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CHAPTER

The New Post Production Workflow: Today and Tomorrow

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To many, post production is mysteriously confusing; a black art performed in darkened rooms, which when executed with a high degree of art and skill, literally becomes unknowably transparent in service to the story. Though its importance to the filmmaking process is undeniable, the fashioning of disjointed bits of picture and sound into a finished work is often eschewed as a lesser and certainly lower-paid skill when compared to the highly visible and better-compensated writer, director, or cinematographer. Post production can often help make marginal work better and cement great work as a timeless masterpiece. It is interesting to note that many directors pose for photographs, pictured in front of editing devices or sound mixing consoles, albeit with nary an editor or mixer, their necessary collaborators and oftentimes saviors, in frame.

The rallying cry of "We'll fix it in post," uttered in reverential tones, although usually without much notion of what actually happens in "post," has helped to urge on countless productions or assuage the horror of the best laid plans gone awry. Post production, which encompasses both creative expression and the technical details of the filmmaking, manufacturing and delivery processes, has been undergoing dramatic technological change over the past 20 years. Electronic and digital tools have helped to point the way to increasing numbers of new processes, which not only have changed the creative character of motion pictures, but also are changing the forms and methods from which the cinema of the future will take shape.

The creative and workflow impact of new electronic and digital tools and "toys" that are the hallmark of "the look" of commercials, music videos, digital animation, and visual effects, has also influenced the motion picture post production process as well, altering the practice that has been decidedly film-based since the beginning of cinema. These new evolving tools and methods will help hasten a merging and blurring of film and digital processes, ushering in the era of what might be called "the modern motion picture."

The stage is currently being set for a cinema of the future that may include digital cinematography, will most certainly utilize an increasingly digital post production process, and is destined to be distributed into what the industry is grappling to envision as the Digital Cinema.

The challenge for many working in the industry today, especially for those who have been tapped to lay the technological groundwork for future cinema, is to ensure that an uncompromised, robust, and extensible technical pathway can be built. For film, when considered as technology, in its relative simplicity and its 100-year endurance, is unquestionably quite elegant.

THE TRADITIONAL POST PRODUCTION WORKFLOW

Regardless of technology or terminology, post production usually does not begin "after production" but more accurately is concurrent with production. Typically and traditionally, post production encompasses the process of preparing, editing, and "finishing" both picture and sound as well as creating the intermediate and final elements necessary for distribution.

The process is usually overseen by a group of post production professionals, some who work for the studio and some who work for the producing entity or the film itself. The management hierarchy extends from the studio or production company VP of post production and his or her staff, through line producers, producers, associate producers, post production supervisors, post production coordinators, editors, assistant editors, and the various people associated with the "vendor community" of laboratory and sound. These relationships are sometimes strained when creative, financial, or scheduling needs clash as the editors, who are often aligned with the creative filmmakers, find themselves in the middle of a tug of war.

The complexity of the post production process is little understood in most studio executive suites and indeed by many producers and production managers, who are responsible for creating post production schedules and budgets and sometimes have precious little knowledge of the intricacies and nuances of the process. The pressure to shave costs and time from a film can often result in the squeezing of post production, as production or *above the line* (story rights, script, actors, director, and producer) costs and issues are oftentimes sacrosanct.

Certain recent developments put an even greater strain on the process of completing motion pictures: the need to create a big splash in a short time at the box office, the fear of piracy, which has contributed to the acceleration of worldwide distribution, as well as the requirement to ready video delivery elements for earlier *windows* (phases of distribution on different formats). The impending need for Digital Cinema elements will further articulate new post production methods that might help to meet the challenges and pressures of today's motion picture delivery needs.

To begin to discuss how these technological and marketplace changes might affect these processes, we must first outline the traditional post production workflow.

Dailies

It all begins with *dailies*, the process by which yesterday's footage is readied for viewing by the creative filmmakers and studio as well as editing. So-called because it happens every day, the importance and timeliness of this step that feeds and enables the post production process can be even better understood when referred to by its name outside of the US: *rushes*. Dailies inform the filmmaking process by enabling the various disciplines involved in motion picture production to gauge the progress of a film.

The film shot during each production day is delivered to the film laboratory where it is processed overnight (except for Saturday and sometimes Friday nights when most labs are closed). For dailies that will be screened on film, commonly referred to as the *workpicture*, the processed negative is *broken down* or separated in the lab into "*A*" and "*B*" negative. The "A" negative, or *circle takes*, includes the takes the director wishes to have printed for viewing and editing. The director asks for them to be circled, or marked as "good," on the camera report that is delivered with the film to the lab.

The "B" negative is vaulted at the lab in case the director or editor later wishes to see an *outtake* printed. The "A" negative then heads to the *timing* department. The dailies *timer* will evaluate the negative film's exposure and determine the proper *timing lights* that need to be applied to the film for it to be properly printed.

Film Timing

The primary tool of the film timer is a device rarely called by its official name, the color analyzer. Instead, it is almost universally known by the name of the company, *Hazeltine*, that designed and made the most commonly used analyzer, sometimes even when the analyzer is made by different company. The Hazeltine made its way into the industry in the 1960s and was hailed as a significant development. As a foreshadowing of the importance of utilizing electronic display and color calibration technology for film, the Hazeltine is a precursor to both the modern *telecine* (a device used in television to transfer film to video) and the digital color timing systems that dominate our industry today.

Named for Professor Alan Hazeltine, who in 1923 invented a new, more easily tunable circuit that became widely used in the broadcast, medical, and photographic industries, the Hazeltine company went on to become a major defense contractor and developed significant technology for radar, mine detection, and electronic defense systems. The analyzer represented a show business dalliance for Hazeltine, which nevertheless ended up winning an Academy Award for its efforts.

The color analyzer is an electronic device that displays the film (similar to a crude telecine) on a monitor and provides timers with the ability to alter the image using values of red, green, and blue and *density* (which simplistically can be thought of as contrast). It is set to a reference called the *LAD* (Lab Aim Density), a standard means to control color and density in the timing process, whose purpose is to calibrate the analyzer so that by changing the values of color and contrast, these characteristics can also be altered in the film print. The LAD contains an image of a woman's face, which helps to establish a flesh tone reference, as well as red, green, blue, and various shades of black and gray patches that serve as a visual reference for the experienced timer. Unlike a telecine, which can display a *WYSIWYG* (what you see is what you get) rendition of a scene for a video transfer, a color analyzer's image is not as visually intuitive in relation to the end result.

Some refer to the process of printing the negative each day as *one light dailies*. This refers to the notion that the timer determines the proper *printing light*—values of red, green, and blue and density—and applies this one light to the entire camera roll for printing. The more accurate description of the dailies timing process might be *best light dailies*. The timer creates a timing value for each unique lighting setup and determines the best light for printing the scene. Cinematographers want to know their printing lights in order to verify that they are exposing the film correctly relative to their own expectations. This is an important reference and calibration tool for them to understand how the exposure of the film correlates to their understanding of their goals when shooting it.

Printing

Once timed, the film is sent to the printing department where it is printed at the lights that the timer has determined. From the printer, the film is usually viewed on a high-speed projector by a representative of the lab. This *lab contact* will communicate with the cinematographer about what he or she saw in the cinematography, commenting on exposure and other issues with the film. The lab contact might order a retiming and reprinting of certain takes if it is felt that they are not accurate representations of the look of the film. All of this activity happens during the wee hours of the morning in time for the assistant editor to pick up the resulting print as early as possible to begin the process of syncing the sound with this silent film workpicture.

Production Sound

The sound that was recorded during production makes its way overnight on a separate path from the film. In the past, the most common method had been to transfer the production sound to 35mm film, which is coated with a magnetic surface, called *mag*. The assistant editor then uses a *synchronizer* to synchronize the mag with the workpicture. This is accomplished by aligning the exact film frame where the slate's *clapper stick* closes with the sound of the closed clapper on the mag. When no sticks were used, the assistant editor must create sync manually by aligning the actor's spoken words with his or her moving lips, or some other reference in the frame. *Syncing dailies* has always been one of the most important tasks of the assistant editor.

