between film and video synchronizing, care must be taken during the transfer to reduce frame flutter. The video is then put on our own in-house write-once disc.

Audio

A Sony Pro Walkman with Dolby provides a way to get clean, noise-free recordings in the field. Good-quality home audio equipment is also useful for adding audio to design example productions.

Editing

The video images can be recorded directly onto the write-once videodisc from videotape or the still image systems. If you add images that turn out not to be useful, you can skip over them with your program. However, it is sometimes useful to edit individual sequences or images onto a videotape first using a video-editing system. An edited videotape is also needed to create the out-of-house LaserVision-compatible write-once videodisc. It is also helpful to have videotape players of the different formats to play back and log videotapes that you might want to use as source material.

We use a standard 3/4-inch U-matic editing system to make most of our videotapes. This system can perform good quality editing and you can transfer video from other sources to 3/4-inch for editing purposes. These editors are often available at audio/video centers. We have also used a video 8 editor, which is much more compact and inexpensive. This is especially useful for editing videotapes we have shot with our video 8 camcorder. For VHS, we use a Panasonic recorder that has some edit features as well.

We use both Microsoft Excel (spreadsheet program) and 4th Dimension (database program) in the lab to keep track of the different images and sounds.

Image and Sound Digitization

We digitize pictures, video images, and sounds into the computer memory to include with the HyperCard software on the Macintosh. The Apple Scanner with HyperScan™ software lets us scan photographs, drawings, and graphics directly into HyperCard. The software allows the size, orientation, and gray scale of the images to be changed. These scanned images can then be modified using the painting tools provided with HyperCard or other software.

Pixelogic's ProViz Video Scanner allows us to digitize frames from a videotape, video camera, or Sony ProMavica Still Image System. Koala's MacVision can be used to digitize images from a video camera as well. Since the images produced by the ProViz are in a TIFF (Tagged Image) format (8 bits, 256 gray levels) that can be displayed on a Macintosh II but not a Macintosh SE, we convert the images to a PICT format (1 bit, black and white) using Letraset's ImageStudio if we are using a Macintosh SE. ImageStudio also allows for resizing the images after they have been digitized.

MacroMind's VideoWorksII running with the VideoWorks HyperCard driver is used to overlay the TIFF images onto a HyperCard screen for the Macintosh II. It can also be used to create color animations. The PICT files can be placed directly into HyperCard as paint images.

We digitize sounds using Farallon Computing's MacRecorder digitizer and SoundEdit software. These sounds can then be accessed by HyperCard.

Computer Systems

Most of our design examples are created to operate on a Macintosh SE or Macintosh Plus connected to a videodisc player. A few have been designed for a Macintosh II where higher image resolution or computer graphics overlay onto video is needed.

HyperCard is used as both the control and display basis for the multimedia system. Because of its extreme flexibility, HyperCard can support many kinds of educational projects. The HyperCard screens ("cards") can be used to present text, drawings, animations, images, and sounds. Links between text, images, and sounds can be created easily. The cards can control the videodisc segments and provide access to individual images and sounds on the disc. (See the description of HyperCard videodisc drivers in the following section.) Further information about HyperCard can be found in the manual that comes with it, and in various books that have been written about it.

We have found HyperCard to be extremely useful for the production of multimedia design examples and products. It speeds up the design process significantly and it is quite easy to learn, opening up the design activity to people who are not necessarily skilled in computer programming.

Videodisc Recorders/Players

There are a number of different computer-controllable, LaserVision-compatible, constant angular velocity (CAV) videodisc players made by manufacturers such as Pioneer, Sony, and Hitachi. We use primarily the Pioneer LD-V4200 in our lab. The player is connected by a serial interface cable to the modem port of the Macintosh.

It is necessary to add videodisc player drivers to the HyperCard software that is packaged with the Macintosh by Apple. These drivers are placed in the HyperCard home card and let you create "buttons" and "scripts" that access the videodisc player frames and operations from HyperCard. A HyperCard videodisc driver set is available from the Apple Programmers and Developers Association (APDA™). HyperCard Videodisc Toolkit v2.0 provides videodisc player drivers for many of the standard videodisc players. Along with the HyperCard XCMD drivers, the toolkit includes a very good discussion of how to talk to a videodisc player from HyperCard. There are also instructions on using a serial driver to create a script to talk to a videodisc player that is not supported. And the manual provides the names and addresses of many videodisc production, software, and hardware resources.

In-House Videodisc Production

In-House Write-Once Videodisc Recorders

We use a Panasonic write-once optical disc recorder/player to do in-house development work. This machine records video and audio onto a special write-once videodisc (which is not compatible with the LaserVision format). This disk must be played using either the Panasonic write-once recorder/player or a Panasonic write-once player. The recorder/player can be computer-controlled just like a standard videodisc player using a special set of HyperCard videodisc drivers that are available in the HyperCard Developer's Toolkit v1.0 from APDA. You can also write your own driver using HyperTalk™ and the HyperCard Serial Toolkit (available from APDA.).

The write-once videodiscs themselves cost about $150 each. These write-once videodiscs hold 24,000 frames, or about 13.3 minutes of video. The player will play only these write-once discs—not any other kinds. While the recorder/player will also play back, it is sometimes useful to have an additional player so that more than one person can design projects at a time.

Quick Videodiscs

Single-copy LaserVision-compatible write-once videodiscs are available from Crawford Communications in Atlanta, Georgia. These discs hold one half hour of video in the CAV mode (computer controlled) and can be played in any standard videodisc player. They are much less expensive than replicated discs when making a few copies. Single copies made on plastic—as opposed to glass—cost about $300. Usually you can get your disc back in 24 hours. For many applications, especially when only a few copies are needed, these discs prove to be more than adequate. These discs can be processed with two sides for approximately twice the cost.

To have a write-once disc cut, you need to send Crawford a videotape containing the video information in the exact order and manner that you want it on the disc. Crawford works from a time-coded professional videotape (1-inch or D1). The company will accept any kind of videotape source, but if you send a video 8 tape, a VHS tape, or an uncoded 3/4-inch U-matic tape, there will be an additional charge (about $200) for producing the time-coded professional-quality tape they need to cut the disc.

Replicated Videodiscs

Replicated videodiscs are made by creating a master that can be used to press as many disc copies as you want—much the way records are made. As with the quick videodiscs, these discs are made from a videotape that you send to the disc-pressing facility. These discs take about two weeks to produce and will cost about $2,000 for the master and $10 to $20 per disc copy in small volumes; the cost per copy drops as volume increases. The discs can be processed with one or two sides.

Two companies that we have used to press our replicated discs are Pioneer of America and 3M Optical Recording Department.

Basic Equipment for a Multimedia Prototyping Lab

The equipment we use in our lab cost a total of about $60,000 to $70,000. However, a basic prototype multimedia lab can be set up for about $25,000 to $30,000, especially if access is available occasionally (by rental or at a local audio/visual center) to other video production equipment such as videotape editors and videotape recorders.

The list that follows mentions the equipment that we have found useful for producing our design examples. Because of the rapid changes in technology and pricing, it is always dangerous to list specific model numbers and prices. We do it here anyway, in order to provide the specifics you need if you are planning to set up such a lab (which we hope you are).

The prices are list prices from manufacturers, or retail prices, as of September 1988; they should be used only as a guide. There may be educational and other discounts available in some cases. For many pieces of equipment, there may be alternatives from other manufacturers that can do the job just as well or maybe even better. Also, we rent some of the equipment that we need for only a few days. We have not tried to be exhaustive, but rather have indicated the kind of equipment that is needed to set up a basic studio.

A listing here does not imply endorsement of a company's products or services by Apple Computer. Prices are given for reference only.

Equipment List

Video and Audio Production

Still Images

35mm SLR amera	$ 400	(approx.)
Desktop lightbox	$ 50	
Camera copystand	$ 250	
35mm slide-to-video transfer system		
Tamron Fotovix	$3,000	
Tamron Industries Inc.		
P.O. Box 388		
Port Washington, NY 11050		
(516) 484-8880		
Still video image system		
Sony ProMavica System		
Camera		
MVCA7AF	$4,000	
Edit/recorder/players		
MVR-5500	$3,800	
MVR-A770 (portable) (optional)	$3,000	
16mm film camera—Bolex w/lens, timelapse		
	$ 100	(approx. rent per day)

Slide Transfer Services

Stokes Slide Service
P.O. Box 14277
Austin, TX 78761
(512) 458-2201

Image PreMastering
1781 Prior Ave., N
St. Paul, MN 55113
(612) 644-7802

Moving Images

Video 8—8mm videotape		
Sony Handicam CCD-V9	$1,600	
VHS—1/2-inch camcorder	$1,500	
3/4-inch portable camera and deck	$ 350	(approx. rent per day)
Film camera—16mm multispeed, w/o sound	$ 150	(approx. rent per day)

(Note: Film is transferred to 3/4-inch video for editing)

Audio

Audio cassette recorder		
Sony Walkman Pro WMD6C	$ 370	

Editing

Video

3/4-inch U-matic		
Sony 3/4-inch U-matic editing system		
VO-5800 player	$5,500	
VO-5850 recorder	$8,500	
RM-440 editor	$2,200	
Sony 3/4-inch U-matic recorder		
VO-5600	$4,000	
VHS		
Panasonic Proline AG-1830	$1,900	
Mitsubishi (stereo 4-head)	$ 600	
Video 8		
Sony EVO-720 editor system	$4,900	
Timebase corrector (optional)		
FOR.A FA200	$4,000	

Software

Microsoft Excel	$ 395	
4th Dimension	$ 695	

Digitizing:

Print Digitizer

Apple Scanner w/o cable (HyperScan software incl.)	$1,799
Caere—OmniPage optical character reader	$ 795

Video Digitizer

Pixelogic—ProViz Video Scanner (includes software)	
Black and white	$1,100
Color	$1,700
Koala—MacVision	$ 349

Audio Digitizer

Farallon—MacRecorder (with software)	$ 199

Image Software

MacroMind	
VideoWorks II	$ 295
VideoWorks HyperCard Driver	$ 100
Letraset—ImageStudio	$ 495
Authorware—Course of Action (education discount available)	$ 695

Computer Systems

(Apple Computer retail prices as of 9/16/88; educational discounts available)

Computers

Macintosh Plus	$1,799
Macintosh SE w/20-megabyte hard disk and keyboard	$3,898
Macintosh II	
1-megabyte RAM, 40-megabyte hard disk	$6,169
w/ video card	$ 648
color monitor	$ 999
extended keyboard	$ 229

