VIDEO PRODUCTION

Video is an electronic form of communication that uses kinetics, visuals, color, design, narration, music, and audio effects to convey meaning to the viewer. Video images are created by production teams whose members' expertise includes videography or cinematography, audio, lighting, graphics, video editing, and video archiving. Producing a video is complex because it requires highly skilled teams of experts using sophisticated electronic equipment throughout the production. The video image is distributed either by broadcasting over airwaves or by nonbroadcast methods such as videocassette, cable TV, closed-circuit TV, CD-ROM, digital video disk, or computer Internet.

Since its inception, video production has relied on evolving electronic technology from cameras to graphics systems to editing systems. Although the means of producing video programs change continually, the process of video production has remained much the same. The video production team must stay current with new technologies to use those technologies creatively in producing the video program. The basic process of video production varies with (1) how the program is distributed, (2) whether the video program is linear (such as a half-hour documentary aired on broadcast TV or shown in a museum exhibit) or nonlinear (such as an interactive video), and (3) what the purpose of the program is. This article describes the basic steps of producing a linear video designed as a nonbroadcast documentary, produced at broadcast-quality production values. This kind of video fits the broadest range of video production.

UNIQUE CHARACTERISTICS OF VIDEO

The video image is recorded, edited, and reproduced for distribution by electronic means. The standards of video image quality are set by what the audience finds acceptable. Although what the audience actually sees are glowing dots of phosphor excited by a beam of electrons moving rapidly across the screen, they perceive that they are looking at a real image.

A video image can be transmitted by satellite anywhere around the world in real time. Thus the viewer perceives video as immediate. Also, using video to record and transmit images immediately has changed the viewer's perception of

J. Webster (ed.), *Wiley Encyclopedia of Electrical and Electronics Engineering*.

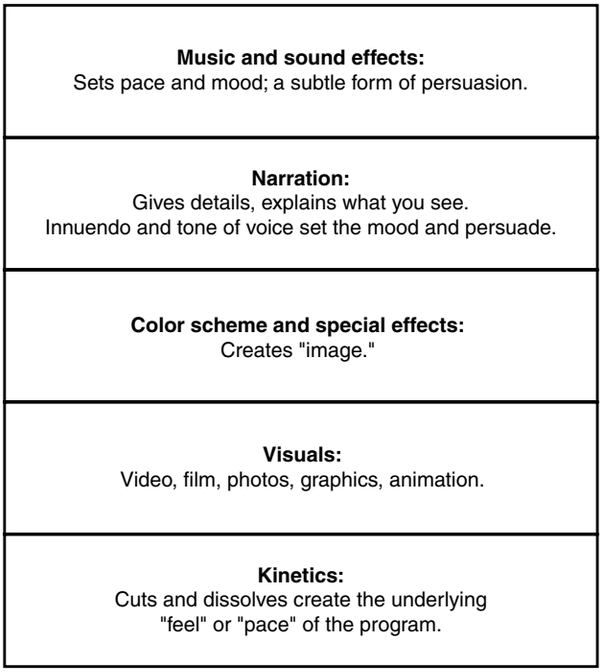

Figure 1. Video, like film, has five basic dimensions of communication. The key dimension is kinetics, or the use of motion, and characterizes video versus other forms of communication.

distance and time. Fifty years ago, events happening in Europe took days, weeks, or months to be shown to audiences visually, using film technology of that time. Today, the events of the Olympics are transmitted around the world instantly. Even when the videotaped program is distributed by nonbroadcast means, the viewer sees the video image as immediate.

Another perception is that video is an intimate form of communication, mainly because video is easily viewed at home or in a conference room. Yet video is a public form of communication because it can reach large, widely separated audiences either simultaneously or over time.

It is easy to manipulate the video image electronically, creating special effects or altering the color and shape of the image (morphing). Messages can be conveyed creatively, and video is exceptionally entertaining. More subtly, video uses many layers of communication simultaneously, combining kinetics, visuals, special effects, and sound to convey meaning on conscious and subconscious levels, as shown in Fig. 1. All these unique characteristics of video are what make it a particularly powerful and effective form of communication; interested readers may refer to Ref. 1.

TYPES OF VIDEO PRODUCTION

The two types of video programs are broadcast and nonbroadcast. Broadcast video uses public airwaves to transmit programs to local, national, and independent stations. Broadcast programs are intended for a general audience and are designed for mass communication.

Most countries have clear-cut standards for producing and distributing broadcast programming; hence the term *broadcast quality* means a video of exceptionally high quality in image, editing, and style. Video terminology for standards, equipment, and formats is defined in Table 1 and Refs. 2–4. These standards in the United States have been in place since 1952 for analog color television techniques. Over the past 15 years, various standards have been proposed for the emerging digital television technology. In late March 1997, the U.S. Federal Communications Commission (FCC) ruled that the major broadcasting markets must have in place the facilities for digital television by December 31, 1998; see Refs. 5 and 6. To comply with this ruling, the industry must agree upon one or two of the almost 20 standards currently proposed.

Nonbroadcast video programs are not broadcast over public airwaves. Cable TV, corporate videos, teleconferences by satellite distribution, interactive video, video incorporated into multimedia programs, and video games all are nonbroadcast videos. Nonbroadcast audiences are smaller and more specialized. Nevertheless, production of nonbroadcast videos is increasing rapidly for use in corporations and home markets. Unlike broadcast videos, which must meet standards, the quality nonbroadcast videos vary greatly in production values. However, many of these videos intended for public use meet, and sometimes exceed, broadcast-quality standards. References 7 and 8 are good sources to further clarify the differences between broadcast and nonbroadcast video.