Once picture and sound are in sync, both are *coded* by a machine that prints the same series of *code numbers* along the edge of each roll of picture and sound. These code numbers are logged by the assistant editor after dailies screening, so that once a shot is cut into a scene, and the clapper reference is lost, the picture and sound can always be easily aligned.

While 35mm picture and mag *double system* (meaning the sound and picture are not on the same element) is still a common way of screening dailies, there has been recent interest in the use of new technology to eliminate the need and expense of mag film. Digital devices on sets and film production locations have largely replaced analog sound recording. Some editors feel that transferring digital sound to a magnetically coated analog piece of film is anachronistic and have begun to utilize what is being referred to as *magless* dailies. There are a number of schemes to accomplish this task. Some transfer sound to computer drives, CDs, or DVDs, or new digital sound playback units, but there is no universally accepted method of syncing film with digital files. It is increasingly common that digital sound is introduced directly into nonlinear edit systems during the initial editing process so that this high quality digital sound can be made available for subsequent post production sound steps.

Using Dailies

Filmmakers traditionally view dailies during lunch or dinner breaks, and every effort is made to ensure that they are prepared in time. Dailies screenings typically are a collaborative and communal event, with the various departments watching them to judge how yesterday's footage compared with expectations or, in the case of the editor, how it might cut with other footage. It is not uncommon for an editor to suggest to a director that other angles or takes might be necessary for a scene to play or cut better.

The amount of footage that is shot each day obviously plays a large role in the dailies process. While there is no such thing as a typical motion picture, the average non-action motion picture today might shoot for 50 to 60 days and expose about 1.5 to 2 hours of negative film each day. From that negative, the circle takes amount to 1 to 1.5 hours of footage. On scenes that involve action or the use of multiple cameras, the amount of footage can grow almost exponentially. Large action films or certain big budget motion pictures can sometimes shoot 4 to 5 hours of negative and print 2.5 to 4

hours of footage each day. The sheer volume of film makes it very difficult to screen all of the dailies. Sometimes the material is viewed at high speed or saved for weekends or nights, or sometimes only the footage from a certain camera is viewed. Obviously, the editor must view all of the footage in order to know the full range of choices.

On most films, the filmmakers see the dailies first before releasing the film to the studio or production company. Some influential filmmakers limit what a studio is allowed to see by creating a *select* reel of only certain chosen scenes that have been approved by the filmmakers for studio dailies screening.

Although new processes for viewing dailies in high-definition video are increasingly being considered, dailies are still primarily screened from a film workpicture, even though the edit room today is invariably working on a digital edit system. The most common method of getting the film workpicture into a digital form for editorial is to transfer the workpicture and the track that was synced by the edit room onto videotape and sometimes onto edit system-compatible hard drives.

In addition, videotape copies of dailies or DVDs are sometimes circulated to studio executives and the filmmakers. One of the issues that this chapter will later explore is this growing interest in transferring dailies for feature films to high-definition video and utilizing digital projection technology to screen dailies.

Editing and the Role of the Cutting Room

The editor is responsible for assembling the footage each day during production using the dailies prepared in the form most appropriate to the editing technology employed. The goal of most cutting rooms is to be *up to camera*. This means that the editor has screened and *cut* (edited) as much of the current footage as has been shot to the extent possible, given the fact that scenes and locations are shot out of order. On big pictures with a lot of footage this can be very challenging. As we mentioned earlier, simply screening the sheer volume of material that can be shot on a big picture can be a daunting task, let alone fashioning it into a cohesive story.

The editor usually has a number of assistants who perform various technical and organizational tasks. The assistants typically deal with the physical tracking of film and electronic elements as well as cataloging the footage so

that it can be conformed when the creative editing is completed. In addition, the assistants are usually responsible for dealing with the lab and other vendors, as well as for coordinating the scheduling of various finishing tasks on the picture. The editor and his or her team also play a crucial role (along with the post production supervisor and the studio post production department, which are sometimes one and the same) for overseeing the creation of all the necessary delivery elements.

Even though many assistants are on a time-honored apprenticeship path to becoming creative film editors, the cutting room is increasingly a technically sophisticated and complex environment. The introduction of electronic and digital technology to the cutting room has created a conflict between the need for extremely technical, computer-savvy assistants and the desire for the next generation of creative editors. Many of today's editors who currently use very sophisticated digital editing technology started their careers physically cutting film. It is very common for these editors to delegate the more technical tasks to their assistants.

With the advent of new editing technology, a future editor who may possess a high degree of creativity ability but is not a computer geek may not be able to rise through the apprenticeship/assistant process, which more and more emphasizes technical skills over creative ability. Hopefully, future editors who today grow up with digital editing tools such as Final Cut and Avid Express literally in their bedrooms may be able to hone enough of their creative and technical skills to enter the craft, even if they are more artistic than technical.

Editors themselves see their primary role as an integral creative participant in the film making process. The editor, who is often hired by the director, usually works alone with the film through the production process. With his or her personal insight and experience as well as the knowledge of the director's vision of the film, the editor fashions the *editor's cut* (or *first cut*) to present to the director soon after the completion of photography. Never refer to the editor's version as a rough cut, which is considered highly derogatory and demeaning to the craft of editing. In fact, today's editors' versions are not rough in any sense of the word, as most editors spend a great deal of time cutting *temp* (temporary) sound effects and music, to the point that they would appear to be finished, polished works to many.

Once the production is complete, the director works with the editor to refine the cut. The director, as a contractual right of the Director's Guild of America contract, is given 10 weeks to work with the editor to create his or

her version of the film, called the *director's cut*. Also during this step in the post production process, visual effects are finalized and cut into the film as it nears completion. As the director's cut progresses, versions of the film will be conformed and screened. Some directors obtain through negotiations the sole right to view these screenings and to invite others of their choosing, who may or may not include representatives of the studio (until they are ready or the 10-week period has passed).

Preview Screenings

Once the director has either finished his or her version or approves it, studio executives will screen the film. The film is then shown to recruited audiences in marketing test *preview* screenings. These preview screenings are usually conducted by a third party market research company that will give the studio marketing department feedback about how test audiences responded to various aspects of the film.

These preview screenings are traditionally double system—a film workpicture and a separate 35mm sound track—although some magless systems have been used as well. Theatres selected for previews, however, normally have only one projector to show *release prints*, where the audio track is physically on the same film with the picture, called *single system*. So the studio post production department must arrange for the necessary audio technology to be delivered to the theatre for the preview screening, which is usually the mag machine or the magless system, and the theatre's existing film projector is usually employed for picture. In addition, representatives of Dolby Laboratories usually participate in setting up the sound that will be played for the preview audience. The sound utilized in a preview is usually a preliminary mix of the film referred to as a *temp mix*.

Preview screenings are usually held in typical suburban cineplexes, in locations such as Orange County or the Valley suburbs in southern California or in New Jersey on the east coast. The reason for this is that the studio wants test market audiences who represent a broader cross section of opinion and input than might be found in "hip" urban environments such as Los Angeles or Manhattan. Sometimes a studio will preview a picture out of town if it is worried about how it might literally "play in Peoria." The feedback from previews usually results in changes being made to the picture, even to the extent that parts of films are re-shot. Most studio films will have

at least one preview, with the typical number being two. Where the studio feels there is a lot riding on the results of the preview, three or more previews may be scheduled.

Once the previews are completed, the picture can be finalized, or *locked,* and the process of *cutting the negative* (conforming the negative to the final workpicture) begins. At the same time, the sound post production work can also begin in earnest. The preview process is becoming increasingly impacted by technology, especially Digital Cinema technology. There is a growing trend to use digital projectors and not the film workpicture for previews. This trend will be explored in greater depth later in the section *Digital Preview and Potential Cost Savings* found later in this chapter.

Visual Effects / Opticals

Visual effects (*VFX*) are as much a part of the production process as post production. Many types of visual effects involve directly photographing elements, such as miniatures, models, puppets, or actors, sometimes on blue or green painted stages, that will later be combined with other live action or computer-generated elements to complete a visual effects shot.