Peripherals

Apple External Hard Disks (SCSI)	
20-megabyte (20SC) w/cable	$1,099
40-megabyte (40SC) w/cable	$1,699
CD-ROM player	
AppleCD SC™	$1,199
Apple Printer	
LaserWriter® IINT	$4,999

Display System

Video-out board for the Macintosh SE	
Mentauris CVA 407 Main Street P.O. Box 567 Martindale, TX 78655 (512) 357-2182	$ 100
Large-screen monitor for the Macintosh SE	
Electrohome EVM2319P4AGFSW	$1,000
Powered speakers (for Macintosh)	
Acoustic Research PowerPartners (with built-in amplifiers)	$ 300 /pair

Software

HyperCard	(included with Macintosh)
HyperCard Videodisc Toolkit 2.0	$ 16
HyperCard Developer's Toolkit 1.0	$ 10

Both toolkits available from:
Apple Programmers and Developers Association (APDA)
Apple Computer, Inc.
29525 Mariani Avenue, M/S 33-G
Cupertino, CA 95014
800-282-2732

Videodisc Recorders/Players

Videodisc Player Systems

Pioneer LaserVision players:	
LD-V4200	$ 1,100
RU-V101 remote control	$ 100
Pioneer-to-Macintosh cable	$ 20
Sony video monitors	
PVM 1380	$ 480
KV 2511CR (large-screen) w/speakers	$ 1,200

Write-Once Videodisc System

Panasonic:	
Recorder/player (TQ 2026F)	$12,500
Player (TQ 2027F)	$ 4,000
Optical disc (TQFH224)	$ 150 each

Quick Videodisc Service

Crawford Communications
506 Plasters Avenue
Atlanta, GA 30324
(404) 876-8722

Plastic	$ 300 per side
Glass	$ 500 per side
Consumer videotape preparation (for VHS, video 8 or 3/4-inch)	$ 200

Replicated Videodisc Service

Pioneer Communications
1058 East 230th Street
Carson, CA 90745
(213) 513-1016

3M Optical Recording
223-5S 3M Center
St. Paul, MN 55144
(612) 733-2142

Master preparation	$2,000 per side
Replicated discs (small quantities)	$ 20 (approx.)
(additional charges for test discs and special procedures)	

Summary

Having the capacity to quickly and quite cheaply mock-up interactive multimedia projects has greatly enhanced our design capabilities. It also lets us enter large-scale productions with some confidence. We hope the sort of lab we've described here can be useful to you as well. Perhaps such setups will even begin to be commonplace, as technological advances make them less cumbersome and more affordable.

For more information on videodisc production, we encourage you to look at the publication that comes with the HyperCard Videodisc Toolkit v2.0 from APDA. We have also written two companion reports on videodisc production which might be helpful: *Videodisc Basics* by Michael Naimark, provides an introduction to the concepts of video and videodisc production; *Videodisc Production of the "Visual Almanac"* provides a case study of the production of a recent project at the Multimedia Lab that utilized a number of different techniques and source materials.

Videodisc Basics

Michael Naimark
Apple Multimedia Lab
November 1988

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Abstract

Videodisc production can be as expensive as any other motion picture project, but it often can be reasonably priced, with little sacrifice of visual quality. (It can even be downright cheap if you're willing to live with some compromises.)

Determining what is appropriate for your videodisc-production needs can be difficult. Though there are many books and articles describing how to make videodiscs (and many are very good), they often imply that there is only one right way of doing things. Professionals may try to convince you that you need $600-per-day video cameras, or 35mm motion picture film production, or stillframe-to-video transfers at $2 per image. You may, but then again, you may not.

The purpose of this paper is to provide an overview of the sort of video knowledge that is helpful for determining what is important to you for your videodisc production. Though it may be technical, it is not written for engineers, but for "the rest of you," Macintosh users.

Video

Video, like audio, consists of signals that pass through cables. It is more or less standardized, such that the "video in" of one machine is compatible with the "video out" of another. The North American and Japanese video standard is called NTSC. It is an analog composite signal consisting of 30 frames per second (fps) and 525 lines per frame. PAL, the standard for much of Europe, and SECAM, the one for France and the Soviet Union, are also analog composite signals, but with 25 fps and 625 lines per frame.

Digital versus Analog

The standard NTSC video signal is analog. This makes it difficult to manipulate on a pixel-by-pixel basis. Also, analog video suffers a cumulative loss of quality when copied over multiple generations.

Digital video requires more bandwidth than analog video to produce the same results, unless fancy compression techniques are used. Analog video can be converted into digital video. In accordance with "CCIR 601," the international digital video standard for sampling, the conversion suffers virtually no loss.

Historically, analog video has been cheaper and has used bandwidth more efficiently than digital video. As digital memory capacity and processing speeds become more accessible, this trend will reverse.

Composite versus Component

The NTSC video signal is a *composite* signal, which means the color information is encoded into the overall signal. When the color components are kept as separate signals, the video is called a *component* signal.

Because component video is not encoded, the color quality is noticeably better than that of composite video, particularly when compared with low-end NTSC encoded video. But component video requires three separate signals (one for each component, for example, red, green, and blue), so routing it from one machine to another is more expensive.

Frames and Fields

NTSC video plays at 30 frames per second, and each video frame consists of two half-frames called *fields*. A field consists of every other horizontal line. When the video image is created on a TV set, the little scanning dot of light first scans across the topmost horizontal line, line 1. Rather than scanning along line 2 next, it scans line 3, then line 5, and so on. When it gets to the bottom (in half of the 1/30-second frame time), it begins at the top again but on line 2, then line 4, amd so on. This technique is called *interlace*, and it was invented because most people see a flickering image if television is scanned sequentially at 30 fps. The two fields making up each frame are called the odd and even fields, appropriately.

In many respects, a video signal is best conceptualized as 60 separate images per second. When video is recorded from a video camera, each field represents an independent sample of time. When video-originated material on a videodisc is stillframed, one may see *flutter:* two different images shot 1/60 of a second apart from each other on the same screen.

Timecode

When video is being recorded, frame accuracy is often necessary. It is achieved through *timecode*, a method of coding a unique number on each and every frame. This coding is standardized by the Society of Motion Picture and Television Engineers, and is called the SMPTE (pronounced "simptee") standard. Timecode consists of four numbers representing hours, minutes, seconds, and frames: for example,

23:59:59:29

Since video actually runs at 29.97 fps rather than 30 fps, two kinds of timecode have evolved: drop-frame and non-drop-frame. Drop-frame timecode literally drops certain agreed-upon numbers to compensate for the .03 fps discrepancy. Drop-frame timecode allows a 30:00:00:00 tape to really be 30 minutes long, and is therefore often preferred by the broadcasting industry. For videodisc applications, it tends to do nothing but create problems, and non-drop-frame timecode is preferred.

Most of the low-end videotape formats, like VHS, do not have timecode. They can count frame pulses on the tape, but are not frame-accurate. Recently, both VHS and video 8 systems have been introduced with their own forms of timecode. (If the suppliers find a market for frame-accurate applications, we can expect further such innovations.)

Recording

Any image, still or moving, can be converted into a video signal, most often through a video camera. Then the video signal can be recorded. By far the most common method of recording video is on videotape.

Videotape

Videotape recording is electronic, which makes it fundamentally different from its non-identical twin, film. Unlike film, it is not possible to record over an existing video image to create a double exposure. Recording over existing videotape always erases it.

Formats

A curious fact about videotape formats is that they range in price from $200 for a bargain-basement VHS deck to over $200,000 for a digital component deck. Nevertheless, both produce the same 525-line, 30-frame-per-second image. The differences lie both in visual quality and in control.

1-inch"Type C." By far the most common professional-quality videotape format is the 1-inch "type C" format. It is an analog composite format, but of a sufficiently high bandwidth to produce top-quality images, even though its color information is encoded. Most experts agree that 1-inch tape recording can easily stand four or five generations without any noticeable loss of image quality. Since it is a professional format, 1-inch tape always has timecode.

Simple 1-inch–to–1-inch editing costs about $250 per hour. A more common configuration is called A-B editing, where two source decks are used simultaneously either for mixing two sources to achieve various effects or simply to save time changing source reels. A-B editing costs around $300-$400 per hour.

Component Beta. The second most common professional format today is component beta (the newest improved form is called beta "SP"), an analog component format. Component beta uses Betamax-style videocassettes that run at faster speeds than consumer beta to achieve higher picture quality. It was originally developed as the first "camcorder," the Betacam, for electronic news gathering (ENG) applications, and until recently was limited to a 20-minute tape capacity.

Though component beta decks are smaller and less expensive than 1-inch decks, the cabling needed to connect them to switchers and other decks is three times more complicated and expensive (since one cable is required for each color component).

Because component beta keeps the color information separate, the overall picture quality is superb. However, it suffers more image quality loss through multiple-generation copying than does 1-inch videotape. Consequently, many videographers prefer to shoot with the compact Betacam and edit directly from beta to 1-inch tape. This is called *interformat editing*. Like 1-inch format, component beta always has timecode capability.

For shooting, Betacam cameras rent for $300 to $600 per day. Betacam editing is less expensive than 1-inch editing, beginning at around $150 per hour.

3/4-inch video. Almost 15 years old now, the 3/4-inch "U-matic" format was the first videotape in a cassette. It is classed as an "industrial" (rather than "professional") format and has been the workhorse medium used by corporations and institutions. Like the 1-inch format, it is analog composite, but with an inferior method of color encoding. Though timecode is not required in the 3/4-inch format, it is available as an option.

Like component beta, the newest version of 3/4-inch video is called 3/4-inch "SP," and it is a marked improvement over standard 3/4-inch video.

For shooting, 3/4-inch portable decks and camera rent for $100 to $300 per day.

VHS and Video 8. VHS and video 8 are analog composite consumer formats. Their picture quality and color reproduction are not intended to compete with professional and industrial formats. Video 8 is the newer and smaller format, and its quality appears to be at least as good as VHS. Both are highly accessible media, and many videodiscs have been produced in these formats.

Standard VHS and video 8 do not have timecode, making it nearly impossible to make frame-accurate edits to them. These formats are often transferred ("bumped up") to 3/4-inch or 1-inch tape to give them the frame-accurate control often required for videodisc editing.