HISTORY OF VIDEO

In 1956, Ampex Corporation developed the Quadruplex videotape recorder with a rotary four-head, segmented scan reel-to-reel tape recording system and a 2 in. wide videotape format. 2 in. Quad was the format of choice for broadcast video programs until the late 1970s. Because Quadruplex was very expensive, it was seldom used to record nonbroadcast programs. A new format known as 1 in. Type C format, using a 1 in. helical scan reel-to-reel recording system, became the broadcast standard in the early 1980s. It has only recently been supplanted by some of the digital formats of the 1990s.

In the early 1970s, a consortium of Japanese firms, including Sony and JVC, developed the U-Matic video system, recording on a $\frac{3}{4}$ in. cassette. The U-Matic was a broadcast-quality helical scan analog tape with a composite signal. Although the overall image quality was less than 1 in. format, the U-Matic was easier to use, smaller, and lighter. U-Matic made quality nonbroadcast video productions more feasible. In the 1970s, 3M Corporation marketed the first videocassettes. In addition, several $\frac{1}{2}$ in. recording systems, notably Betamax (Sony) and VHS (JVC), with low cost and long recording time, were developed for home use, opening the market to home distribution of videotapes. Sony developed the Betacam tape, a professional $\frac{1}{2}$ in. format that recorded analog component signals on video cassettes. Because of its high resolution and compact format, Betacam and later the Betacam SP (Superior Performance) quickly became standard for broadcast-quality electronic news gathering and field productions; VHS became the standard format for distribution copies.

During the 1980s, with the advent of computer-generated graphics systems such as the Quantel Paintbox, Chyron, and Ampex Digital Optics (ADO), spectacular graphics and special effects became an integral part of video production; Table 2 gives information on these and other manufacturers. Com-

Table 1. Video Terminology for Systems and Equipment

Aspect ratio: The ratio between the length of the horizontal portion of the television screen and the vertical. For analog television screens, the current standard aspect ratio is 4 : 3. Video footage, photos, graphics, and all other visual elements must be designed with the television's aspect ratio in mind.

Breakdown: The process of taking apart the lighting, audio, and cameras that were setup for a video production.

Chrominance: Part of the video signal giving data for color and hue.

Component signal: Chrominance and luminance are recorded separately, retaining maximum bandwidth.

Composite signal: Chrominance and luminance are recorded together, resulting in efficient transmission and recording; however, the two cannot be separated in postproduction.

D-2: An 8-bit digital recording system with composite signal using a $\frac{3}{4}$ in. videotape cassette. D-2 was the first widely accepted digital tape format.

D-3: A 10-bit digital recording system with composite signal using a $\frac{1}{2}$ in. videotape cassette, writing information at 143 megabytes/s. D-3 is a newer alternative to D-2.

D-5: A 10-bit uncompressed digital recording system with component signal using a $\frac{1}{2}$ in. videotape cassette, writing information at 270 megabytes/s. With a processor, D-5 is able to record high-definition television (HDTV).

Degradation: The video image loses quality when a copy is made from one tape to another. Also known as generation loss.

Digital Betacam: A 10-bit compressed digital recording system with component signal using a $\frac{1}{2}$ in. videotape cassette. It is currently the format of choice when upgrading from analog Betacam or Betacam-SP machines.

Gamma: Also known as crossover, gamma controls the midlevel shades that are picked up by the camera. The three levels that are balanced or matched are white level, black level, and gamma.

Generation: When a copy is made of a videotape, how far removed from the original tape denotes generation. For example, the original is first generation; a copy made from a first-generation tape is second generation. Copies made from analog to analog video degrades when taken down a generation, whereas digital to digital copies retain the same level quality as the original.

Helical scan videotape recorders: A technology of wrapping tape diagonally around a cylinder that houses a spinning disk with record and playback heads attached. Audio tracks are recorded by stationary headstacks longitudinally and video tracks are recorded diagonally by rotating heads, thus reducing the amount of tape required to record audio and video signals.

Live switch: During a live broadcast or the taping of a live event, transition from one camera shot to another is made manually at a video switcher.

Luminance: Part of the video signal giving data on brightness.

NTSC (National Television Standards Committee): In 1952, a US standard was recommended for color broadcast television (analog), specifying a video image of 30 frames per second; interlaced scanning of 525 lines by 720 pixels per line of resolution; about a 30 : 1 contrast ratio and a 4 : 3 aspect ratio.

PAL (phase alternating line): European standard for color broadcast television (analog) with a video image of 25 frames per second with 625 scanning lines.

Pixel: Shorthand for *picture element.* Each picture element contains data for chrominance and luminance.

Production values: The values considered essential to quality video production, such as quality of video image, clarity and style of editing, artistic quality of graphics, and clean sound techniques. Broadcast programs have specific standards regarding camera work, lighting, audio, graphics, and editing; nonbroadcast programs are measured against these standards to judge their relationship to them in terms of production values.

SECAM (Système Electronique Couleur Avec Memoire): French standard for color broadcast television (analog) with a video image of 25 frames per second with 819 scanning lines in each frame.

Setup: During camerawork, the time it takes to setup the cameras, the lighting, and the sound recording devices for a particular scene.

Telecine: A system that transfers film to video.

Teleprompter: A device used during production that allows the peson to read a message or speech and simultaneously appear to be looking at the camera lens. This device eliminates memorizing the message or using notes.