Visual effects originated as photographic or optical solutions, hence *opticals.* Traditionally, opticals such as matte painting, titles, composites, fades, dissolves, variable speed effects, reverse action, blow-ups, and shot repositioning have been accomplished in a film environment using film cameras and special optical stands. Over the past 10 years, however, visual effects have increasingly become computer generated, with 3-D animation and compositing technology virtually eliminating certain types of film-based opticals and visual effects. While film opticals are still common today for dissolves, fades, and titles, the move to digital post production of entire films will some day make the film optical process a thing of the past.

Today, even films that are not primarily visual effects films take advantage of the new digital toolkit. Techniques such as crowd enhancement, where people are literally copied and pasted so that a couple of extras can be made to look like a cast of thousands, have become commonplace. So have virtual extensions on buildings or the painting out of signs, telephone poles, wires or other objects in films whose historical setting did not include what was seen by the camera and should not be seen by the audience.

The sophistication of visual effects technique both from an artistic and technical point of view has elevated the importance of the *visual effects supervisor,* who participates in both the production and post production processes. Sometimes working with the cinematographer and sometimes directing his or her own photographic unit, the visual effects supervisor directs the creation of photographic foreground or background elements that will then be combined in post production digital compositing with other live action or computer-generated elements. The visual effects supervisor must also coordinate with the editorial team so that the shots to be created are of the right length and character to intercut with existing footage.

It is not uncommon for a large visual effects film to have many hundreds of individual shots subcontracted out to multiple visual effects vendors, depending on their field of expertise or the need to create many shots within the tight time frame of a film's schedule. The final approval of visual effects shots is exacting and usually maddeningly "last minute."

The cinema of the future will increasingly be composed of digital elements as the technology itself and the visual effects community continues to push the envelope to satisfy the desires of an audience which has come to take sophisticated photo-realistic visual effects for granted.

Conform and Negative Cutting

During the process of making a film, whether edited using film-based or digital edit systems, it is very difficult to get the full impact of the film by viewing it on the relatively small screen of the edit system itself.

Since most films today are edited digitally as opposed to the traditional physical cutting and splicing of the film workpicture, a separate conform cutting room is utilized. A team of assistant editors works alongside today's digital editing system. By using the edit system's *edit decision list* (EDL) or *cut list*, the assistant will conform the film workpicture by physically cutting and splicing it to prepare the version for screening. When necessary, the edit room may need to order *reprints* of scenes that have been cut in one version, but are now extended in another. This is necessary because when making a physical splice in film, one frame is usually lost on either side of the splice.

By the time the picture is ready to screen for studio or preview audiences, because of the cutting and re-cutting of the workpicture, it usually

shows signs of dirt, scratches, and other marks of its constant handling through the editorial process.

One of the most important jobs of the assistant editor is to keep track of the film, its relationship to sound rolls, the original camera reel of a particular scene and take, and the other information that will be necessary to quickly find the film and prepare it for conform. Referred to as the *code book* in the past, this paper journal has for the most part been replaced by both electronic databases kept in the edit system and frequently as a separate database file maintained by the assistant.

Once the picture is locked, the final conformed workpicture is prepared for delivery to the *negative cutter*. The negative cutter, who has one of the most exacting jobs in the filmmaking process, is responsible for matching the original camera negative to the now conformed workpicture. The negative is first separated, or *broken down*, into individual scenes and takes so that each scene is easier to find. The negative cutter begins the process of assembling the negative by utilizing code book information that designates the *key numbers* imprinted (at the factory) on the edge of the negative film every foot or 16 frames, and then in the dailies process at the lab printed through to the workpicture. The negative cutter consults the list provided by the edit room that designates a scene/take and a specific key number entry point of the cut. Once this piece of film is found, the negative cutter locates the precise frame to cut by locating the correct key number. The list will designate a key number plus a certain number of frames as the in-point or *head* of the cut as well as a key number plus a certain number of frames as the out-point or *tail* of the cut.

Using the workpicture as a visual reference, the negative cutter verifies that the number in the list, the image on the workpicture, and the image on the negative are all identical before a cut is made. Because cutting the film destroys the frame adjacent to the head and tail, great care has to be taken to ensure accuracy. Although mistakes do sometimes happen, the negative cutting profession prides itself on its steady hands, steady nerves, and its incredible track record of accuracy. This is definitely not a job for the shaky of hand or of confidence!

Cutting the negative usually takes about a week. The negative cutter usually does not splice the film. This is more commonly done at the lab using devices that can create a very smooth splice. The goal is a cut that is joined with a minimum of excessive thickness at the splice point. If the splicing is

not done carefully, a thick splice might cause a noticeable disturbance or jump as it passes through film printers or scanners.

Final Color Timing

Once spliced, the film can now be prepared for the final film release. One of the most critically important as well as most creative steps in the motion picture process, color timing is where the final *look* of the film is created. During production the cinematographer has lit, exposed, and sometimes processed the film in a certain way. During dailies, the dailies timer has provided a dailies film print that represents the best light for each particular shot or scene. But now that the film is cut together, there is another opportunity to adjust the color: first, to make the color within each sequence consistent from shot to shot, since consecutive shots in a sequence are often filmed on different days; and second, to creatively apply a color palette and look to the film that will further help to illustrate the story and set the mood.

The timer will, after meeting with the director and cinematographer, time the picture using the color analyzer to set the timing lights. Through timing, making a print, screening the film for the filmmakers' reaction, and then going back to make the necessary changes, film color correction proceeds through an iterative process. Because the filmmakers cannot make changes directly while viewing the film, changes are noted, re-timed, and then a new print is made, usually overnight. The early prints that come off are sometimes referred to as Hazeltine prints. They are usually discarded in the process, but they can sometimes be used as a picture reference in the sound post production which is usually concurrent with timing. While every film is different, it typically takes about two weeks to get the final print, called the *answer print*, approved by the filmmakers. The answer print contains the results of the final timing of the cut negative.

Traditionally, the final timing is accomplished by collaboration between the director, the cinematographer, and the *final timer* in the lab. The timer who helps guide this process is highly regarded and certainly holds the most highly paid and respected position in the hierarchy of technicians in a film laboratory. Usually the final timer has come up through the ranks in the lab, starting in the film lab equivalent of the mailroom in jobs such as film vault, negative make-up, splicing and then

sometimes apprenticing to a more seasoned timer. In some labs, these apprentices are called *timing pooches*, literally dogging the traditionally manual procedure of noting the timing values of particular scenes and making sure that this information is transferred to the subsequent print. Their first official timing position might be to time dailies, sometimes for many years, before they are qualified to be a final timer of motion pictures.

This long apprenticeship process is in stark contrast to the relatively short training received by most *colorists* (the video equivalent of the film timer). For the most part, colorists, who have achieved a nearly cult-like status in the world of digital timing, do not have the deep understanding of film, lab process, or color theory that film timers learn over their many years of apprenticeship and experience. Yet their salaries can reach many times that of the highest paid film timer (as much as half a million dollars a year or more!) Many film timers are chagrined at how the cult of the colorist has begun to overshadow the lab's most respected creative technicians. Some film timers have become colorists, but for the most part, the digital timers are young video "computer heads," who came up through the video facility equivalent of the mailroom—tape vault, tape operator, and dailies colorist—before landing the big money opportunity in commercials or feature film *mastering* for video or DVD release.

While the timing process in the lab has become increasingly electronic with computers employed to note timing values and sometimes to carry timing information from dailies, the creative, technical, and physical limitations of film timing have led to the significant interest in the notion of digitally timing motion pictures. It seems that the role of the film lab timer is destined to diminish over time as the interest in new digital timing technology and methods supplants the traditional film timing process.

Intermediate Elements and Release Printing

Except for the answer print, the original cut negative is usually not used to make *release prints* for distribution to theatres. Such use could damage irretrievably what is the most pristine version of the film record. Even if major damage were avoided, the process of high-speed printing required for release prints would inevitably produce wear and tear. So it is necessary to produce one or more *duplicate* (or *dupe*) *negatives.*

Using the timing values derived from the answer print, intermediate elements are made to protect the negative and serve as the source for the release prints that will be sent directly to theatres.