A new component form of VHS, S-VHS, produces a remarkably good picture. Some experts say it can be intercut with 1-inch or Betacam images, with the difference barely noticeable. Editing systems for S-VHS that use a new form of timecode have been introduced recently. More such systems can be expected.

Similarly, a new line of video 8 decks and editors that have timecode and are capable of single-frame edits has been introduced. And not surprisingly, we can expect a higher-quality version of video 8 similar to S-VHS.

D1 and D2. D1 and D2 are two significant, relatively new videotape formats. Both are digital and can withstand multiple-generation editing with absolutely no loss of quality. D1 is component, and is considered the highest-quality 525-line format available today. D2 is composite. D2 decks are significantly less expensive than D1 decks and it is predicted that they will replace 1-inch decks over the next few years.

Sync and Pre-Roll

In order for any mixing or editing of video signals to occur, all source and record decks must be in sync with each other, running at exactly the same speed and in identical phase. (You can picture the process as being similar to transferring goods between trains running alongside each other.) In editing facilities, all decks are fed a common sync signal, called "house sync."

Almost all videotape decks need a running start to get up to speed; this is called *pre-roll,* and varies between machines from about 3 to 10 seconds. This means that for every edit, source and record decks must first stop, count backward the exact number of frames required for pre-roll, begin playing simultaneously, then at the precise edit point begin recording. It is a mechanical and electronic marvel that video editing can be frame-accurate at all.

Consider massive stillframe editing, where thousands of single frames need to be edited accurately. With pre-roll, such editing is time consuming and therefore expensive—and with all of the tape shuffling required, it's potentially risky.

There are two preferred methods for minimizing pre-roll problems, and experts don't agree on which one is better. One method uses Ampex VPR-3 1-inch decks, which can edit with only three seconds of pre-roll. The VPR-3 is considered the most reliable 1-inch deck, but there is always a chance of failure when performing thousands of edits non-stop.

The other method is to use the only 1-inch deck capable of recording without pre-roll: the Sony BVH-2500, built for massive stillframe editing (presumably for video animation and videodiscs). Though it is significantly faster than the VPR-3, it suffers a slight loss in overall picture quality. The difference is very slight, but enough to create a controversy.

Dynamic Tracking

Videotape decks can freeze-frame, sort of. Until recently, when a videotape deck paused to create a still image, it was actually reading only an individual field, and repeating it to create a full frame. For years, when we said "freeze-frame", we meant "freeze-field."

This was because individual fields, as recorded on videotape, comprise only half of the horizontal lines in a frame. The tape head scans helically to read fields, but only one at a time, since precise coordination is required between the tape's lateral movement and the tape head's spinning movement.

A new generation of video heads can "bend" back and forth enough to find an adjacent track and follow it. This is called *dynamic tracking* (sometimes "delta heads") and for the first time allows true freeze-frame rather than only freeze-field display. It also allows for variable speed playback, including playing in reverse, which otherwise is not possible.

Timebase Correctors

Since synchronization between videotape decks is so important, it is imperative that all decks perform at precisely the same speed. Speeds always vary, at least slightly, due to VCR velocity errors and tape strech. A timebase corrector, or TBC, is a video processor that stores part or all of an incoming video frame and stretches or compresses it to its proper duration for output. Since TBCs require enough fast memory to perform this function in real time, they are not cheap: professional-quality TBCs cost in the tens of thousands of dollars. Newer TBCs for industrial use are now down to $4,000.

TBCs are essential for any kind of multiple mixing of input from videotape source decks, including wipes, dissolves, and overlays. Each source deck must have its own TBC, and each must be synchronized to "house sync."

TBCs are also used simply to "clean up" the timing of a recorded video signal. These TBCs act like black boxes, taking in unstable video and putting out stable video. Because they work alone, without house sync, they are often called standalone TBCs.

Digital Disk Recorders (Abekas and Harry)

Digital disk recorders are like videotape recorders with large digital disk memories instead of tape; they can typically hold 1,500 to 3,000 frames at a time, and can record and play back in single frame steps (with no pre-roll, since there is no tape involved), at

variable speeds or at 30 fps. Digital disk recorders are available as both component and composite machines; the component versions are higher quality and more expensive.

Digital disk recorders usually have two memory disks to allow internal recording and playback. They can mix an incoming video signal with a stored one and record the net result simultaneously. Since everything is digital, this mix can be performed repeatedly, producing layer upon layer of moving images.

The most well known digital disk recorders are the Abekas A-62 (a composite machine), the Abekas A-60 and A-64 (both component machines), and the Quantel Harry (also a component machine). They are fairly expensive to rent, ranging from $250 per hour for the A-62 to $500 per hour for the Harry.

Though the Abekas and Harry are similar hardware, they are designed somewhat differently. The Harry has a rich visual interface, showing the operator many "clips" on a single screen; the Abekas is a more programmable machine, if one is interested in "hacking."

Another difference is that Harry recorders are often built into dedicated suites in video-production facilities, while Abekas recorders are integrated into the normal edit suites. The Harry is usually used as a standalone or in conjunction with its "sister" machines: the Encore (an ADO-like device) and the Paintbox, both described below.

Film

Film is a wonderful medium. While videotape is simple in structure but requires complex machines for recording, film is complex in structure but requires simple recording machines. Film cameras are simple and elegant machines, and the camera itself is the recorder (or perhaps more precisely, the film itself is the recorder).

Motion Picture Film

Motion picture film can be recorded at any frame rate, if the camera allows. There are no technical requirements for a particular frame rate as there are with video, other than conventions such as sync sound. Each film frame is simply exposed to light, then advanced. Many film cameras have variable-frame-rate capabilities, and some have automatic aperture compensation, allowing a continuous change of frame rate with a constant exposure—a concept totally foreign to video.

16mm and 35mm. 35mm film has four times the surface area of 16mm film, and therefore four times the resolution. Comparing film to video is complicated because they have different visual characteristics, but most experts agree that 16mm film is noticeably inferior to 35mm when transferred to video. There is also general agreement that 35mm film is superior to 525-line video, particularly when viewed theatrically.

Both 16mm and 35mm film cameras can record at various frame rates, and some cameras can stop-frame record, performing very much like a still camera with an immense film capacity. Stop-frame recording can be clock-driven (timelapse), distance-driven (moviemaps, using a fifth wheel to trigger the camera), or event-driven.

Stop-Frame Cameras. The Bolex is the most popular 16mm camera with these capabilities. It is small, lightweight, and can even be operated with no batteries using its wind-up capability. It costs about $5,000 and can be rented for under $60 per day.

To obtain the same features in a 35mm camera is more difficult and costly. There are two variable-speed and stillframe motors that fit on popular Arriflex and Mitchell cameras: one by Fries Engineering, the other by Norris Film Products (both in Los Angeles). A complete 35mm system of this type costs $40,000 to $50,000 and rents for about $300 per day, which is still cheaper than a video Betacam.

But film is more expensive than videotape, especially since videotape can be reused. At 24-fps recording, 16mm film stock, processing, and transfer to video costs about $40 per minute; 35mm about $115 per minute. Though this sounds expensive, it comes out to $.03 per frame for 16mm and $.08 per frame for 35mm film, which is very reasonable when shooting small quantities over long periods.

Still Picture Film

Still picture film and cameras are often an appropriate way to shoot for video transfer, particularly if little or no motion is needed. Motor drives or simply fast manual triggering can achieve rudimentary motion in as little as two frames. Videodiscs are an ideal medium for exploiting such an effect.

Since the 35mm film format for still cameras is so established as the standard, even for easy-to-use cameras it is an ideal production medium for videodiscs since the resolution is more than enough for video.

Transferring Film to Video

Because film has a greater dynamic range than video, that is, it can record a greater range from light to dark, there are certain advantages to shooting in film and transferring to video. This is part of what is called "the film look." Film transferred to video can often show detail (shadow detail, for example) that video cameras couldn't capture at all.

The following techniques are arranged in chronological order of development—which is also in order of quality and cost. They apply both to still and motion picture film.

Projection. The oldest, cheapest, and lowest-quality method of transferring film to video is by projecting the film image onto a screen and shooting it with a video camera. Its principal advantage is that it requires no special equipment.

Telecine. A telecine consists of a projector without the lens; a video camera is aimed directly at the illuminated film to record it. Since it has only one set of optics instead of two, this is a more direct method than projection and the result is a higher-quality transfer. A telecine requires a special light source (far less than required for projection) and a precision mount between the camera and the film shuttle.

Ranks and Boschs. The newest and highest-quality method for film-to-video transfer involves no lenses at all, but only a dot of light on one side of the film and a light sensor on the other side. There are two state-of-the-art scanners of this type, one made by Rank and the other by Bosch. The Rank uses a small picture tube as the source of the dot of light. This is called a flying-spot scanner. The Bosch uses a one-dimensional CCD array.

Both the Rank and the Bosch produce excellent results. Some experts believe the Bosch produces cleaner transfers, since there is no high voltage near the film as there is for the Rank's picture tube, which attracts dust. Even the tiniest specks are more likely to be noticed on a medium like videodiscs where the user may scrutinize every frame. Some Ranks have been modified to add an air jet near the picture tube to keep the film clean. Other experts believe the Rank has less of a "stairstepping" look caused by the CCD array on the Bosch. The Rank has the advantage of changing the scanning size electronically, allowing control over the size and position of the film area being scanned.

Both machines have highly developed methods of color correction, allowing very selective work. For example, a single shade of color in a particlular area of the picture can be changed without affecting anything else. Both machines cost about $350 per hour of actual use, which can add up to a lot if extensive color correction is being done.

Transferring Motion Pictures. If all motion pictures were shot at 30 fps, transferring them to video would be simple: there would be a one-to-one correspondence between film frame and video frame. But they are not: film usually runs at 24 fps and video at 30 fps (the world *is* perfect in Europe, where film and video both run at 25 fps). The present technique for transferring 24-fps film to 30-fps video is called *3-2 pulldown.*

During the film-to-videotape transfer process, every fourth video field is repeated. Or, to put it another way, the first frame of film is transferred to the first *two* fields of video, the next frame of film is transferred to the next *three* fields of video, and so on: 3-2-3-2. The fact that every other film frame is displayed 50 percent longer than the others slips right past our eyes and we rarely notice.

Before digital memory was available for repeating every fourth field, the common technique incorporated a five-bladed shutter in the film projector or telecine, splitting the film into 1/120 second flashes and resulting in two exposures of film for each video field. Since these would not necessarily be of the same film frame, the video fields would often have two different images superimposed.