White balance: Adjusting the luminance (brightness) and coloration of the camera by having a person hold up any white object in front of the camera. White level, or gain, sets the highlights; black level (or pedestal) determines how dark the black areas of the picture is reproduced. White balance assures that the camera reproduces white objects without any color errors.

puter-generated graphics quickly replaced time-consuming and expensive film cel animation. Also, film-to-video transfer systems such as the Rank-Cintel telecine allowed footage to be shot in film and the origiinal camera negative then transferred to and edited in video, taking advantage of the photographic quality of film and the speed and flexibility of video editing.

In the mid-1980s, nonlinear editing systems using computer hard drives for storage were developed, allowing for film-style editing rather than the more traditional linear videotape editing developed in the 1960s and 1970s. Currently, facilities are beginning to move towards digital video recording and editing. All these developments in recording systems, graphics, and editing systems have made video an increasingly cost-effective and flexible form of communication.

Because of the electronic nature of this medium, video technology is constantly changing; as a result, a wide range of formats are available at any one time. This often results in uncertainty among video facilities, which must invest considerable capital in video equipment. In order to keep their facilities competitive, they must continually make tradeoffs between the best format and the one that will most likely become the standard over the next 5 to 10 years. Standard formats are usually selected by market share, which are not necessarily of highest quality and performance. Although video producers may not have the same concerns as those of the video facility owners, they must learn new technologies to design how the video will be produced.

Professionals who are skilled at video production have mastered the creative and technical elements to produce the

kind of high-quality, effective video programs that audiences have come to expect. The video production team understands that the audience relates to video as a real, immediate, intimate, entertaining, and persuasive form of communication. The production process is designed to maximize on these perceptions. The production team is adept at conveying meaning with color, sound, visual images, pacing, graphics, and special effects.

THE THREE STAGES OF VIDEO PRODUCTION

Video production has three distinct stages: preproduction, production, and postproduction. Preproduction includes conceptual design; costing; client authorization; budgeting and scheduling; scripting; procuring camera crews and editing facilities; and obtaining copyright releases and permissions. Production is the process of capturing visual and sound images using cameras and audio equipment. Postproduction includes recording narration, creating graphics, titling, and editing the program. For live programming, production and postproduction are done simultaneously. In recorded programs, unless a live event is being taped, they are done separately.

During all stages of production, the producer (1) manages the project from concept to distribution, (2) creates the proposal, (3) raises funds and gains client authorization, (4) has overall creative and budgetary control of the program, and (5) in collaboration with the director begins planning resource and labor requirements for production and postproduction. The goal of the video producer is to ensure a high-quality, cost-effective program that is watched by a large audience for broadcast programs or generates a significant return on the client's investment, tangible or intangible, for nonbroadcast programs. If the video program does not evoke a high viewer response, then no matter how handsomely produced, it did

Table 2. Major Video Manufacturers and Associations

Ampex Corporation (magnetic and digital recording systems)
500 Broadway
Redwood City, CA 94063-3199
tel: 415-367-2011
website:www.ampex.com

AVID Technology, Inc. (nonlinear editing systems)
P.O. Box 647
Stoughton, MA 02071-9915
website:www.avid.com

Chyron (character generator systems and editing systems)
5 Hub Drive
Melville, NY 11747
516-845-2046
website:www.chyron.com

Cintel International Limited (Film-to-video telecine systems)
Watton Road, Ware
Hertfordshire, SG12 OAE, England
tel: +44(0) 1920 463939

Discreet Logic, Inc. (Flame graphics system)
5505 boul St. Laurent,
Suite 520C
Montreal, Quebec
H2T F6, Canada
website: www.discreet.com

International Television Association (ITVA)
6311 N. O'Connor Road, LB51
Irving, TX 75039
214-869-1112
website:www.itva.org

National Association of Broadcasters (NAB)
1771 N Street, NW
Washington, DC 20036
202-775-3527
website:www.nab.org

Panasonic Broadcast & Television Systems Company (video recorders, cameras, monitors, videocassettes)
One Panasonic Way
Panazip 2e-3
Secaucus, NJ 07094
tel: 800-524-0864

Philips Broadcast Television Systems GmbH
Im Leuschnerpark I, D-64347
Griesheim, Germany
tel: +49 6155 870-0

Quantel, Ltd. (graphics systems)
Turnpike Road, Newbury
Berkshire RG14 2NE England
(01635) 48222
website:www.quantel.com

Sachtler Corporation of America (tripods)
55 North Main Street
Freeport, NY 11520
tel: 516-867-4900

Silicon Graphics, Inc. (Alias/Wavefront graphics systems)
2011 N. Shoreline Blvd.
Mountain View, CA 94043
800-800-7441
website:www.sgi.com

Society of Motion Picture and TV Engineers (SMPTE)
595 W. Hartsdale Ave.
White Plains, NY 10607
website:www.smpte.org

Sony Corporation (video recorders, cameras, monitors, audio, videocassettes)
800-635-SONY
website:www.sony.com

Tektronics (Grass Valley editing systems)
430 Mountain Avenue
Mountain Heights Center
Murray Hill, NJ 07974
tel: 888-TEK-VIDEO
website:www.tek.com

not communicate effectively. The video producer must make sure that the video produces the intended results.

Preproduction

Proposal. A video program begins either with a client requesting a video or a video producer suggesting to an organization an idea for a specific video program. Either way, the producer must present the client with a proposal. The proposal clarifies the subject of the video; why it is important to produce a video on that subject; who the intended audience is and why; and what kind of impact that video is intended to have on the audience. The proposal will also clarify the treatment, use of film or video, personnel, and costs.