The first intermediate element, the *interpositive* (IP), is carefully made in direct contact with the cut negative of the picture. In this step, the negative is printed onto a specially formulated very fine grain film stock. The interpositive is referred to as an intermediate element because of its role as the source for the next element in the process—the *internegative* (IN). The IP is printed with the answer print timing values so that the timing will flow through to the subsequent steps in the process. An IP is usually printed on a *wet gate* printer, a special device in which the film is immersed during the printing process in a chemical liquid that has the same refractive quality as the base of the negative film. If there are scratches on the film's base layer, this liquid fills in the scratches and reduces their apparent visibility on the print (see Figure 2.1).

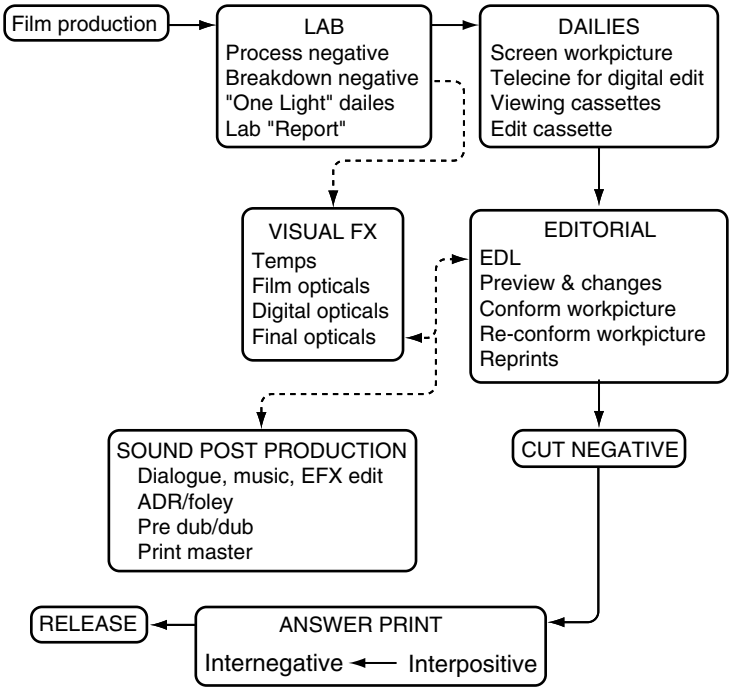

FIGURE 2.1 Intermediate elements workflow.

Even though the IP is a positive element, it is not designed and cannot be used for direct viewing or projection because it is printed on negative film stock. From this timed IP, the IN (the next intermediate element) is made, either as *direct contact* or *optical* print.

In contact printing, the source (the element from which a duplicate will be made) is positioned *in contact* with the raw unexposed film stock in an elaborate and tightly controlled threading path. The calibration and alignment of the printer is critical, as excess movement or lack of calibration can affect the quality of the duplicate element. The printer incorporates illumination that passes first through the source, exposing its image onto the raw unexposed stock, thereby creating the duplicate image. In the case of printing an IN, the positive image of the IP when exposed onto intermediate stock will create a negative image—the internegative (IN) (see Figure 2.2).

The IN can be thought of as a duplicate of the original negative. Because it contains the timing of the answer print, it can now be used as a source for

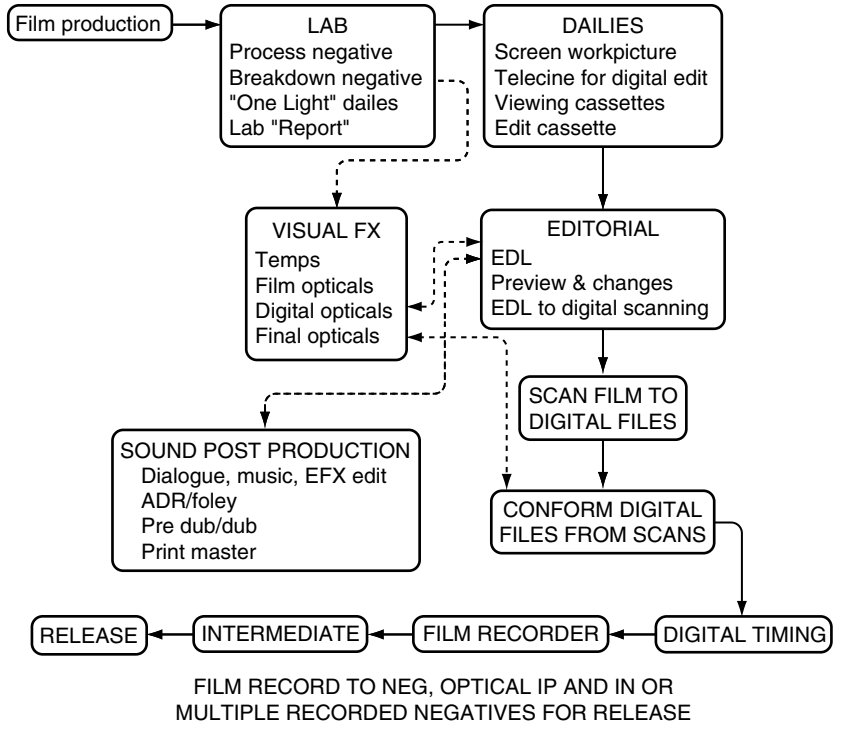

FIGURE 2.2 Release printing workflow.

release prints. For large release orders, multiple dupe negs are created as these elements can wear out during the printing process. Generally a single dupe neg can create 800 to 1,000 release prints before it is considered worn.

Sometimes it is necessary to make this IN element as an optical print. One reason this might be necessary stems from the aspect ratio of the original photography. Some widescreen films are shot using a method that is commonly referred to as *Super 35*. Unlike *CinemaScope* (sometimes called simply *Scope*), which utilizes anamorphic lenses to create a wide screen image on the film, Super 35 utilizes spherical or *flat* lenses. Both techniques make use of the entire surface area of the film, although Scope takes the wide-screen image and squeezes it into the negative area, while the widescreen image of the Super 35 frame must be cropped from within the 35mm frame.

For Super 35, an *optical printer* must be employed to take this cropped wide-screen image and blow it up to fill the entire frame of the IN. An optical printer is essentially a projector and a camera. The lenses and optics of the printer are used to accomplish this process. The impact on quality is an important consideration in deciding to use an optical step in making an intermediate element.

There is an overall concern about the loss in quality (resolution, stability and the increase in film grain) with each successive film duplicate generation. With optical printing, there are additional concerns. The characteristic of the lens in the printer itself also becomes of prime importance and can absolutely affect quality. In addition, with Super 35, it is necessary to enlarge (or *blow up*) a smaller negative area of the original negative (compared to Scope) to fill the full anamorphic frame size. These factors not only have an impact on the quality of the intermediate, but more importantly, also affect the quality of the prints made from this element.

Optical printing is also employed when a film originated in 16mm and a 35mm release is necessary. In that case, the optical blow-up to 35mm usually occurs in the creation of the interpositive element.

One of the factors driving interest in the *digital intermediate* process (the timing of films scanned into a digital post production workflow) comes directly from concern about generational and optical issues in the film process.

Once the film intermediate elements are produced, a check print is made from the IN. This print is used to verify that the answer print timing values are reflected in the prints from the IN. After any timing calibration

and screening to give the filmmakers this assurance, release prints can be made.

For film laboratories, release printing has traditionally represented the largest source of their revenue. The typical motion picture release print order today is approximately 3,000 prints, and many more in the case of blockbusters. A major lab using high-speed printers can print and ship this size order in a week.

The number of release prints for a film seems to be constantly rising due to the studio's piracy concerns and current marketing/distribution strategy and box office attendance trends, which seek to emphasize opening weekend results. The interest in simultaneous (or *day and date*) release worldwide has created a need to generate increasingly large numbers of release prints for distribution.

The major labs have built huge worldwide release print capacity in order to react flexibly to shorter turnaround times and to the increasingly larger print orders, especially for the studio's biggest releases. It is not uncommon for a lab to print a large release in several of its worldwide plants.

It is this huge worldwide capacity of high-speed printing that has made the wide release possible. Ironically, it is the lab's highly efficient release print capacity and worldwide infrastructure that the Digital Cinema process seeks to supplant, primarily in the name of release print and shipping cost savings.

Sound Editing and Mixing

To understand the importance of sound to a film, try watching one without it. The dialogue, natural background sounds, sound effects, and music add essential elements to the telling of the story. In recent years the term *sound design* has come to describe the *foreground* use of sound as a storytelling element. This vital part of the post production process begins in earnest as picture editing nears completion. The sound post production is oftentimes scheduled to complete literally a few weeks ahead of the release.