Of course, it is still possible to transfer motion picture film at 30 fps and have a one-to-one correspondence between film and video frames. Both the Bosch and the Rank machines can do 30-fps transfers (appropriately called 2-2 pulldown). This is invaluable for motion picture footage where 24-fps playback isn't important (for example, stillframes on film, timelapse, and film specifically shot at 30 fps for video transfer).

Transferring Still Pictures. Transferring still images frame by frame onto videotape is a task unique to videodisc production. Since videodiscs can stillframe on any of the 54,000 frames on each side and hold it indefinitely, the goal is to somehow put each still image down on only one frame of videotape.

Consider what the result looks like when this is viewed as regular video. Regular video plays at 30 frames per second, which is why we see motion. But when each frame is a totally different image, the result is a lightning-fast montage. Such an effect is not normal in the world of motion picture and television production (let alone the real world), so even seasoned experts will disagree on what is the best method of stillframe transfer to video.

The cheapest method is to aim a video camera at a front-projected image from a slide projector or at an evenly illuminated print. A better method is to use a telecine or a video camera in a computer-controlled copystand, such as the one made by Interactive Motion Control (IMC), with controlled lighting and a special close-up lens on the camera. These often cost about $200 per hour. Best and most expensive is to use the Bosch or Rank machines (at $300 per hour), both of which handle slides as well as motion picture film.

There is at least one special-purpose device made for transferring slides to video inexpensively and with reasonably good results: the Fotovix from Tamron. It is about the size of a toaster and costs about $3,000. Slides are loaded manually, and the Fotovix has controls for color, position, rotation, and zoom, with a commendable degree of control. The quality is better than shooting off a screen and is as good as a medium-grade telecine.

Direct video methods of stillframe capture still require actual recording onto videotape, with or without pre-roll, or onto a digital disk recorder. If a digital disc recorder is used, it is as a reliable intermediary for dumping off to tape later. Since it is digital, there is no generation loss.

Another method for stillframe recording is to use motion picture film, typically 35mm, as an intermediate medium. The big advantage of this is that the film can be transferred to video on a Bosch or Rank at 30 fps, so even while these machines cost $300 per hour, tens of thousands of frames can be transferred in an hour if they do not require individual color correction. The disadvantage is that the additional film generation will be apparent, slightly. Also, since slight variations in exposure will be amplified during the transfer process, additional correction may be necessary.

Slides can be transferred to 35mm motion picture film at a number of facilities that specialize in such things, like Stokes Slide Service in Austin, Texas, and Image PreMastering in St. Paul, Minnesota. For "straight" transfers, they charge about $.75 per slide (which does not include the film-to-video transfer rate).

Similarly, hard copy can be photographed onto slide film using a copystand in-house or at a local photographer's, and the slides can then be transferred directly to video or to motion picture film.

Slides and hard copy can be transferred to 16mm film for very little money, by using a camera such as a Bolex on a real or makeshift optical printer and copystand. Though the result is inferior to 35mm film, such a 16mm system can be used in-house. All of the film costs total only $.03 per frame.

Videodiscs

"Videodisc" has come to refer to all video media that are disc-shaped, regardless of whether they are optical or magnetic, digital or analog.

Laserdiscs

Eight-inch and twelve-inch laserdiscs are analog composite read-only media, recorded once in a special production facility, and not erasable. Constant angular velocity (CAV) discs hold one half hour per side, and each of the 54,000 frames is internally coded and accessible. Constant linear velocity (CLV) discs hold a full hour per side but the frames are not individually coded or accessible. Both CAV and CLV discs have a visual quality similar to professional-quality videotape, noticeably better than 3/4-inch, VHS, and video 8 formats.

CD-size laserdiscs have a variety of competing formats, including CD-I (digital but not full motion), CDV (analog with motion but short play), ICVD (analog with motion and longer play), and DVI (digital with full motion, but requiring slow and expensive preprocessing of the material). Generally, the trade-offs involve visual quality versus duration.

Write-Once Videodiscs

There are presently two popular write-once videodisc systems on the market, one by Teac and the other by Panasonic. Both are analog composite systems. Both allow still and moving image recording on noncompatible laser videodiscs. The Teac holds 54,000 frames, while the Panasonic holds 24,000 frames; both machines are controllable by an external computer.

Both companies make separate recorders, which cost about $15,000 to $18,000, and players, at about $3,000 - $5,000. The nonerasable videodiscs cost about $150. The image quality for both machines is not professional quality, but closer to 3/4-inch industrial quality. These systems are popular for mocking-up interactive programs.

Electronic Still Cameras

Electronic still cameras, like the Sony Mavica, deserve mention. These are cameras that look like something in-between a still and a video camera, and record on a two-inch disk that holds 25 frames or 50 fields (or 10 seconds of voice-quality audio). The disks are erasable and reusable. The encoding is analog component, like component beta, but with less bandwidth (and therefore a noticeably lower-quality image).

Electronic still photography has been used for "electronic journalism," where images are shot in the field and sent by portable modem from any available phone. Sony and other companies have also developed color printers of relatively high quality.

It's not clear at this time what sort of fate this format will have, but if the cameras become cheaper, smaller, and better, they may replace still picture film cameras for many applications.

Editing and Effects

Once the material is recorded on videotape, these tapes become source reels for recording onto an edit master videotape. Recording from the source tapes to the master tape is where the frame arrangement and special effects takes place.

Editing

Editing is the process of selecting the frames and arranging them on the edit master videotape. Particularly for videodiscs, this process may involve thousands of single-frame edits and must be frame accurate.

Offline

Since the actual edit session in a professional video facility is very expensive (usually at least $200 per hour for basic editing and around $700 per hour for complex effects), it is always best to make all editing decisions in advance. This is called offlining.

Window Dubs. The trick to offlining is to always have access to the timecode for all of the source material. If the source medium is of professional quality, like 1-inch tape, then viewing the material is expensive and complex. But it is also unnecessary: the material can be transferred to a more accessible medium, like 3/4"-inch or VHS tape, with the

timecode "burned in" on the picture, usually near the bottom. This is called a *window dub*. Each video frame is marked permanently with the exact timecode number. The advantage this offers is the ability to see the timecode on any VCR without a timecode reader. Even though the "window" with the timecode numbers obscures a part of the image, it assures frame accuracy. Window dubs are made for offlining, not for presentation. They are the video equivalent of workprints in film.

Edit Decision Lists (EDLs). The Edit Decision List, or EDL, is the data controlling the editing computer during an online session. It lists "in-points" and "out-points" for both the source playback decks and the record deck. These "events" can be for video, for audio, or for both. The EDL may control all sources, various effects machines (for fades and dissolves, for example), and the record deck.

Online

The online session is where the actual editing and effects take place. It occurs in an edit suite with a professional editor. Again, the more prepared you are, the better. It is common to budget an additional 50 percent time and cost over realistic expectations since "things happen." It is *very* easy to go way over your estimate.

CMX. The CMX is the most commonly used editing computer. The EDL is loaded into it and it executes the edits and effects by controlling all of the required video machines (actually, it may not control *all* of them; certain operations may need to be done manually). Most editing computers, including ones made by CMX, Sony, Ampex, and others, use the same standard editing language.

Auto-Assemble. If all of the editing decisions are made offline, and the EDL is loaded into the CMX (done manually, most often, but PC- and Macintosh-based programs now exist), the actual editing is automatic, executing one event after another. This is called *auto-assemble* mode. During auto-assembly, the editor monitors video and audio levels, but does not need to control each edit.

Effects

Effects involve any manipulation or processing of the video or audio signal. Though they are often used as gratuitous "gimmickry for gimmickry's sake," they can also be used for valid functional and aesthetic design purposes. Video effects seem to change annually, and are heavily technology-driven. Since they sometimes cannot be simulated in an offline environment, the best way to prepare to use them is to first get demos (free) from various video facilities.

The Switcher

The switcher, often called the video effects board (and earlier called the "special effects generator" or SEG), is the central router and mixer of video source material. Switchers are generally analog devices, and are capable of performing analog effects as well as switching incoming channels. These effects include fades and dissolves, wipes and borders, and keys (opaque overlays based on replacing black or a particular color).

Switchers come with the basic editing suite and are almost always included free with the base rate.

The Audio Effects Board

The audio effects board is like the switcher, and acts as the main router and mixer for source audio. Here audio levels are adjusted, mixed, and filtered. Usually audio effects are kept to a basic level in a video editing session. More complex audio work is usually performed in audio recording studios.

Charactor Generator

A character generator is used for titles and credits. It is a high-end word processor for video with a wide variety of fonts and sizes available. The most common character generator is the Chyron.

These devices generate text over a solid frame. The text can then be keyed over an image. They usually have many pages of memory, so they can be loaded for scrolling or for multiple frames at the same time.

Character generators, like switchers, often come with the edit suite at no additional charge. The best option is to load the character generator before an edit session at a much cheaper cost, perhaps $50 per hour.

DVEs

A DVE ("Digital Video Effects," common trade names include ADO, Encore, and Mirage) is a realtime frame buffer that can zoom in and out, reposition, and freeze frame in real time. Some can also warp video frames into trapezoids, cylinders, and spheres to create a variety of special effects. When ADOs are used on more than one channel, effects such as "push-offs" and "quad split-screen" become possible in real time.

ADOs typically cost $300 per hour per channel.

Paintbox

Though Paintbox is a trade name (by Quantel), it is generically used to describe a digital paint program capable of drawing and shading images from scratch or from digitized video frames. The Paintbox creates only still images, but sequences of animated images can be made from the still images (by loading frame by frame onto a Harry, for example).

Paintboxes, like Harrys, are generally in a separate room rather than in a videotape editing suite. They cost about $250 per hour.

Special Videodisc Effects

While the above-mentioned effects are common to regular video production, ther are two effects that are unique to videodisc production (in fact, practically unique to the Multimedia Lab—these terms and techniques are not regularly used)—"compression" and "video defluttering."

Compression

In addition to conserving frames by careful trimming of in-points and out-points, it is also possible to compress the video material by recording only every "n"th frame (in filmmaking, this is called skip-framing). Normally this would result in fast-motion during playback, but since videodiscs can play at slow speeds, actual "realtime" playback can always be maintained (but at the cost of losing access to the audio tracks). The result is coarser motion (but, again, at significant savings of disc "real estate").

Compression can be done in real time using a Harry. As the machine is being loaded from a source videotape, it can be programmed to grab only every "n"th frame.