Because video is a relatively expensive medium, a video proposal is crucial. On the average, a nonbroadcast video program costs $1,500 a minute; costs can range from $500 to $5,000 a minute. In general, broadcast programs are considerably more expensive than nonbroadcast programs. Also, the time to produce a video ranges from a day for a live newscast to a couple of weeks to prepare for videotaping a corporate meeting to almost a year for a 30-minute documentary. Producing a video requires much specialized technical and creative skills as well as current communications and television technology. The proposal justifies the value of producing the video to the client. The more specifically the video is described in the proposal, including the cost and the production requirements, the more likely it is that the program will be approved and funding allocated.

Audience. The proposal identifies the audiences and also specifies how that audience will be reached (for example by means of multimedia through the Internet, by videocassette, or by satellite distribution) and why that particular mode of distribution is most effective for that type of audience.

A nonbroadcast program, shown to smaller groups by means of cable TV, satellite TV, or VCR, also has two distinct audiences: (1) a specifically targeted primary audience interested in a particular topic, and (2) an audience comprising the corporate clients who authorize and show the video to that targeted primary audience. A growing segment of nonbroadcast video is interactive video: a large group is targeted, but each person watches the video alone and interacts with it individually.

A broadcast program, which is televised simultaneously to large groups in many different locations, has two audiences: (1) a primary audience, whose demographics have been researched so that the largest market share may be gained, and (2) a secondary audience, whose demographics differ from the primary audience but who might nevertheless watch the program. The goal is to appeal to the largest possible general audience in order to dominate the market share.

Treatment. The treatment is a narrative description of the video program, including what will be said, what will be seen by the viewer, and what kind of video style is planned. The treatment is designed to give the client or sponsor the best possible idea of how the final video program will look and what it will communicate. The treatment may include a storyboard, which visually illustrates the scenes of the program. The treatment is critical to the proposal because it explains fully to the client or sponsor the subject and goal of the video; see Ref. 9 for discussions on the audience and the treatment.

Film Versus Video. During preproduction, the producer must decide whether to shoot the footage in film or in video. Film and video are similar in that they both use kinetics, visuals, and sound to convey meaning. Film images are considered to be higher quality than video, because of the higher quality of photographic resolution (saturation, contrast, and hue); also, the audience perceives the film image to be three-dimensional and the video image flat. Film processing is time consuming, whereas the video image is recorded and can be transmitted immediately. As a result, audiences perceive what they see on film as of past events and fantasy and what they see on video as real and immediate. In terms of production, sound and image are recorded separately for film and simultaneously on video; film processing is more expensive, film crews are generally larger, and graphics are much more time-consuming and costly in film than in video. Film is best used as a stand-alone presentation, in theaters and for a large group. Video can be used with a wide range of other media in intimate settings such as the home or small groups.

One of the ways a producer takes advantage of the higher photographic quality of film is to shoot material in film and then transfer the footage to video for editing and distribution. Knowing the difference between film and video enables the video producer to make production decisions that optimize resources. Because the choice of film or video affects the cost, the logistics, and the timing of the production, it should be made as soon as possible and included in the proposal. References 1, 8, and 10 further discuss the differences and uses of film versus video.

Personnel. The proposal includes an estimate of the kind and number of personnel engaged in producing a video. A 5-minute industrial video demonstrating a new piece of machinery may need a camera crew of one to three persons to take care of lighting, videography, and sound, and the video may be edited in-house by corporate video experts. A 10-minute recruiting tape for a major university may require several camera crews at various locations using film or aerial photography; postproduction may require animation and a team of audio and video editors in a broadcast-quality video facility. The range of technical expertise needed as well as the size of the team directly affects the budget, the logistics, and the schedule and should be specified in the proposal; Ref. 11 gives an exhaustive list of personnel and resources required for each step of the production process.

Budget. The budget, the final part of the proposal, is based on the length of the proposed script; the length of the video program; the kind of personnel involved; the location shots; and whether film, graphics, and special effects are used. A cost proposal can be devised based on limits set by the client, or the proposal can present a range of costs depending on the technique and complexity of the video production. A simple industrial video of about 5 minutes with simple shots and editing may cost $5,000 or less; an annual video report designed for stockholders or an intricate interactive video may cost $50,000 to $150,000 or more. The client must know these costs before deciding to produce the video. Reference 12 gives a representative breakdown of costs for a typical video program.

Research and Script. Once the video program has been approved and funds allocated, the next step is writing the script. A video script is the backbone of the video production; it drives the cost of the program. It includes a narrative portion and defines the kinds of video footage to be shot. A script specifies the location shots, studio shots, interviews, acting, and other elements required to tell the story. Often a script will indicate breaks or pauses in the program, which will be used to determine the kind of special effects or transitions that will be used in the edit to indicate a change in pace or topic. The pace of the narrative script sets the pace of the program.

The script tells the director and the camera crew what to videotape, for what purpose, what kind of pacing to use, and what kind of mood to evoke. In postproduction, the script, modified to reflect what was actually videotaped versus what was intended to be videotaped, is used to select the music, create the graphics, and determine the style of editing.

The basis of a good script is the research: library work; consulting art, photo, film, and video archives; interviewing people; and studying places of importance. The research yields material for the narrative script and indicates possible location shots and interviews. If the research is thorough, then it is much easier for the scriptwriter to produce ideas for an interesting and evocative program. 90% of the work in developing a script is research; for further reading on developing a script, see Refs. 9 and 13.

Planning for Production. The next step in preproduction is planning for production or designing a logistics plan. Either the producer, acting as director, or a director hired by the producer develops the production plan. The director keeps a log book of such information as services hired, schedules, agreements, and points of contact.