Sound post production is usually thought of as having three distinct components: music, sound effects (or simply *effects*), and dialogue. In fact, on motion picture sound mixing stages (or *dubbing stages*), there are traditionally three mixers whose function is to oversee the mixing of each of these three components that have been brought to the stage after extensive sound editing and preparation. The *lead* mixer is responsible for the most

crucial of the elements, the dialogue. There has been a move over the years to consider two mixers, one for backgrounds and sound effects, the other for dialogue and music. This two-mixer configuration, while practiced on some features, is most popular outside of Hollywood, especially in New York. Most major Hollywood films that mix at the top mixing stages usually use three mixers.

Sound post production begins with selecting, or *spotting*, the areas of the film that will be enhanced with music, sound effects, and possibly dialogue replacement. This is usually done from as final, or *locked*, a version of the picture as possible. During this *spotting session*, the supervising sound editor will meet with the director, and usually the editor, watch the picture with them, and discuss the plan for the sound of the film.

During the session, it will be determined how much dialogue replacement is required. Dialogue replacement, also called *looping* or *automated dialogue replacement* (ADR), is necessary to account for line readings that the director feels can be improved or for technical issues such as live background sounds that interfere with the clear understanding of dialogue (for example, an airplane passing over during the scene). The supervising editor prepares a *spotting sheet* of the lines that need to be re-recorded, listing the time needed for each character so that the actors can be scheduled for their ADR sessions. These lines are often recorded in different cities because of an actor's current work commitments, and sometimes actors' schedules require that ADR be done before the picture is locked. In recent years, a number of technological ADR advances have been employed, such as mobile ADR studios and high-speed telecommunications connections, which link studios in different cities to record the actor's lines.

A similar spotting session is held with the composer, including the *music editor*, a job function both technical and creative. The music editor *cuts in* (or *lays in*) each musical *cue*, or section, often contributing creative ideas about when to use a music cue and when not to. It is common for the composer to see earlier unfinished versions of the film. This allows the composer to begin composing general themes and prepare for the types of scenes that will need to be scored. The composer is anxious to get final timings of scenes as soon as possible because the music score must typically be composed and recorded within a 4-week period of time.

During the picture editing, the editor will request temporary (*temp*) sound effects from the supervising sound editor. The supervising sound

editor will select (*pull*) these effects from a library for the picture editor, which will help make the film in process more realistic and believable. Due to the increased use of digital edit systems, the editor can deliver digital sound files from the edit system to help the sound effects process along by giving sound editors *in-sync* effects taken from production sound recording. These effects, along with others that the supervisor or the sound effects editor may choose, will be prepared for the eventual mix of the film.

Sound editors usually take on a single task such as dialogue editing, which involves assembling a complete dialogue track from the original sound that was recorded on the set. The dialogue editor will smooth out the dialogue track, eliminating lip smacks or other extraneous sounds so that the dialogue is more intelligible. The editor will prepare the dialogue with *handles* (extra frames of sound before and after words) so that during the sound mixing process, the mixer will have greater flexibility on how the dialogue can be mixed (for example, when multiple characters speak at once). Generally speaking, a dialogue editor can cut between 5 and 7 minutes of dialogue in one day.

Once the scope of the sound task is known, the supervising sound editor will divide the task of editing sound among a group of sound editors. Typically the sound post production will take 6 weeks from the locked picture to the completion of a finished mix, although on a large feature it will often take 6 weeks to do the final mix alone. During this "race to the finish" time period, all of the following steps must take place: the sound editing, ADR, music composition and scoring, *Foley* (the physical re-creation of specific sound effects), *pre-dubs* (preparatory mixes of music, dialogue, and effects) and the final mix. It is a hectic time in which all the final elements must come together to create the finished picture.

What makes this time even more harried is that sometimes the director makes picture changes during the sound editing or even on the mixing stage itself. The editors and assistants need to be able to react immediately to these changes by re-cutting the affected scenes and re-conforming the affected reels, providing either newly conformed workpicture or electronic viewing copies from the edit system for viewing the changed picture during the sound post process.

Digital sound technology, in music and sound effects creation, composing, as well as editing and mixing, has now become standard in the creation of the finished soundtrack. This new digital sound workflow is about to be joined by the increasing digital picture workflow due to new tools, creative approaches and new digital distribution opportunities.

THE MODERN MOTION PICTURE—THE NEW DIGITAL WORKFLOW

In considering the future of theatrical motion pictures, especially as it relates to what we in the early part of the 21st century are thinking of increasingly as Digital Cinema, it is important to note that this transition has been underway for more than 20 years. The worldwide computer and telecommunications revolution, as in so many other industries, has also provided our industry with a pathway to the evolution of cinema, in both creation and distribution.

Nonlinear Editing and the Birth of the Digital Workflow

Beginning in the early 1980s, the industry's toolkit has increasingly been filled with new tools that have emulated and extended the existing film process. The most important of these tools is the *nonlinear editing* (NLE) device, which set the stage for a totally new approach to post production.

The first of these devices—the legendary EditDroid (built by George Lucas's R&D team), the Ediflex, the Montage Picture Processor (a word processor for pictures), and the BHP (Bell & Howell Products) TouchVision—allowed film to be cut electronically in a very different way from the video editing devices of their day.

These new edit systems differed from both traditional film editing and video editing. Unlike film, which is physically cut and spliced together, they allowed non-destructive editing. Unlike video, where the first edit must be re-recorded to a new tape, and each successive edit re-recorded onto this new tape in a linear fashion, a cut could be made in any part of a scene or take. These early nonlinear devices were not digital, but rather electronic, using multiple copies on analog videotape or laser disc, which allowed for the illusion of *random access*, as the first cut was played from one tape or laser disc, the next from another, and so on. If a change needed to be made, the device would just play it another way. Nothing was ever physically cut or copied until someone wanted a copy, which was then output to tape.

Although imperfect and often cumbersome and clunky (the Montage had 18 Betamax VCRs and the Ediflex had 12 VHS VTRs, which noisily clattered as they switched from tape to tape to give the illusion of seamless play), these early devices pointed to a new way to edit film. The ability to attempt

an edit without having to worry about losing frames at a splice point was both liberating and maddening, as the endless variations of potential edit points could lead editors and directors in circles. Film editing, with its very cerebral planning of what will flow together, based on the immutable fact of a physical edit, was being challenged by an electronic upstart in which one could try out multiple edits in the same amount of time it would take to splice, undo a splice, and re-do an edit. Hailed by the early sales proponents of these devices as time and cost savers, electronic editing delivered neither. The cost was many times that of the film-based editing tools of the day, and hardly anybody saved time when those as yet unseen, endless variations were just a few clicks of the keyboard and one more edit away. This is the electronic editing equivalent of Parkinson's Law, which states that "work expands to fill the time allotted!" However, these new tools, as immature as they were, seemed tremendously attractive to a creative community that saw them as potentially powerful extensions of their creativity.

These new film editing tools were at the heart of the new methods that swept television post production introduced by Pacific Video's (which became LaserPacific) Electronic Laboratory process in 1984. The Electronic Laboratory spelled out a workflow that began with the scanning of film from negative on a telecine, transferred as best light, edited on a nonlinear edit system, conformed electronically, and then color-timed shot-to-shot and scene-to-scene on an electronic color correction system. This workflow, which was analogous to the film process, provided a new range of flexibility and quality. These imperfect but powerful new electronic nonlinear editing tools, the image enhancement associated with the transfer of film directly from the negative, and the practice of tape-to-tape color correction on new, more powerful electronic timing tools than were available in film, soon won many converts (see Figure 2.3).

For example, in 1984, 80% of prime time television programs were shot on film and 20% on videotape. Of the 80%, all but one show was edited on film. The exception was *Fame LA* whose editor was experienced in the linear video offline techniques of the day. By 1989, as a direct result of the impact of the Electronic Laboratory approach, of the 80% of television that was still shot on film, all but one show used electronic post production techniques. The last film holdout, steadfastly defiant and indifferent to these new ways, was the long-running Universal hit *Murder She Wrote*. In a short 5-year time span, film post production for television ceased, overtaken by a new electronic workflow that offered a new creative flexibility that was undeniable.