It is also possible to hand-select individual frames at irregular intervals. This involves tedious offline decision making. Each selected frame has to be logged as a single-frame edit. (The other alternative it to grab frames "live" using an Abekas, Harry, or Sony BVH-2500, but this will not be as precise.)

Compression is new terrain, applicable only to media like optical discs, where total capacity is more important than maintaining fixed playback speed (which is necessary with film and tape). Determining compression is the temporal equivalent of determining spatial composition of the frame.

Video Defluttering

Video stillframes (not fields)—material originally shot in video—may flutter since each frame consists of two slices of time taken 1/60 of a second apart. When video source material is viewed on a videodisc as stillframes, the flutter is usually apparent, with the degree of flutter dependent on the degree of motion between fields.

One solution is to throw away every other video field and repeat the remaining one in its place. Half of the resolution would be lost, but there would be no flutter. We call this *video defluttering*. It allows shooting in video, which has the advantage of live monitoring as well as saving time and money. It also allows stillframing of acquired material originally shot in video. Without defluttering, video is the worst source medium for interactive videodisc.

Video defluttering can be done with a Harry, but not in real time (the Harry requires "digestion time" for such tasks, as well as requiring three internal passes), and the Harry can deflutter only 84 seconds of video at a time. Defluttering can be more efficiently done with an Abekas by feeding it video at twice normal speed (throwing out every other field), then playing it out at half speed (repeating each field). This is faster but still requires two passes. Only 200 seconds of video can be defluttered at a time with an Abekas.

It turns out that the Video Department at the University of Iowa modified some hardware to deflutter video a number of years ago. They call the machine "AFI," for "alternate field interpolator." It interpolates the missing fields based on the remaining ones, rather than simply repeating them. This produces less "stairstepping" in diagonal lines. The AFI works as a realtime processor, so there is no limit to the duration processed, and the University charges a very nominal fee ($90 per hour plus tape stock) for this service. Given that this method throws out half of the resolution, which is apparent on stationary objects, the results are very good.

Premastering and Field Dominance

Premastering is the term used for preparing the edit master videotape for videodisc mastering. It most often is used interchangeably with "postproduction." But one aspect of videodisc master tape preparation involves determining how to "flag" the videodisc frames to achieve the proper correspondence between full frames on the videotape and full frames on the videodisc. This is called *field dominance*.

Since video frames consist of two fields, a video edit can take place either before the first field or before the second field. This is a function of the CMX and of the videotape decks, and has an odd (and somewhat arbitrary) history.

When the edits are performed before the first field, they are called *field-one dominant.* When the edits are performed before the second field, they are *field-two dominant.* Typically, an edit system is set up one way or the other and doesn't change.

To master a videodisc, one must specify field dominance. If a video facility edits with field-two dominance, and the disc is mastered with field-one dominance, every frame at the edit point will be a mixed-field frame and will flutter.

Field dominance can be specified to change as many times as you like. This data, as well as chapter and auto-stop data, is called the *action-point list.*

Video

If the source material is entirely video, every frame may flutter (depending on the amount of motion between fields), so field dominance is not important. However, if any of the material consists of single stillframes, such as one-frame titles, then the field dominance of the videodisc must be the same as the field dominance of the edits.

30-fps Film

Film transferred to video at 30 fps has the fewest complications of any format for videodisc production. There is a one-to-one correspondence between recorded frame and videodisc frame, and as long as the field dominance is correctly specified to the disc mastering facility, all frames will be "stillframe-able." If the field dominance is wrong for 30-fps film material, then *every* videodisc frame will flutter. The field dominance for film transfers is determined by the transfer machine, such as a Rank or Bosch, and is known by the video facility.

24 fps-Film

For 24-fps film, the disc-mastering process "flags" the correct two fields for each film frame of 3-2 pulldown material. This is also called *3-2 pulldown* (it really should be called 3-2 *flagging* to avoid confusion with the actual transfer process).

The 3-2 flagging is only for telling the videodisc players which two adjacent fields constitute a single image to avoid flutter. It is only relevant for stillframing and playing at speeds slower than 30 fps.

The 3-2 flagging performed during disc mastering is only semi-automatic. It flags two fields, then skips one, then flags the next two fields, and so on. But it cannot be aligned to the correct starting point automatically, and for each scene, there are four possible starting points: 3-2 field-one dominant, 3-2 field-two dominant, 2-3 field-one dominant, and 2-3 field-two dominant. The only way to determine which 3-2 dominance to use is to scrutinize the source material *field by field,* trying to visually detect the repeated field. This can be done with a window dub, and is very, very tedious. It can also be done by transferring the material to videodisc with normal (2-2) flagging and deducing it from the flutter frame sequence. Then one must count forward to the first frame. Luckily the 3-2 cycle is five frames long, so this can be calculated.

It gets worse. If the 24-fps film material was edited in video, this must be done for every edit.

And even worse, older film transfers done with a five-bladed shutter are unfixable, since often two of the film frames are "double exposed" on video fields, thereby being inseparable. And there is no way to determine five-bladed shutter transfers from 3-2 pulldown transfers without checking on a field-by-field basis.

No one has automated this process. But there are alternatives and they involve compromises:

1) Ignore the whole affair and just make the disc. Remember, all of this effort is only for playing at slower than 30-fps speeds and for stillframing. If the disc is exclusively for 30-fps playback, none of this matters. Furthermore, all misflagged 3-2 pulldown film material will alternate between two fluttering frames and three good frames, so if single stillframes are occasionally required (for example, for digitizing), there will always be three flutterless frames out of every five;

2) Deflutter the videotape of the film transfer as if it were video source material. All frames will be flutterless, but every fourth frame will be a redundant frame. Some resolution will be lost.

The best solution is to either get the original film footage and transfer it at 30 fps (if realtime motion isn't important and if there is no sync sound) or transfer it at 24 fps with 3-2 flagging if all of the frames are to be stillframe-able.

Disc Mastering

Videodisc mastering is done like audio disc mastering: in a facility where, in theory, a faithful replication of the master tape is made. You don't have to be there, and your supervision is not necessary.

There are two basic disc-mastering processes, resulting in "quick discs" and "replicate discs"—similar in principle to photocopying and offset printing, respectively.

Quick Discs

Quick discs are made like photocopies, one at a time, with the disc being etched in real time. These range in price from $300 to $1,000 per disc side and can be made overnight (or even while you wait). Quick discs are often used as intermediary check discs to help software designers or to determine the field dominances of the film material. Crawford Communications in Atlanta makes medium-quality plastic discs for $300 or high-quality glass discs for $500. There are several other such companies. If the quick disc is for intermediary in-house use as a workdisc (like a film workprint), high visual quality may not be important.

Replicate Discs

The replicate disc mastering method is similar to offset printing. A master stamper is etched and used to press plastic replicate discs. The master stamper costs around $2,000 per disc side, while the replicates can be pressed for $10 to $20 per disc side. The replicate mastering method is best for producing discs in quantity (say, over five copies), and takes about two weeks. (Faster turnarounds are possible, but at a significant cost increase.) "Check" discs, discs pressed soon after the master is made, are available for around $300.

One-inch videotape is practically universal as the mastering format recommended or required by disc-mastering houses, but it should be noted that component beta and 3/4-inch tapes are accepted by some facilities as well.

It is entirely possible to avoid online sessions altogether and work completely with whatever resources are available. For example, the popular 3/4-inch editing systems can be used to master videotapes from a wide variety of source material: VHS, video 8, videodiscs, and 3/4-inch, as well as stillframes from Mavica disks and the Fotovix. These editing systems cannot reliably make stillframe edits, so stillframes must be redundantly recorded as a guarantee. This 3/4-inch videotape can be used as a master tape at some video-disc facilities. The worst-case situation is where the tape would have to be transferred ("bumped up") to 1-inch tape, which can often be done by the mastering facility for a nominal fee.

Though video engineers at professional facilities may scorn it, there is nothing fundamentally wrong about making videodiscs out of VHS and video 8 material, even crudely edited or not edited at all. Though the visual quality will be lower than the capability of the disc, it won't be any worse that what is seen from the original material: what you see is what you get.

And this sort of "lowest-end" activity is to be encouraged. We have the luxury of over a century of evolution of cinematic production quality: we know how to do it well. But we have very little experience with cinematic interactivity, and need to get better at it.

Videodisc Production of the "Visual Almanac"

Michael Naimark
Apple Multimedia Lab
November 1988

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Abstract

The Multimedia Lab's "Visual Almanac" videodisc is a broad sampling of themes and styles of images for use in schools. From a production point of view, this disc is equally broad, with source material shot and acquired in the forms of 16mm and 35mm film; slides; large transparencies; hardcopy; video in 1-inch, Betacam, 3/4-inch, VHS, and video 8; CAV and CLV videodiscs; OMDR discs; and Mavica disks.

This is a report on the videodisc production portion of the "Visual Almanac." It assumes a basic knowledge of video and videodiscs. Other reports, *Videodisc Basics* and *Casual Multimedia Production* may be useful as background material for the Macintosh and HyperCard user unfamiliar with the world of video.