The director studies the script for (1) pacing, (2) the kinds of shots that may be used within the budget constraints, and (3) the special camera work required (location, studio, or aerial). The director then creates shot sheets, which outline the kinds of shots required for each scene of the script. Once the shots are identified, the director groups the shots according to location and considers the following:

1. How many locations must the camera crew shoot?
2. How long will each location session take to set up and shoot?
3. What kind of travel arrangements must be made?
4. What special considerations and permissions may be needed for each location?
5. What kind of camera crews and camera services need to be hired?
6. Is special lighting or audio recording required?
7. Are interviews necessary? What permissions are needed to conduct interviews?
8. Does the script call for actors?
9. Which are sequences to be videotaped are most important?
10. Does the script call for archival material? If so, where can the material be found and what permissions are required?

Before location shoots, scouting is often necessary. During the scout, the director or the director's assistant goes to the location and finds out whether clearances are required, what protocols the crew must observe, where the power is located and what kind it is, where equipment can be unloaded and loaded, what kind of services are available (food, hotels, etc.), and other details that are not possible to anticipate without going directly to the site. A scouting session will also reveal unanticipated shots that will enhance the value of the program.

The director has technical mastery of what the cameras and camera crew can do, and can plan for various types of shots and angles; terminology for camera shots are defined in Table 3. The director must have a sense of kinetics and esthetics and a personal style. The director looks for what no one else might think important, but which often turns out to be crucial to making a normal shot a great shot. The crew takes direction from the director only and expects the director to act as liason to the client so that they can concentrate on their specialties. Conversely, the director must make quick decisions and communicate well with the client, the nontalent personnel being included in the video, and the actors. Fundamentally, the director envisions the camera work so that the audience receives the full expression of the program's intent.

With the camera crew and talent (actors) hired, nontalent interviews agreed upon, location shots planned, and studio facilities arranged, the director makes shot lists for each day of shooting and specifies what day and what time the crew is to report for work (crew call). Production is ready to begin.

Production

There are two kinds of production: taped and live. A taped program can be a staged production in which retakes can occur without loss of integrity, or it can be the recording of a live event during which no retakes can occur. In live productions, the camera crews videotape and broadcast an event as it progresses. Mechanical breakdowns almost always occur during camera shoots; therefore, the director and the camera crews must prepare immediate solutions to any possible problem so that the cameras continue to record the event.

Video productions are shot either (1) *on location,* also known as *remotes* or *field productions* or (2) in a studio. Location shots provide more action and interest; the backdrop could be a highway, a city street, a mountain, or a myriad of other sites. It is difficult, however, to control the weather, the power, people who are not actors but are used in the program, and other external factors.

The studio is a highly controlled environment; however, creative staging is necessary to match the interest of location shots. For productions in which a controlled environment communicates the message best, this is the method of choice (for instance, a newscast, a game show, or a formal corporate message to employees).

Camera Work. The illusion of depth created in the TV image is produced during the camera work by stage design (if in a studio), lighting, how the picture is framed, and the various camera shots (such as tilt up or wide shot) that are edited to provide context. The quality of the video program depends on the quality of the camera work.

Table 3. Editing and Digital Video Effects (DVE) Terminology

A-B roll: In an edit session using analog videotape, the original footage of the program is the "A" roll. Some or all of the original footage is copied to the second tape (B roll). The purpose of this is that for editing in analog, it is not possible to create dissolves or special effects moves if two scenes are taken from the same tape.
Assemble editing: The program is edited in strictly linear fashion, with one scene laid down, and then the next.
Cross fade: As one scene fades out, the next scene fades in.
Cut: A transition between two scenes that has no dissolves or special effects. It is an abrupt transition that allows for fast pacing and an energetic feeling to the program.
Cuts only: A video program that is edited with cuts, no dissolves, and no special effects.
Digital video effects (DVE): The wide array of special effects that can only be edited using digital.
Dissolve: The transition between one scene and the next is slow, and blends with each other. This slows down the pacing of the program and creates an elegant mood.
Edit master: The final edit of the program in its original format. All duplication masters are created from the edit master.
Fade: The scene goes from full video image to black (or white). The transition usually signifies the end of a section or the end of the program.
Freeze frame: A transition from full motion within a scene to freezing a frame of the video, creating a snapshot effect. Used when a point is being made.
Insert editing: Using linear editing methods, footage is inserted into a program that already has been edited; usually one scene is inserted to replace another scene. Using nonlinear editing methods, footage can be inserted between scenes without having to superimpose over a former scene, allowing the video edit process to be closer in technique to film editing than was possible using linear editing methods.
Jump cut: If a cut is used between one scene and another, and the subject in the first scene, for example, was shot close up and during the next scene was shot wide, the resulting transition is perceived by the viewer as "jumpy." Once frowned upon as poor style, jump cuts are now considered trendy and exciting, particularly in music videos.
Multilayering: Using a sophisticated computer graphics system or a digital editing system, many different visual images can be superimposed upon one another, creating a layered effect. Often used in an opening or closing of a program to give an overview of some of the highlights of the program.
SFX: Special effects.
Slow motion: The normal pace of a visual image is slowed down using a special videotape recorder player.
Sweetening: All the audio elements of the program are blended together in terms of volume, balance, and other values to achieve a cohesive counterpart to the visuals.

In terms of camera work, the production can use a single camera that is moved from location to location as each scene is shot, or it could involve multiple cameras set at different locations. Single-camera productions allow production and postproduction to be two separate steps. Multiple-camera productions are used to tape an event or for live-audience TV shows; they can be edited on the spot for live broadcast, with production and postproduction steps occurring simultaneously.