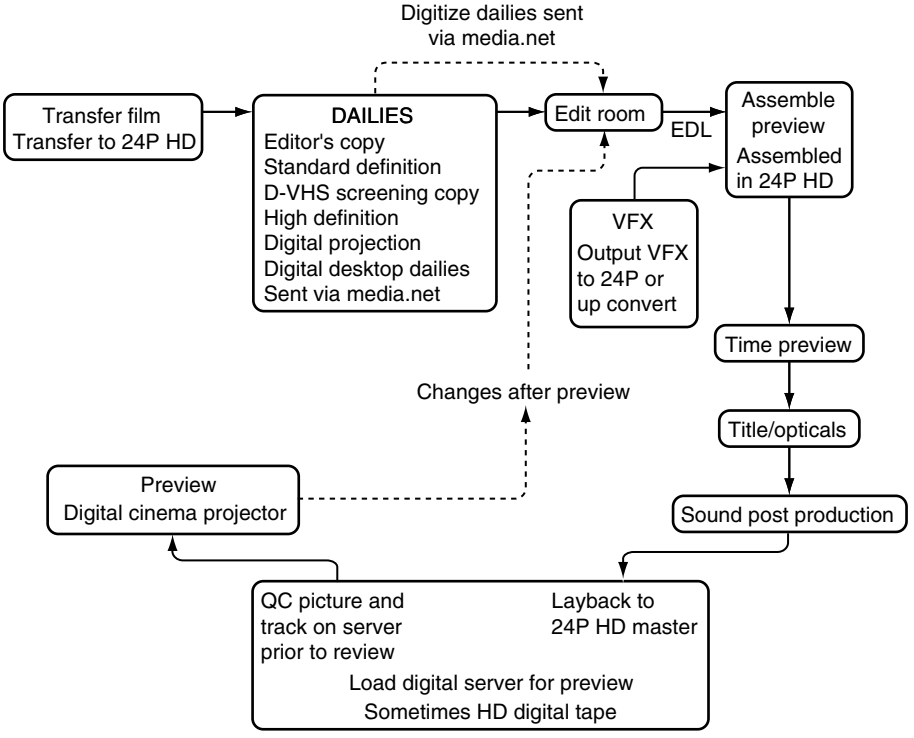

FIGURE 2.3 Digital preview workflow.

While the picture editing revolution was decidedly *electronic*, sound editing workflow was the first to become *digital*. Experiments with a digital sound effects library at the sound post production company Nieman-Tiller presaged the work that was to see the first fully realized end-to-end sound editing and assembly process in 1989. That system, introduced by Pacific Video and created by a company called Cybermation (later to become Waveframe), was the result of collaboration between Chuck Grindstaff, an aerospace signal processing engineer; his father, well-known film sound editor Doug Grindstaff; and Pacific Video and its President, Emory Cohen (who had hired Doug Grindstaff to help it enter the sound post production business).

This system was the digital equivalent of the physical splicing and preparation of magnetic film sound tracks. Like the early electronic picture editing tools, this system helped lead the way to the now virtually ubiquitous digital sound post production workflow. Sound was the industry's first digital process for a simple reason: in digitized form, sound's smaller file size

and storage requirements made it more practical for the era's relatively limited computer processing and storage technology.

Digital technology for pictures had begun to influence certain broadcast and post production applications beginning in the late 1970s in the form of new digital signal processing tools. Introduced by NEC by the now generic acronym DVE (*digital video effects*), these first digital tools took analog images and digitized them to resize an image within another (*picture in picture*) and move an image off the screen. Soon spinning digital cubes, page turns, and all manners of ways to fly images on and off a video screen became the rage in "video post production." Even though the Montage Picture Processor used digitized images as the picture reference in its electronic edit system, it was not until 1989 when the first practical digital edit systems premiered. That year at the National Association of Broadcasters (NAB) Convention and Exhibition, attendees marveled at a true digital edit system from EMC^2, which was acknowledged as a "hit of the show." Also, in a small corner in the back of the hall, a small Massachusetts-based company called Avid Technologies showed their approach as well.

Enabled by digital compression technology that allowed video images to be digitized at rates appropriate to the storage and computer power of the era, these new edit systems were not embraced by Hollywood at first. Because of the limitations of compressed image quality, which made it very difficult to actually see if dialog was in sync, and storage limitations that prohibited storing footage for a full reel, digital edit tools were destined to cut their teeth on short form projects such as commercials.

Soon rapid advances in digital compression image quality, along with computer processing and storage, helped to create a market for some evolved edit tools such as digital versions of the Montage and Ediflex. In addition, new edit systems such as the UK-built Lightworks, and early desktop tools such as the Media 100 appeared. But by 1992, Avid held the lion's share of the nonlinear edit market, displacing at that point many of these second- and third-generation nonlinear edit devices.

It is important to note that while a handful of motion pictures experimented with new edit tools, the electronic and digital post production revolution at first was decidedly a television phenomenon. Theatrical motion pictures did not embrace these tools for a variety of reasons. Traditional film editing devices such as the KEM simply displayed better images than these new edit systems. Negative to first-generation print presented a higher

resolution than even the finished release prints. Although the workpicture through cutting and handling becomes a bit beat up, scratched and dirty, the undeniable quality of the film image represented a very compelling reason to continue physically cutting film for movies. Having a film print made it possible to screen the picture in a theatrical environment on a big screen, which enabled the creative team to determine how it would play there by viewing it in the proper scope and scale just not possible on a video or computer monitor.

Many also felt that these tools were more geared to television than motion pictures. Editors and directors looked at the screens of electronic edit devices as low-quality televisions and felt that their art and the time-honored editing craft was somehow degraded if practiced in the TV way. In addition, the methods needed for creating proper lists and guidance for negative cutters were not initially developed for these tools. But eventually the power and flexibility of these new nonlinear digital editing systems became too attractive to ignore. The Lightworks edit system in particular featured the same film shuttle control as the KEM, which many film editors found friendly. The team from Avid took great pains to listen to editors and build features and capabilities based on their input. By the mid-1990s the majority of features was edited digitally, and by the end of the millennium the transition to digital editing was virtually complete. Avid's dominance of the edit system market for both television and features was so complete that it was a very rare exception if a Lightworks or a Media 100 was used on a project. Apple's Final Cut Pro promises to be the first new edit system to be seriously considered for features, although the few highly publicized films cut on the system are still very much the exception to Avid's continued rule.

By 2000, even though feature films were using electronic edit systems, virtually all motion pictures also continued to screen film dailies, as well as to conform the film workpicture to the digital cut. Now there were two edit rooms—one digital, one film—and the edit crew and budget grew to accommodate this structure. This budget and labor allowance became a true testament to the power of these new digital tools because once most directors and editors experienced their impact there was no turning back. One of the most notable exceptions to the complete digital transition is Steven Spielberg and his long-time collaborator and editor Michael Kahn, who prefer to physically cut film for what they feel are important creative considerations.

The Evolution of the New Workflow: on the Path to the Modern Motion Picture

As we envision the era of digital distribution of motion pictures, the post production process is undergoing significant and dramatic change. The Electronic Laboratory workflow that was once the domain of television is increasingly becoming a model for feature films as well. At the heart of this transition is the interest in *digital preview* and the promise of a complete end-to-end digital workflow.

Possible cost savings initially drove much of the interest in using high-definition post production workflow and digital projection for motion picture previews. But in practice, the quality of the images and the potential for time savings have also impressed many studios, producers, directors, and even cinematographers, who usually prefer to see film images.

In 1999, with LaserPacific's introduction of the 24P high-definition laboratory workflow concept, the industry quickly adopted high-definition post production at the same 24 fps frame rate as film. During that same time, companies such as Texas Instruments and JVC began showing new digital projection devices that were beginning to reproduce images more cinematically than existing video projectors.