Introduction

The production process involved in making the "Visual Almanac" was, in concept, quite simple: the goal was to make two 30-minute master videotapes, each containing 54,000 frames of still and moving pictures, and two tracks of audio, to be used to master a two-sided videodisc. Getting from our diverse source material to master videotapes took three steps:

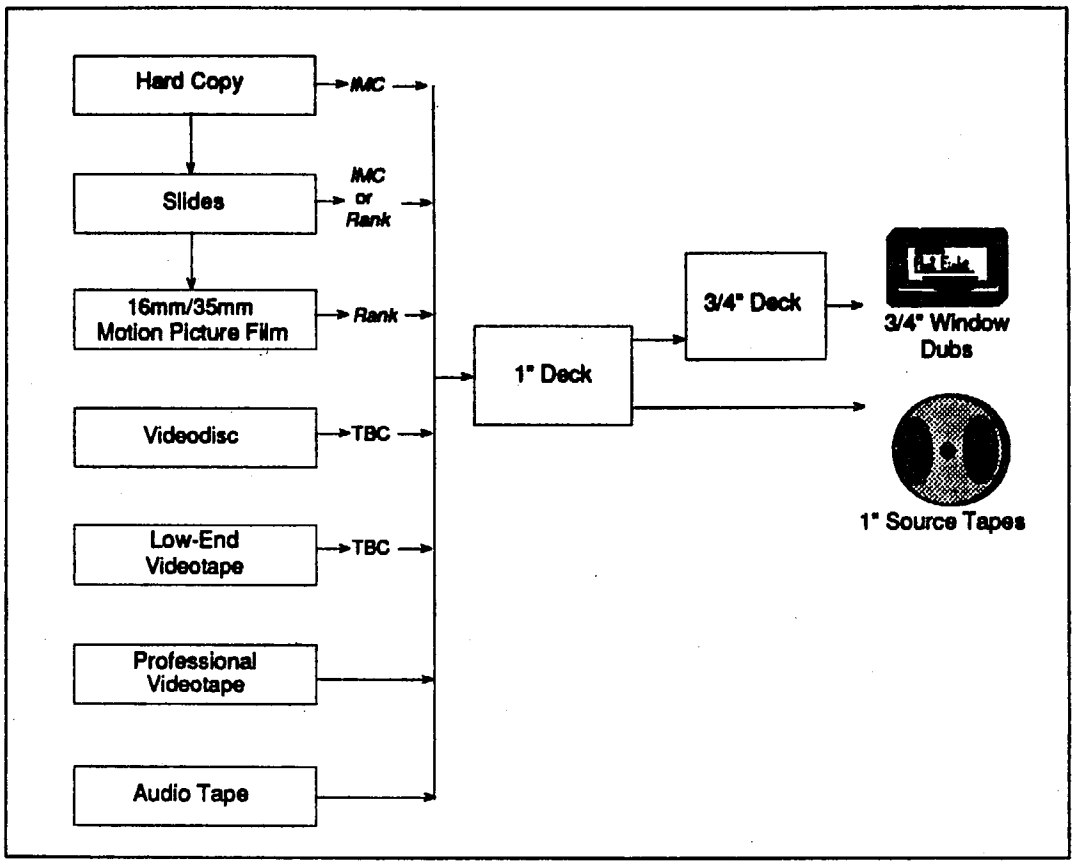
1) Transferring all of the source material to a professional quality videotape format that could perform frame-accurate edits. We chose 1-inch videotape, by far the most common professional tape format.

2) Making the editorial and aesthetic decisions about what would be used, how it would be arranged, and whatever special effects would be necessary. Since the facilities required to implement these decisions are not cheap, usually costing $200 to $800 per *hour*, all decisions are best made in advance, in-house with the meter off. This is called *offlining*.

3) Implementing these editorial and aesthetic decisions in a professional video facility with expensive equipment and expert staff. This is called *onlining*.

This report describes each of these three processes. Since many of the tasks are unique to videodisc production, we often tried different approaches to the same task. I have outlined alternatives whenever possible.

Once a final master tape is made, it is sent off to a videodisc mastering facility. The actual videodiscs are made there, requiring no supervision on the part of the producer. The producer's responsibility is to produce the master tape and provide related data.



Still images, moving images, and audio from a variety of media are transferred onto 1-inch video source tapes. Copies with visible timecode are made on 3/4-inch videotapes called window dubs.

Source Material

We had two classes of materials: those that we acquired and those that we shot ourselves. In both cases we needed to transfer the material to 1-inch videotape.

Videotape

Professional

Much of our acquired material came to us on 1-inch videotape. This was perfect; we could simply edit this directly onto our 1-inch master tape. When we needed to shoot our own high-quality video, we shot with component Beta SP. Since we used a high-end package, we paid $600 per day for rental. Like many professional videographers, we edited directly from our component beta source tapes onto 1-inch videotape.

Consumer and Industrial

Consumer and industrial video, such as video 8, VHS, and 3/4-inch can be transferred to 1-inch videotape with virtually no loss of quality (and no gain either, of course). Some of our acquired material came in on VHS and 3/4-inch tape. We also shot some video 8, desirable because of its ease of use and portability.

We brought our own video source deck (as well as our own timebase corrector, or TBC) with us to the high-end video facility, where our output was recorded onto the facility's 1-inch tape decks. Many video facilities now have consumer video players on hand for customers like us. They all have 3/4-inch tape decks, many have VHS, and an increasing number now have video 8. They also have TBCs for the types of players they have.

Motion Picture Film

We shot in both 16mm and 35mm film. When we had a "serious" production (usually the criterion was relatively high overhead), we shot in 35mm. This included the merry-go-round sequence, where we boomed the camera directly over the center of a playground-style merry-go-round, and the teeter-totter sequence, where we shot permutations of three people in 12 positions. The merry-go-round was shot for live action, and consequently we shot at 30 frames per second to retain the feel of realtime motion. The teeter-totter required shooting almost 400 "scenes," most of which were only a single frame, while the balanced positions were shot at about 8 fps to give some motion. We used a camera specially equipped with a stop-motion motor. We rented such camera systems for about $400 per day. Film stock, processing, and video transfer cost a total of about $.08 per frame.

For more casual shooting, we shot in 16mm film with a Bolex, the standard of the multi-speed 16mm cameras. Much of our material was "tabletop" stuff that we shot in our lab: cream pouring into coffee, marbles accumulating in a glass jar, fruit being sliced, water boiling, and so on. Just as our designers determined the compression factor for acquired footage, we would determine what frame-per-second (fps) rate would best tell the story. Bolexes rent for under $60 per day, and the film stock, processing, and video transfer cost a total of about $.03 per frame.

We also acquired both 16mm and 35mm footage from various sources. Much of it was time-lapse material. Some of it was stillframes transferred to 35mm film. Since we wanted the material transferred at 30 fps (rather than the more common 24 fps transfer) to maintain a one-to-one correspondence with video frames, we did it ourselves.

We transferred both 16mm and 35mm film to video at 30 fps using a Rank flying-spot-scanning system (modified with an air jet to blow the dust off) because we could zoom and reposition during the transfer, which would save us a special-effects step later in editing. It cost about $350 per hour of actual use. The amount of time spent was mostly dependent on reel-changing and color correction.

Videodiscs

We transferred over 1,000 separate sequences from CAV videodiscs, CLV videodiscs, Optical Memory Disc Recorder (OMDR) videodiscs, and Mavica disks onto 1-inch videotape. All of the CAV and CLV discs were under Macintosh control, and the transfer took barely longer than realtime search and playback of the material. The video facility charged $235 per hour (a "night rate") for its computer-controlled 1-inch deck.

Though we could control our disc players with a Macintosh, the CMX editing computer could not. Consequently, if we needed frame-accurate edits when transferring from our discs to 1-inch videotape, we had to first transfer the disc material to intermediate 1-inch source tape and edit onto the master tape from that.

As frustrating as it was, there was a particular advantage to transferring videodiscs rather than transferring videotape: the player can be computer-controlled to make the job more efficient. We walked into the video facility with our own disc player and TBC, and also brought with us a Macintosh, loaded and ready to call up all of the scenes we wanted to use. Again, the Macintosh was ours and the CMX computer was theirs, and the two didn't talk to each other, but at least our Macintosh never kept their CMX waiting. There are a number of ongoing projects that promise such Macintosh-CMX communication, which could help us a great deal in the future.

An exception to the need for transferring to intermediate source tape was with stillframes, from CAV videodiscs, OMDR discs, or Mavica magnetic disks. Since there was no motion, there was no need for synchronized beginning and end points. When we needed stillframes edited into particular frames on our master videotape, we transferred directly. However, if we had a sequence of many stillframes in a row (say, more than 10),

it was more efficient to treat it like a motion sequence and transfer it directly to intermediary source tape.

Stillframes

We used a variety of methods for our stillframe transfer, dictated in part by cost, quality, and the need to reposition images (which requires supervision).

Most of our slides—the ones requiring no repositioning—went to Stokes Slide Service in Austin, Texas, for transfer to 35mm motion picture film, which we then transferred to video on a Rank. We also acquired some 35mm transferred material from Image Premastering in St. Paul, Minnesota, and "Ranked" it to video as well. Both were mostly very good. Problems occurred mainly with numbers: both facilities tried to correct color and exposure for every slide, and occasionally made mistakes. (Most were caught and corrected.)

Most of our hard copy was shot onto slides and then shipped to Stokes with the rest of the slides. Any repositioning was done during the hard copy–to–slide transfer.

For slides requiring repositioning or cropping, we shot directly on video at a video facility using an Interactive Motion Control (IMC) copystand (fitted with a high-quality Ikegami 79D camera) and recorded onto an Abekus A-62 digital disk recorder. At the end of our session we dumped the frames at 30 fps onto a 1-inch source tape. The results were better than with the slide–to–film transfers, since we were watching and determining color and composition.

We used this same technique for large transparencies and for special hard copy (for example, when we acquired some first-generation Muybridge prints from the Stanford University library). Again, the results were most impressive.

We paid $250 per hour for the IMC transfer, so the per-slide cost was mainly a function of how fast we could decide on color and composition. It's difficult to do more than 100 per hour (and it's very easy to do much less!). The Stokes transfers cost $.75 each; adding the Rank cost for a large run increased the total cost to about $1.00 per slide.

Audio

Though various methods exist for interfacing professional audiotape to video editing, we found the simplest solution was to transfer whatever audio source material we had onto

1-inch videotape, just like everything else. Like other video transfers to 1-inch tape, audio transfers cost $235 per hour. It turns out that we had enough silent material on 1-inch tape that we could use the two unused sound tracks for audio transfers, which was fine since we could edit audio and video independently.

Offlining

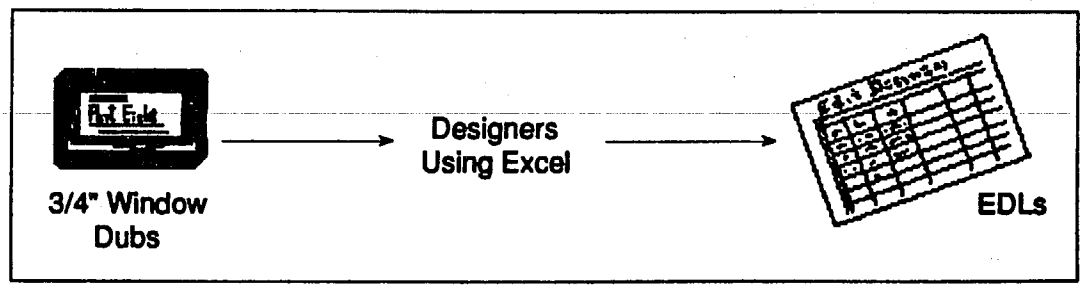
With all of our source material on 1-inch videotape, we proceeded to determine exactly what we wanted, how to arrange it on the master videotape, and whether or not to manipulate images with special effects. The base price for simple 1-inch–to–1-inch editing was around $250 per hour. Adding various effects can drive it upwards of $800 per hour, so, again, it was best to make all decisions offline.