Single-Camera Production. Single-camera production is used in broadcast and nonbroadcast programs that are taped, usually staged events or events that can be reshot if necessary. Because of the long process of setting up lights, checking for white balance, making sure the framing and continuity is correct, and breaking down the camera setup to move to a different location, it takes more time to videotape all the footage necessary; with single-camera production, however, the lighting can be designed much more artistically and the wide range of camera locations add interest to the program.

Multiple-Camera Production. Outdoor productions using multiple cameras, such as a sports event, have weather considerations and, if the event occurs during the evening, lighting considerations. Generally, a stationary camera with telephoto lenses for close-ups shot from long ranges is set up in the back of the event to capture the widest possible view and to get direct head-on shots of any speakers. Two or three roving camera crews, generally consisting of a videographer and a tape operator, are assigned areas in which *cutaway* shots are taken, which provide interesting angles or close-up reaction shots. All the crews communicate with one another and with the director by headphones. Multiple-camera productions allow for depth of action and for flexible editing. The material being shot could be broadcast to a live audience, with use of a live switch to edit the scenes as they occur, or it could be edited into a videotaped program.

Indoor productions using multiple cameras have the problem of difficult lighting conditions. Because the lighting must be set up so that no camera picks up shadows or bright spots, the illusion of depth is lost. Additionally, there is always movement occurring in a video, resulting in continually changing lighting of the subject. The cameras must be matched for colorimetry, white balance, black balance, and gamma to maintain a consistent look. Almost all live TV shows use the multiple-camera technique. For further information on camera work, see Refs. 4, 14, and 15.

Aerial Shots. Aerial camera work, although expensive, is a dramatic addition to video productions. Video is sometimes used for aerial shots, but quite often film is used and then transferred to video for editing to get the best depth and quality of photography. Aerial photography requires the camera be mounted on an antivibration platform so that the helicopter's movements provide the least disturbance to the camera. For aerial shots, the crew includes the helicopter pilot, the camera operator, the tape operator, and sometimes the director.

Audio during Production. The two major sources of a sense of motion, or kinetics, in a video program are the visuals and the sound. The blend and coordination of sight and sound develop the mood and the interest of the video program, so the relationship between the audio and the video elements of the program is important.

During production, the primary audio concern is to record people who will appear on camera. The secondary concern is to record the background sound, which establishes an environment for the visuals. If the camera recorded a passing car but neglected to record the sound of the car approaching, passing, and receding, it would be difficult to recreate the exact audio environment in the edit session, even if the video facility has a large sound effects library. Sometimes footage with no sound is used; then the sound effects that create the appropriate audio background are developed in the audio mix at the edit session.

The audio specialist uses a variety of microphones, depending on the environment in which the camera work is being done. Clip-on microphones, with or without wires, are used to capture speakers' voices with a minimum of environmental disturbances, such as wind. Omnidirectional microphones capture environmental ambience. When there are many speakers, either unidirectional microphones (called *shotguns*), mounted on long poles, or large mechanical booms (*perambulators*) are used to follow the action. References 4, 16, and 17 discuss audio techniques and equipment in greater detail.

To inexperienced directors, adding a sound specialist seems like an unnecessary cost. Accurate recording of sound during production proves invaluable, however, preventing audio problems during postproduction.

Lighting. Lighting is essential for video production for three reasons. First, most video cameras are not light sensitive, so they need adequate lighting to produce a clear video image. Second, the video camera can capture height and width, but lighting creates the illusion of depth. Third, indoors or outdoors, the relationship of the subject to the light creates mood and adds quality.

In setting up a video shoot, setting up the lighting takes the most time. During production, three kinds of lighting situations can occur during production: indoor lighting, outdoor day lighting, and outdoor night lighting. Standard three-point lighting, using a key light, a back light, and a fill light, creates the depth of the video image. Key light is the main source of lighting; back light separates the subject from the background; and fill light enhances lighting intensity and reduces shadows. Specialty lights draw the eye to certain areas of interest: fresnel spotlights for focused, consistent, intense lighting; softlights and scoop floodlights for soft, diffuse lighting; many other kinds are used to focus attention. Also, scrims (cloth or fiberglass filters placed over the light) and gels (cellophanelike pieces of plastic of various colors) can soften the image; focus attention; and create mood, form, and texture. On the same object, different lighting can evoke either a sense of reality or fantasy. See Refs. 4 and 18 for further information on lighting.

Interviews. Interviews enhance video productions considerably because persons are being interviewed usually understand the subject of the program well; they can articulate concepts, opinions, and emotions far better than the scriptwriter does. Interviews provide variety of expression and lend authority to the video.

Celebrities, senior corporate managers, and people used to public recognition are often trained in how to be interviewed. Usually, however, when confronted by the bright lights and the camera lens, with no perceptible audience from which to receive reactions, most people freeze up in the interview. The director must prepare the person for the interview and gets their consent in writing. If the subject is complex or sensitive, the person might receive in advanced a list of questions that the interviewer will ask. Also, the director knows what kind of image works for various people being interviewed and will advise them on what to wear for the best effect.

The interview can be conducted off-camera: the interviewer stands or sits directly to the right or left of the camera and has the subject look at him or her instead of the camera. It can be conducted on-camera, with the interviewer and the person being interviewed both visible in the video image. Sometimes, the interviewee will look directly into the lens of the camera, but that technique should be reserved for persons trained in its use. The same holds true when using a teleprompter, which will result in the person looking awkward and inauthentic unless properly trained.

The interviewer, working in close collaboration with the camera crew, must gain the trust of the person being interviewed. Then the person comes across on the screen as authentic, authoritative, and knowledgeable. Without that trust, the person appears nervous and wary, and the audience will be distracted from the message.