Through the solicited input of the cinematography and technical community, these projector manufacturers began to become more knowledgeable and responsive to the needs and quality expectations of Hollywood's creative professionals. Texas Instruments, in particular, went out of its way to understand how the nuances of color, contrast, dynamic range, and resolution in film might be emulated in its digital projectors. Through a series of side-by-side digital and film projection comparison demonstrations (particularly in the Entertainment Technology Center's Digital Cinema Laboratory), they gained valuable feedback about how to create digitally projected images that were trustworthy.

One of the most important issues relating to the adoption of digital post production and Digital Cinema workflows and techniques has been the long-standing role of film as a predictable reference point for filmmakers. While that may seem self-evident, most cinematographers learn how different film emulsions, exposures, lighting characteristics, color timing, lab processes, and print stock affect the look of dailies or the finished film. This knowledge serves as the cinematographer's reference for the calibration of his or her work.

In a digital process such as a telecine film transfer, a colorist has the ability to alter the look of the digital transfer almost infinitely. Displaying the digitally transferred image on a digital projector can create an unnerving array of variables for a cinematographer whose expectations and career have relied on understanding his or her work in a film system, where the lab's film printer lights can impart valuable information about exposure and validate that the cinematographer accomplished what he or she set out to do.

This issue of how cinematographers and other creative film professionals will calibrate their work and expectations continues to be one of the major challenges of the new digital workflow. That being said, the adoption of digital preview is a significant step toward a complete end-to-end approach that will at some point help to define the modern motion picture as one with an increasingly accepted and trusted digital process.

Digital Preview and Potential Cost Savings

The continuing advances in digital projection technology have made it practical to display large-screen, high-quality cinematic digital images to preview audiences at the same local cinemas that currently house film previews. New, next-generation, high-quality, highly portable projectors also have made it possible for high-definition dailies to be screened on location and in studio screening rooms as part of this new motion picture post production process that results in a digital preview master.

The potential savings that drive the interest in digital preview screenings come from a number of areas. Many films that are previewing digitally reduce costs by reducing the film daily print and reprints. Most films using the preview process continue to print certain selected takes when there is a question of calibration or "how it will look on film." Some films are shot in Super 35 3 Perf (exposing either a 2.35:1 or 1.85:1 aspect ratio over 3 film perforations instead of 4). This results in a 25% savings in both film negative stock and processing. Printing any amount of film in 3 Perf is not very practical as there are few 3 Perf-capable film projectors to use for viewing. Additional savings also result by totally eliminating the daily print. The interest in 3 Perf is also related to the interest in using new digital intermediate finishing methods, since many are shooting 3 Perf as a trade-off for the costs of digital conform and digital color timing for release. In addition, with digital preview the film-conform cutting room (space, equipment, personnel, and

overtime) can also be eliminated. Furthermore, there can be a reduction of costs associated with creating temp opticals for preview.

Opticals and visual effects are one of the key reasons the digital preview process began. For films that have a significant number of incomplete VFX shots or opticals, a digital preview allows the VFX and optical teams to continue working on *finals* while temps are completed in a high-definition video environment or output from digital files to HD, without having to create *film outs* (film recorded from the digital data) of digital shots.

Digital Preview Workflow

Films can be previewed digitally by transferring a cut film workpicture to a digital master, with opticals, titles, and subsequent versions conformed digitally. Many who first realized the benefits of the digital preview used this process.

A second method involves outputting the current version of the cut directly from the edit system and *upconverting* (*electronically transcoding*) *standard definition* images to high definition for preview. Depending on the image quality of the edit system, this can result in a projected image of acceptable to marginal quality. Some studios and directors accept this marginal quality by comparing the process favorably to the workpicture, which at the time of a preview has been handled so extensively that it is certain to show wear and tear. Traditionally, preview screenings are initiated with a proviso to the audience that they have been invited to see a work in progress and should expect the film to look a bit rough.

A third method of previewing a film assembles the standard definition elements from the initial telecine transfer and upconverts this version for digital preview. This method can yield slightly better quality than output from the edit system.

But a fourth method is beginning to define a new workflow for motion pictures: a process whereby film negative is transferred directly to 24P high-definition digital videotape as dailies. This method also yields efficiency in subsequent preview screenings, featuring images significantly more pristine than can be derived from a cut film workpicture (see Figure 2.3).

Using this method, dailies can be screened in high-definition on a variety of devices including CRT monitors, plasma *flat panel displays* (FPDs), or with high-quality digital projectors. In the past, the quality of digital

projection, and the corresponding ability to discern critical resolution and contrast, was limited. Directors and cinematographers especially were concerned that these early-generation digital projectors could not adequately convey what had been captured on the film. These new breeds of D-ILA projectors from JVC, as well as projectors featuring the Texas Instruments DLP technology from a variety of manufacturers, represent a significant advancement in digital dailies screening projection technology with unprecedented resolution, contrast, and image quality.

Transfer Negative to 24P High Definition

The film laboratory processes each day's film negative, and if no daily print is needed, the film is usually available for the digital transfer earlier than if it was to be printed and synced on film. This unbroken-down negative is transferred and sunk with the production audio track in a telecine suite to 24P high-definition digital videotape. During this transfer the data needed for the edit system are generated. The color timing of this *digital daily print* is made, based on input from the cinematographer and consultation with the dailies colorist. The communication of this look from the cinematographer to the digital dailies process is a component that is crucial to the success of this approach.

Some cinematographers rely on a relationship with a colorist with whom they have worked in the past and whom they trust. Similar to the bond of trust with a film lab contact, this helps the cinematographer. There are often phone conversations discussing how to interpret the camera report notes or what might have been seen during the transfer. The colorist becomes the eyes of the cinematographer in the transfer of the images to the digital tape for dailies.

Look Management

New tools are evolving for *look management,* a process of communicating the intended look of the picture more directly to the post production process. In 1999, Panavision and Kodak launched a system called PreView, which enabled a cinematographer to better visualize and communicate the result of film emulsion, filters, lab process, and other variables to the

director and other collaborators such as the lab or the telecine colorist. The system consisted of a digital still camera, a thermal printer, and a laptop with software that could emulate these processes. While the system garnered significant interest, especially because of the power of the software, the early digital camera and print technology was immature and a bit cumbersome, and the system was not pervasively used. Many cinematographers devised their own methods, often using Adobe Photoshop to create still images that communicated their intended look. These systems too, had drawbacks, as it was difficult to create a print of the exact look on the digital screen. Oftentimes, these stills were sent as computer JPEG files, which itself became problematic because of the lack of calibration between display devices.

Kodak has recently introduced a new approach called the Kodak Look Manager System, which includes display management and calibration as part of the toolkit. The updated software package contains powerful emulation tools that enable the cinematographer to view the color, film stock, filtration, lab, and telecine processes on a calibrated viewing device, which is designed to match another calibrated device at the lab or in telecine. In this way, cinematographers can be assured that the look has been communicated and that all who view it are viewing it in the same way.

In addition to communicating the look to dailies, this tool also promises to actually communicate the intended look directly into the post production process. The vision is to codify the look as a recipe that will create a 3-dimensional *look-up-table* (LUT) that will modify the scanning (either as HD video or data scans) so that the intended look will be created as the image in dailies. The idea is that these LUTs would be traced through the post production process, allowing the look of the film to be created early in the filmmaking process and used to inform the other steps in *look realization*. These new tools, as well as others such as the TrueLight system being marketed by FilmLight, coupled with color management, promise to play a large role in creating a reliable and predictable digital process in the future.

Dailies Screening Copies

From the timed high-definition dailies master, various screening copies are generated. There are many options for high-quality dailies screening.

D-VHS

A new, cost-effective method is now available to screen dailies in high definition. Developed by JVC, *Digital VHS* (D-VHS) is a format that records a high-definition digital file on a new type of videotape that is the same size as VHS tape used in conventional VHS players. When this tape is played on a D-VHS VTR, high-definition images of higher quality than HDTV broadcasts can be displayed on digital projectors or high-definition monitors. This format has both a consumer and a professional variant. In its professional mode, it can be used to create a tape that can be played only in specific players, or groups of players, pre-designated for a specific production as a security precaution. In addition to this security feature, the VTR itself can be locked with a password. The role of security in the digital production process is an increasingly important issue that the technical and creative community is struggling to address.