Window Dubs

We made 3/4-inch window dubs of all of our source tapes, which allowed us to view and log timecode on our in-house equipment. We often made VHS copies from the 3/4-inch window dubs, to use while working at home, for example. The visual quality wasn't terribly important, but the frame accuracy was.

Window dubs are not cheap. We paid about $100 per hour plus the cost of 3/4-inch tape stock. Since we made updated window dubs daily, we recycled old 3/4-inch stock (which also made our lab less cluttered with outdated tapes). Of the 34 hours of 3/4-inch tape stock used for window dubbing, almost 21 hours was dubbed on reused stock.

The Edit Decision List (EDL)



The designers use the 3/4-inch window dubs to make creative choices concerning layout and effects offline. These decisions are entered on Edit Decision Lists (EDLs).

Having accepted the fact that we would have to enter our EDL data into the video facility's CMX computer manually, we built our own EDL spreadsheet using Microsoft Excel. The program was generated by our designers; there isn't any magic about keeping a log of frames we wished to use. (There is one thing you should remember: according to convention, in-points are inclusive and out-points are not. If you want to record a single frame at 04:59:59:29, the in-point is 04:59:59:29 and the out-point is 05:00:00:00.)

Our EDL was designed to leave ample room for descriptions and comments, so that each scene or stillframe could be recognized with the help of a few words. There was also ample room left for description of special effects, if desired. Since most of the offline work was performed by our designers, I would often have to describe the range of effects possible, and what their cost could be (see below).

Compression

Our EDL had a unique column labeled "compression factor." Since disc "real estate" is always a scarce resource, our designers always asked themselves how many frames were necessary to accomplish the desired effect. In addition to conserving frames by careful trimming of in-points and out-points, they also conserved by using only every "n"th frame (in filmmaking, this is called skip-framing). Normally this would result in fast-motion during playback, but since videodiscs can play at slow speeds, actual realtime playback could be maintained. The result is coarser motion (but, again, at significant savings of "real estate").

The method of performing compression online was through a particular digital disk recorder, the Harry, that can compress in real time as it is being loaded. It is expensive (typically $500 per hour), but these sequences are usually short.

There were times when the designers wanted compression, but not at regular intervals. Rather, they wanted to surgically pull carefully selected frames where the selection was determined by action rather than by time. We sometimes called this "reverse keyframing." Because these were individually selected, they had to be treated as individual single-frame edits.

Special Effects

Occasionally there was a desire to make modifications within the frame itself. These are called special effects and are wide-ranging and machine-dependent.

"Fashions" in special effects change often. Since these can't be simulated in an offline environment, the best way to prepare was to get special-effects demos (free) from various video facilities. Individual effects machines are usually charged for on a per-hour basis on top of the basic editing cost. Typically, these effects are billed in 15-minute increments.

For example, we used an ADO (which originally stood for "Ampex Digital Optics"), a popular realtime frame buffer, to create a left-right mirror image of the teeter-totter sequence, cutting in half the number of permutations we had to film. We also used an ADO to shrink four frames to fit in the quadrants of a single frame, to show four simultaneous points of view for our roller-coaster sequence. ADO-type devices are expensive, usually $150-$300 more per hour than straight editing.

We used the video switcher, the major routing and mixing console, for adding wipes and borders to various sequences. Switchers are included with the price of the editing suite.

We used an Abekas A-62 for video "keying," a method of applying opaque overlays of one image over another. The Abekus (and Harry) perform keys digitally, while the video switcher is capable of analog keys.

We used a Paintbox, a digital paint program capable of drawing and shading images from scratch or from input video frames, to add color and graphics to our teeter-totter sequence. The graphics, which were images of other playground items, were loaded from other videotapes and shrunk, then repositioned onto a colored background. The result was a single static frame that could be keyed over the entire teeter-totter sequence. We also used a Paintbox to touch up the numbers on the thermometer in the ice-boiling time-lapse (which you probably wouldn't have noticed; now you will). Paintbox prices are usually around $175-$300 per hour.

We used a character generator (the most popular one is the Chyron) to generate titles, many of which were single frames. Charactor generaters are the video equivalent of word processors, with a wide variety of fonts and sizes available. Further, they can hold multiple "pages" either for separate title frames or for scrolling through material. Though character generators generate only a solid color background, the text may be keyed over video imagery. Like switchers, character generators often come with the editing suite at no additional cost, but it's even better to load them in advance for a nominal cost, typically about $50 per hour.

In-House Tools

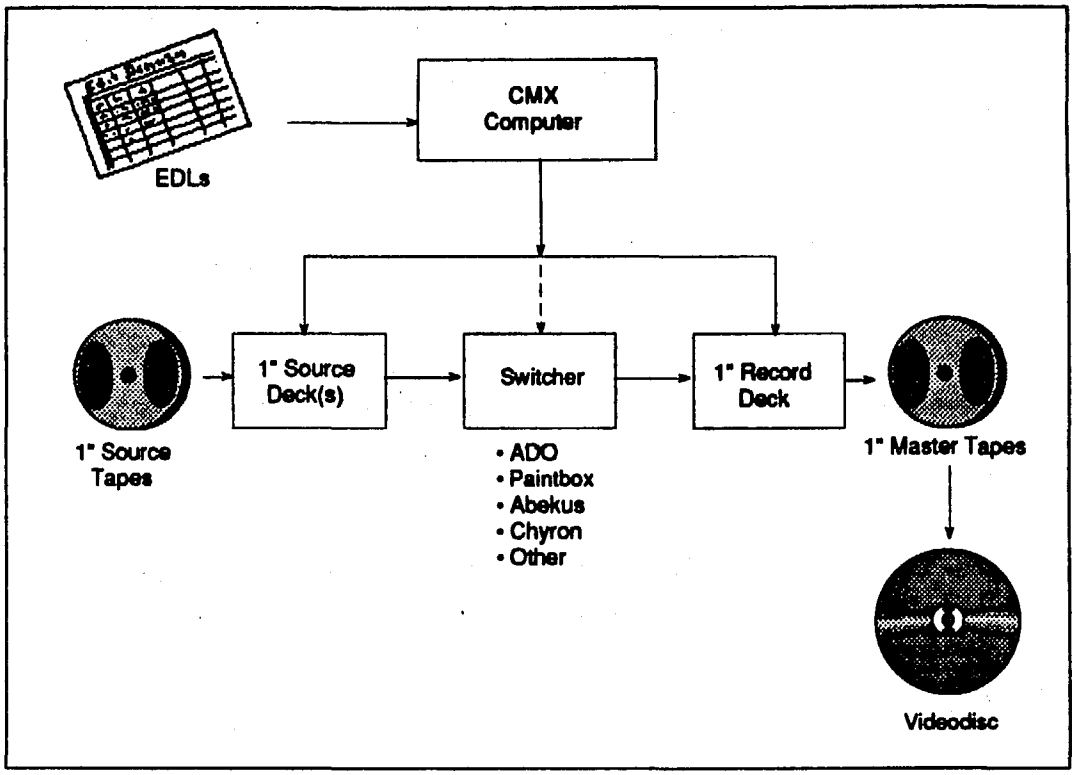
In addition to our window dubs, we used various tools in-house to help us make offline decisions. Most of these tools are relatively inexpensive. Remember, if a $500 tool saves you four $200-per-hour online editing hours, you've saved money. These tools are decribed in detail in the *Casual Multimedia Production* report.

We purchased write-once OMDR videodisc recorders and players made by Panasonic (Teac also makes one). Though these videodiscs are not compatible with any other laserdiscs, they are computer controllable, so we used them for testing interactive concepts, where they proved invaluable. They are not cheap: $14,000 for the recorder and $4,000 for the player. Discs cost $150 and hold 24,000 frames or about 13 minutes.

We also bought a Fotovix slide-to-video box made by Tamron and sold for about $3,000. This device accepts slides and allows for X-Y positioning, zoom, rotation, and color correction. Its output video can be recorded with the write-once disc recorder. Its quality is not quite professional grade (it's closer to 3/4-inch videotape), but having the ability to "master" stillframe videodiscs in-house far outweighed the quality issue.

We often used a video 8 camera for videotaping and a Sony Mavica electronic still camera for snapshots. Video 8 is a popular consumer technology, and priced accordingly (around $1,000 for an 8mm camcorder); Mavica is a newer technology (presently the camera costs $4,000 and the player $3,000). Mavica can hold up to 50 images on a 2-inch microdisk, and its quality is far superior to pulling still frames off video 8, though admittedly less than that of high-quality 35mm slides tranferred to video.

Finally, we became almost nonchalant about ordering quick discs from Crawford Communications in Atlanta, Georgia. The videodiscs cost $300, with a one-day turnaround time. It seemed astonishing to us, but the fact was that if making a quick disc saved us an hour or two of online editing, we saved money. Since these videodiscs are standard CAV videodiscs, we used them to test interactive ideas, to edit larger amounts of material, and to scrutinize material frame by frame. We would usually make these discs with burned-in timecode, just like window dubs.



The Edit Decision Lists and the 1-inch source tapes are used in an online editing suite to create the master tape, which is sent to a videodisc mastering facility.

Onlining

The Sessions

Since we had over a dozen people on our staff, it was tempting to have a small crowd in the suite during editing. This was always a disaster. (My rule of thumb is to increase your online budget by 50 percent for every person you work with.) The fewer people, the better. The editor should be listening to only one person. Aesthetic debates have no place in an editing suite.

Even if I felt we were totally prepared, I budgeted an additional 50 percent time and cost to whatever I thought was reasonable. "Things happen," as they say in the editing suite. Furthermore, we were doing various tasks that were somewhat experimental, including video defluttering (see below), compression, and massive single frame-editing.

During our more than 20 edit sessions for the "Visual Alamanac," we were ambitious and sometimes uneven in achieving our daily goals. We prepared EDLs and loaded them in

the CMX in advance if we could so that our edit sessions could be mostly auto-assembled. We performed over 1,000 edits during one six-hour session (which may be a record). Other sessions were bogged down with making decisions based on hard-to-visualize effects.