Postproduction

Postproduction involves all the work done after the footage has been shot. Narration, music, editing, graphics, and special effects all come together to complete the program. The director (or producer/director) begins by planning the material to be used in the program. Deviations from the original concept occur when unexpected footage was shot that might enhance the final program.

The first step of postproduction is scene selection, using:

1. A copy of the script
2. The footage copied onto VHS with visually burned-in time code.
3. A log of the footage, with time code and scene description
4. Photos planned for use in the program
5. Archive material: artwork, photos, video, or film transferred to video
6. Transcripts of the interviews and speeches shot for the program

Off-Line Editing. Scene selection starts with generating an edit decision list (EDL) either by hand or word processor. An edit decision list is a scene-by-scene list of the footage to be used in the program, matched up to the script. Burned-in time code VHS copies are used to identify the scenes. Once the rough edit is completed, either on paper or using off-line editing, an edit decision list that can be loaded into the online system can be generated by computer, based on the in-points (the point at which the scene begins) and out-points (the point at which the scene ends) of each scene.

Time code is a SMPTE standard of an 80-bit digital address that identifies each frame of video with the hour, minute, second, and frame numbers. Time code is recorded on the address track or the audio track of the videotape. Burned-in

time code (BITC) means that the numbers marking each frame are visible to the viewer; generally, the director uses BITC VHS copies to identify exactly which scenes will be used.

However, even with burned-in time code to identify scenes accurately, the scene selection process is the most time-consuming part of the entire production. Each Betacam SP tape used to record the footage has 30 minutes of material. If 20 tapes were used, the director must search through 600 minutes of footage to find the 10 minutes of scenes that will be used in the program. Scene selection requires reviewing the material to ensure that the production values are acceptable as well as for content and relevancy. A great scene that does not fit with the program must not be used. The director must identify (or qualify) the scenes that will fulfill the program's purpose.

Off-line editing uses nonbroadcast-quality editing equipment to build the structure of the video program. Until the 1990s, the only way to edit video has been to lay down the audio and video elements in a linear, scene-by-scene fashion onto videotape. Linear off-line edits are built with cuts only, no dissolves or special effects; see Table 3 for editing terminology. If the director later wants to change material in the middle of the program, there are two options available: (1) take the program down a generation by making a copy of the program, which results in degraded quality, or (2) reedit the program. Off-line editing is significantly less expensive than on-line editing and serves to build the form and pace of the program. However, using linear video equipment for off-line editing, a director must have an exceptionally clear idea what the program will look like before the edit begins. References 19 and 20 discuss time code and edit decision lists.

Since the early 1990s, nonlinear digital systems have been developed, such as AVID's Media Composer and Touch/Vision Systems' D/Vision Pro. The footage and audio are digitized into the system using JPEG, a compression technique developed by the Joint Photographic Experts Group. In this way, hours of material can be compressed enough to be stored on the disk drives. The material is manipulated in a nonlinear fashion until the kinetics, pace, form, and style are satisfactory. With the nonlinear approach, the director has more creative latitude and can make changes freely throughout the program.

Once the look of the program is created, the EDL can be generated by computer and loaded into the on-line editing system for the final edit. Instead of going to on-line edit, however, some producers of nonbroadcast video programs choose to complete the video at this stage, reducing cost. Production values of such a video is considered as good as on-line quality for nonbroadcast programming but would not meet standards for broadcast programming and has a limited rate of transitional options. Manufacturers continue to develop these systems to meet broadcast standards.

Graphics. In the early 1980s, the development of computer-generated graphics revolutionized the use of graphics in video. The Quantel Paintbox system (1981) became the standard graphics system in the industry. The advantage of computerized graphics was that if a client wanted blue, not red, for a graphics, the artwork could be changed in seconds rather than days. This greatly accelerated the approval process, an important step for any video project. Graphics systems have evolved to include three-dimensional graphics, multilayering of visuals, morphing, and a wide range of special effects.

Graphics are the best tool available to visualize concepts not easily expressed by words. Technical visualization is an important tool for a standard, rapid understanding of concepts from which to launch more sophisticated dialogues. The real power of graphics and animation in a video, however, is that unrealistic, fantastic images can be created that previously existed only in the imagination. As discussed in Ref. 21, graphics can be used in the video as stand-alone elements or superimposed on actual images.

On-Line Editing. On-line editing is the final edit of the program. The editing accesses a highly sophisticated system, often digital, which usually includes using video tape recorders (VTRs) of various formats, a video switcher, a special effect generator, a character generator for titling, audio equipment, monitors, and display consoles. Mastering video editing takes years of training. The editing crew includes the video editor and an assistant editor, plus a number of technical and engineering personnel managing the wide range of equipment housed in the engineering room (usually adjacent to the editing suite). References 4, 11, and 22 discuss off-line and on-line editing.

The final edit combines all the elements of the program—narration, music, graphics, tilting, and visuals—to produce a polished piece that includes transitional wipes and special effects. The narration and the music of the program, which sets the pace of the program, often is laid in before the visuals. All elements have been transferred from photo or artwork or film to video, and all audio elements have been recorded or created, so that in the edit session and the audio mix, the only elements manipulated for a final product are visuals and sound. The richness of the various original sources, however, conveys the feeling of dimensionality and provides the interest so important to an effective video.