By far the majority of the time and expense for our online sessions simply went toward cuts-only editing rather than special effects. We spent a total of 67 online hours editing (and less than 22 hours on costly effects). Again, the amount of sheer brute-force editing was massive: it totaled over 3,600 edits for the two 30-minute master tapes, an average of one edit per second of videotape, and an average of about one edit per online minute.

Pre-Mastering Issues

Following are two areas of videodisc production unique to videodiscs. Professional video facilities not experienced with videodiscs may not be well versed in these areas.

Field Dominance

Determining field dominance in our wide-ranging material was tedious. Deciding what to do once it was determined was difficult: there isn't a single good solution. Field dominance is a somewhat tedious area and is covered in more detail in the *Videodisc Basics* report.

Some material was easy. All 30-fps film transferred to video was consistently field-two dominant since we transferred it ourselves on the Rank. (This included shot and acquired time-lapses, and the stillframe transfer.)

The most difficult material was film already transferred to videotape at 24 fps. Some of the older 24-fps material was transferred to video before the 3-2 pulldown method (of repeating every fourth field) existed, when a five-bladed shutter was used on the film telecine. This meant that two film frames were occasionally superimposed on the same field, which could only be detected by scrutinizing individual fields. This material was unfixable for stillframing, by definition, so we left it alone.

Most of the 24-fps film we acquired was transferred with 3-2 pulldown. Since there are four modes of 3-2 pulldown, every clip had to be scrutinized on a field-by-field basis using our window dubs. The trick was to detect the repeated fourth field (to compensate for the 24–to–30-fps change going from film to video), then count back to the first field of the scene. This all had to be done by eye and was dependent on the degree of movement in the clip. It was nerve-racking.

In some instances, we flagged each 24-fps clip with the right 3-2 mode. In addition to the tedium, mixed flagging of 3-2 and 2-2 created a confusing sequence of videodisc frame numbers, since 3-2 flags at only 24 frames per second while 2-2 flags at 30 frames per second.

In other instances, we did nothing, having it flagged normal (2-2) field dominant. The result was three good still frames alternating with two fluttering still frames. For browsing, this may be unsatisfactory. But when only occasional single frames are needed, as for digitizing, doing nothing was an acceptable solution.

In any case, we found a third alternative: video defluttering

Video Defluttering

Consider what would happen if you threw away every other video field and repeated each remaining one. You would lose half of your resolution, but the result would be a still field in the place of a stillframe: no flutter. We call this *video defluttering*. It allowed us to shoot in video, which has various advantages, such as live monitoring as well as saving time and money. It also allowed us to deflutter acquired material originally shot in video. (Without defluttering, video is the worst source medium for interactive videodiscs.)

Video defluttering is a very unusual request. (Most facilities won't know what you're talking about—in fact, I believe we invented the phrase.) We tried various methods. We did some tests with a Harry, but it cannot deflutter in real time (it requires "digestion time" for such tasks, as well as requiring three passes) and can deflutter only 84 seconds of video at a time. We also used an Abekas by feeding it video at twice normal speed (throwing out every other field), then playing it out at half speed (repeating each field). This was faster but required two passes and could do only 200 seconds of video at a time.

It turns out that the the Video Department at the University of Iowa modified some hardware to deflutter video a number of years ago. They call the machine "AFI," for "alternate field interpolator." It actually interpolates the missing fields based on the remaining ones, rather than simply repeating them. This produces less "stairstepping" in diagonal lines. The AFI box functions as a realtime processor, and the university charges a very nominal fee ($90 per hour plus tape stock) for this service. Given that this method throws out half of the resolution, which shows on stationary objects, the results are very good.

We defluttered both high-end component beta and video 8 material. The loss of spatial resolution is noticeable on stationary objects. It is painful to shoot with a state-of the-art Betacam and throw away half the resolution (resulting in an absurd 700-line horizontal by 250-line vertical resolution). Perhaps not surprisingly, the defluttered video took on a "film look" because of the film-like motion coarseness of 30 samples per second (versus the smoother video motion of 60 samples per second). The effect is rather remarkable—both video and videodisc experts thought we had shot in film.

We also defluttered some of the 24-fps film transferred to video. Defluttering 3-2 pulldown material, while making every stillframe good, repeats every fourth frame.

Disc Mastering

We sent our two 30-minute 1-inch edit master videotapes to 3M for videodisc mastering in July, six months after we began full-time design, four months after we began production, and two months after we began post-production.

Then we took a break. The easy work was over.

Three days later we got our first check discs back. As much as we tried to write software based on videodisc frame numbers in advance, getting the first check discs back was really the beginning of this monumental task, and the next phase, "software summer," had begun.

Appendix One

Post-Production Costs for the "Visual Almanac" Summer Version

This is a summary of the post-production invoices cross-compiled with my day-by-day post-production logs:

Video Facility

I. Transfer				
1/4-inch playback (audio)	(7.25 hrs.)	$400.00		
Edit suite (discs, tapes)	(21.75 hrs.)	$3,350.00		
IMC (slides+H.C.)	(13.75 hrs.)	$3,100.00	(~1,500 stills)	
Rank (16mm, 35mm)	(11.5 hrs.)	$2,940.00		
Additional hardware	(6 hrs.)	$210.00		**$10,000.00**
II. Edit (3,630 cuts total)				
Edit suite	(25 hrs.)	$8,002.50		
Edit suite	(42.25 hrs.)	$10,331.25		**$18,333.75**
III. Effects				
Abekas	(11.75 hrs.)	$2,512.50		
ADO	(1.25 hrs.)	$262.50		
Harry	(4.5 hrs.)	$2,250.00		
Paintbox	(4.25 hrs.)	$1,168.75		
Character generator	(10.5 hrs.)	$530.00		**$6,193.75**
IV. Dub and Stock				
3/4-inch dub	(5:35 hrs.)	$525.00		
1-inch dub	(5:11 hrs.)	$1,270.00		
3/4-inch stock	(13:40 hrs.)	$648.00	(+ 20:50 hrs reused)	
1-inch stock	(9:05 hrs.)	$2,190.00	(+ 3:00 hrs reused)	
Window dub	(26:45 hrs.)	$2,030.00		**$6,663.00**
V. Misc.				
Additional hardware		$150.00		
Freight		$211.24		
Handling		$63.38		
Meals		$629.48		**$1,054.10**
		Subtotal		**$42,244.60**
		Sales Tax		**$743.58**
		Total		**$42,988.18**

Slide Transfer Facility (3,403 slides transferred): **$2,647.13**

Total Spent On Post-Production: **$45,635.31**

Things To Do and Notice:

1. The transfer costs may seem high, but they include everything (except the slide-to-film transfers): audio, videodiscs, all VHS, video 8, and non-timecoded 3/4-inch tape; all IMC stillframes, and all motion picture film.

2. The effects-to-editing cost ratio is relatively very low, about 1:3. More often with video production, the effects bill can go through the roof, often on single but very complicated effects.

3. The bulk of post-production work was massive cuts-only editing.
   a) We have an average of about one edit every 30 frames on the final videodisc (this is not apparent since so much of the material was already edited, or was transferred as stillframes, or was compressed rather than edited).

   b) We averaged about one edit per online minute. This is very high and is the result of preloading the CMX and autoassembling. We peaked on June 14 when we performed over 1,000 edits in under six hours (possibly a record)—about three edits per online minute. Given the10-second pre-roll we had, plus cueing, plus initializing, three edits per minute is about the absolute maximum attainable with the equipment we were using.

4. We needed a lot of videotape stock, but much of it was for short-term use. It was imperative that we had window dub "dailies" after every online session. Of the 34:30 hours of 3/4-inch stock we used, 20:40 was recycled, resulting in savings of about $1,000, not to mention a lot fewer useless tapes cluttering the lab. We could have been better, but not by much—maybe another 20 percent.

5. We got what we paid for with stillframe transfer. The IMC stuff looks terrific, I think for two reasons: we controlled the composition and we were always monitoring as we worked through video, so we saw what it really looked like. The IMC transfers averaged about $2 per image, while the Stokes transfers averaged about $1 per image (when the Rank transfer time is added to the $.75-per-slide charge).

6. This bill is not representative of a "typical" videodisc production. It's probably typical of the bill for several videodisc productions, because of its diverse source material and unique needs: it has a little of everything. From the point of view of "production research," it is very rich. Various pieces of the bill may be useful for budgeting other videodisc projects.

Appendix Two

Postscript: Post-Production of the Final Version
Fall 1988

Working with Digital Videotape

We are just finishing post-production on the final version of the "Visual Almanac," and I am happy to report that we are making our master edit on D2 digital composite videotape. These machines are very new; they were not available last summer when we did most of our post-production work.

For the first time ever, we haven't had to worry about generational loss, and that has changed the way we think. For example, when we must shorten a scene, we can simply make a two-edit copy onto another tape. In the analog domain, this would result in generational loss, and other options are usually considered (such as filling in the gap with different material or reediting everything that followed). Consequently, the scene is often left as is.

Since frame accuracy is so important, we concentrated on designing a final layout and sticking to it. If individual frames needed modification, that could be done in a later step by pulling them off and reinserting them on the same tape. Again: no generational loss!

3-2 Flagging Tip

The drudgery of flagging 24-fps film material transferred to video has been alleviated by our colleagues at Pioneer's Laserdisc Corporation in Japan. If one makes a standard (2-2) flagged quick disc of such material, three good frames are followed by two bad frames. The people at Pioneer observed that the last good frame before the two flutter frames is always the beginning of a 3-2 sequence (the math is obvious in retrospect, as usual).

In addition, we make sure to stay in phase by always cutting 3-2 material in increments of five frames, preserving the cycle.

Retransferring Stillframes on the Rank

We were not totally satisfied with all of the slides transferred to 35mm film motion picture film. The overall exposure seemed to vary by the time it was transferred to video. The reason is that video has a narrower dynamic range than film, and slight exposure

differences are greatly amplified during the film-to-videotape transfer process. These differences are not apparent to the naked eye when looking at the film.

The good news is that all the information is there on the film. The bad news is that each frame had to be individually corrected during a retransfer on the Rank. More good news: this goes quickly because the individual corrections can be stored in one pass and accurately executed at 30 fps in a second pass. More bad news: it took us about 12 hours to individually correct over 3,000 frames.

If there is a lesson here, and with 3-2 flagging, it is that if you give users the opportunity to scrutinize each and every frame under their own control, each frame requires individual care—all 108,000 of them.

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