Visual transitions throughout a video program are analogous to paragraphs and punctuation marks in print. Transitions can include cuts, dissolves, fades, and a wide variety of special effects. Visual transitions are often enhanced with transitions in music. If the edit master is recorded on 1 in. analog tape, then the director must create a "B" roll of the original footage ("A" roll) in order to use dissolves and special effects as transitions from one scene to another. Using digital tape recorders, dissolves can be created using footage from two different areas of a single-source footage reel using a read-before-write technique (Preread), so that no "B" rolls are required, thus saving time and money. Table 3 and Refs. 2 and 3 define many editing terms, including transitions.

Titles and credits for the program can be designed on the graphics systems before the program is edited. Frequently, however, the title, subtitles (often used to identify on-camera speakers), and credits are composed during the edit using a character generator.

Audio. Although the narration is taped and the music chosen before the edit begins, the actual mix of the audio occurs after the visuals are edited. A simple audio mix can be done at the end of the edit session, using the editing equipment. If the audio components of the video are complex, or music is composed specifically for the program and added after the edit

session, a separate session for audio mix is necessary. In the audio mix, all narration, sound effects, music, interviews, and natural sounds from the video footage are blended carefully, using a complex audio console, to provide a sound environment as complete as the visual portion of the program. The time code is critical to synchronizing the audio elements with the video elements of the program.

DISTRIBUTION

Once the video production process of a program is complete, the final step is to distribute the video to its target audience. For nonbroadcast programs, the most common way of distribution is by videocassette distributed by mail or courier. Consumer demand of videos bought by means of catalogs and direct mail and through retail stores is increasing. In addition, rental video stores and public libraries provide videos on almost every topic.

Broadcast programs are transmitted by public airwaves; other forms of mass transmission are microwave and satellite distribution. The large amount of bandwidth required for video transmission has limited the use of video by Internet technology; such technology as integrated systems digital network (ISDN) and asynchronous transfer mode (ATM) are being developed so that video can be integrated fully with the Internet.

EMERGING TECHNOLOGIES IN VIDEO

As with all state-of-the-art technology, information on the advances in video production technology is best gained by discussions with experts in the field; see Ref. 23 and also Table 2, which lists the major video suppliers and associations.

Video Production Equipment

Future standards for a video format, include the following: (1) the format will be digital, (2) it will use a component rather than composite signal, and (3) it will involve aspect ratios for wide-screen television displays. As broadcast facilities in particular come to terms with standards for implementing digital television technology by end of 1998 in the United States, development of video and audio standards for cameras, audio equipment, and editing equipment will be incremental and will be directed by consumer demand.

Developments in the mid-1990s include professional camcorders with memory cards, so that production setup can be copied from one camera to the next in a multiple-camera production. This eliminates time-consuming and inaccurate matching of video images in the edit. Also, current monitors manufactured by Sony are software-based, which does not affect the video image produced but does affect how the monitor is set up. Instead of local control of monitors, there now can be one control panel for up to 20 monitors.

Archiving

A key emerging technology in video production is how material that is videotaped or filmed is archived for future use. Archiving is especially important for large film and video libraries of general or specialized topics, such as sports events or governmental affairs, and for the major motion picture firms. For example, NFL Films has a huge archive of football footage, collected over decades; the United States National Archives has a century of film and video footage stored in its vaults.

Scene selection is a creative process: the more resources that are available, the richer the result. For the producer, however, it becomes difficult to retrieve select footage due to the sheer volume of material that must be looked at and assessed for quality and content. This problem is compounded by the increasing and constant inflow of new video material. As a result, a small percentage of archival footage is actually used over and over again. The best programs result from having a good archiving system by which the footage is easily accessible to the producer.

Facilities that house large archives of video footage are developing archiving systems by creating new processes using existing technologies; Ref. 24 lists some of the major archives for video and film. One system under development involves logging all the footage for content in a text database and attaching a low-quality MPEG-1 video file, a Moving Picture Experts Group standard for the television industry, to the database. Working at a conventional desktop computer, if the text log interests the producer, an attached MPEG-1 file of the video can be viewed at low resolution, low quality to qualify the shot. The broadcast-quality footage is stored on videotape; copies of the footage (video and audio) are loaded into a central server as JPEG files so that a tremendous amount of footage can be stored and retrieved quickly. Thus, the producer can access a greater range of footage than usual under the time constraints. Once the shots are qualified using the text files with MPEG video, the JPEG files of the shots are downloaded for off-line editing on a nonlinear system. The edit decision list is generated from the off-line edit; from that list, the videotapes with broadcast-quality audio and video are retrieved from the archive and used in the on-line edit.

Film-to-Video Transfer Technology

To gain the high production values of film and the flexibility and speed of using videotape during production, footage can be shot in film and transferred to video. Current technology involves transferring original camera negative film to tape at analog television standards. Several corporations and alliances are now developing telecines that can transfer film to video and still retain film resolution of up to $2K$ ($K = 960$ pixels per scanning line). The film is corrected for accurate color, and transferred at film resolution to the server. The visual information is stored as digital files at $1K$ resolution for 16 mm film and higher resolution and data rates for 35 mm film. From the server, the film resolution data can be down-converted to current TV standards but have the potential to meet future digital standards for broadcast-quality programming.

The advantages of film-to-tape transfer at film resolution is threefold:

1. A digital archive can be created at full quality.
2. When TV standards allow for higher-resolution visual quality (such as high-definition TV), visual data can be created at that level of quality from existing digital databases.

3. The visual data can be backed up on magnetic data tape or an optical format such as magneto-optical or, in the future, digital video disk (DVD).

Film and motion picture studios as well as such institutions as the US National Archives and firms with large film libraries stand to benefit from this new technology in terms of true archiving.

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JULIE A. LONGO
Julie Longo & Associates, Inc.