Hard Drive Dailies

There are also a number of different systems that allow the viewing of high-definition dailies directly from a hard drive. While the quality of the image (MPEG2 at 25 mb/sec) is identical to D-VHS, the ability to create playlists or randomly jump from one scene or take to another is of great interest and utility. In film dailies, it is quite common to high speed through the film, especially when there is a lot of footage. While D-VHS does have a fast forward function, the ability to create a play list or store all of the dailies at once is a great attraction of these hard drive dailies systems.

When film dailies are printed, the negative is assembled in the order of the scene coverage, with all the cameras and the takes arranged in a meaningful way. In typical video dailies, the negative is transferred in the order that it was shot, because it is very slow and inconvenient and requires excessive negative handling to put up and take down camera rolls so that the transfer has the same *coverage order* (or *script order*) as print dailies. With a hard drive dailies system, the playlist function can be programmed to emulate this coverage order.

DVD Dailies

Another increasingly common method in which dailies are viewed is on DVD-R (recordable) discs. Unlike D-VHS or hard drive systems, dailies on

DVD are currently standard definition, albeit much higher quality than the VHS cassette, which still exists as a popular but low-quality method of screening dailies. For the most part, DVD dailies are intended for individual viewing and not the large-screen, high-quality collaborative viewing that is used for the high-definition dailies sources. Many post production facilities provide DVD dailies discs that allow the user to access individual scenes or takes. Some provide additional functionality such as viewing in coverage order.

Digital "Desktop" Dailies and Connectivity

The Internet and other private, high-speed telecommunications networks are also being used to transport dailies and other digital files such as for edit systems or for visual effects. The quality of images and the size of files that can be sent are directly related to the amount of bandwidth and connectivity available to the user.

For the most part, dailies sent and made available over the Internet are standard definition and can have quality ranging from VHS-equivalent to images that exceed DVD. Sometimes called *desktop dailies* because a computer is usually used as the receive station, these dailies can be stored on a computer hard drive and played through a computer monitor, laptop, or television set if the computer is equipped with a graphics card with *video out.*

There are a number of set-top devices that can be used to connect to a DSL or a higher-bandwidth Internet line to serve as the receive or send station for digitally delivered dailies. It is increasingly common for films shot outside of the United States to send or receive dailies or versions of cuts through the Internet, by either posting to a website that can be viewed from an authorized computer or to one of these set-top devices.

Another use of these networks is to send digitized edit system data directly to the cutting room. Post production houses routinely create digitized files for the edit system and can transmit these files directly to the cutting room, assuming sufficient bandwidth and connectivity. In addition, this technology can also be used for creative collaboration sessions. A typical use might enable a remote working session with an editor and a director in different cities. By using a private network or the Internet, the editor can show a cut to a director who can comment and direct changes in real time as they both watch. Dailies using efficient new compression schemes such as MPEG 4 and Windows Media9 may soon result in practi-

cal high-definition images sent over telecommunication links. Next-generation blue laser-based DVDs, which can also hold high-definition content, could very well be used in dailies well before their consumer debut, due to current industry effort to define standards and security issues prior to a consumer introduction of the high-definition DVD.

The Edit Room and the Digital Workflow Process

The digital preview process allows the cutting room to start working considerably earlier than with traditional film dailies. There is no need to sync and code the track prior to the transfer. And because the editor's source material comes directly from the negative to a high-definition transfer master, the downconverted standard definition image and sound quality in the edit system are superior to the typical print transfer video dailies.

The editor has a number of options of how the dailies will be digitized into the edit system. Whereas 3/4″ videotape cassettes are still one choice, the poor image and sound quality make them the least desirable source. BetaSP, while a component source, is still an analog format in both picture and track and is prone to tape damage and *dropouts* (momentary loss of image because of uneven magnetic coating on the tape). Edit systems are beginning to be equipped with digital tape decks such as DVCam and DVCPro, which offer a clean digital component picture and digital track from which to digitize into the edit system.

But increasingly, the most desirable choice for the edit system is a direct digitization from the high-definition master to the standard definition edit system file. Many post houses provide a service in which the edit system files are either transferred to portable digital hard drives (typically *IEEE 1394*, sometimes called *FireWire*) or sent directly to the cutting room via a network service provider. The main advantages of digitized edit system files are, first, superior picture quality and, second, that cutting can begin as soon as the edit room receives digitized edit system files. In addition, the sound files are of the same digital quality as what was recorded during production. This means that these files can be used as the source for dialogue editing for the final mix, by merely outputting the editor's digital sound for delivery to the post production sound crew.

Additional significant benefits are derived due to the better image quality in the edit system, so output tapes are far superior to the poor quality tapes that directors and executives have had to put up with for many years.

Preparing Visual Effects for Preview

In the digital preview process, fades, dissolves, freezes, and variable speed effects that are part of the edit decision list are automatically assembled as part of the preview assembly. Other visual effects that are to be part of the preview need to be transferred to 24P high-definition in order to be inserted into the preview assembly. If these visual effects are computer-generated and the visual effects house does not have the capability to transfer to 24P high-definition videotape, there are many methods by which visual effects files can be transferred to high-definition.

Preview Conform / Assembly and Color Timing

Once the film is ready for preview, it is assembled from its high-definition sources to a high-definition master. The film is then color-timed digitally using a digital projector with the same characteristics as the one that will be used in the theatre preview. This is a departure from the model of previewing film, where the workpicture is generally not re-timed. Directors and cinematographers are beginning to use the opportunity of digital preview timing as a way to visualize the final timing of the picture. If the film is to be finished digitally in the digital intermediate process, this early timing session allows the filmmakers to understand how the film might be digitally timed for the final release. As end-to-end systems are developed, it is envisioned that this preview timing will be applied to a subsequent data scan and digital timing for film record or digital cinema.

Once timed, any temp titles for preview will be electronically prepared and inserted into the preview master. During this session, any opticals that were not inserted prior to the assembly or additional opticals such as blow-ups, repositions, or other opticals that can be accomplished in an electronic environment are inserted into the picture.

Temp sound editing and mixing for the preview is done to a video version of the picture derived either from the output of the edit system, from a downconverted copy of the assembled high-definition preview master, or in some cases (as sound stages become equipped) from the high-definition version. The picture is edited and mixed in reels. Once mixed, a final (*print master*) version is created on digital hard disc or digital audio tape to be used to *lay back* (*transfer*) to the 24P high-definition preview master reels.

Building the Preview Element

After sound post production, a high-definition version with the final six track mix is created on D-5 high-definition tape (the *long play version* or *preview master*). This long play version on videotape can be used as a source for the preview, to load a digital server that will play the picture and track during the preview, or for the various tape copies of the film that are ordered for studio marketing or production executives after the preview. The HD D-5 videotape format is usually used because this format can accommodate up to eight tracks of uncompressed digital audio.

Load and QC Server for Digital Preview

A digital server, such as the QuBit made by QuVIS, is a common device used for digital previews. The advantage of using such a server is that these devices store a digitized version plus a back-up version (a *mirror*) that will play instantly if there are any problems with the main digital file. In addition, these devices can be programmed with a playlist so that only the changed reels need to be loaded for subsequent previews. These devices provide very high-quality images and sound and are portable and straightforward to run at the preview. Sometimes, an HD VTR is used to run the picture at previews, but these devices are usually more expensive and do not have an automatic back-up mode.

Once the preview master is created, either on a server or on tape, a complete quality evaluation of the main and back-up picture and sound elements are conducted to verify that the elements are ready for preview. Generally, the layback of the track, the creation of the long play, the loading of the server, and the QC can be done in one day and usually take place the day (and evening) before the scheduled preview.

The Digital Preview at the Theatre

There are certain theatres that have installed digital cinema projection technology that have been used for previews. However, these theatres are generally not in the outlying or suburban areas preferred for previews, so digital projectors are usually brought into an existing film cinema. Digital projectors used for previews can be set up within a few hours. It is common either to use a theatre's view port or to move the existing film projector aside to accommodate the digital projector.

Subsequent Previews

After notes are compiled from a preview, editorial changes are made in the edit system. The changes are then conformed in a second high-definition assembly and any un-timed or changed footage is timed, the server is again loaded with any changed reels, and another QC takes place. The projector and server are brought to the theatre, and if there are any changes from this second preview, the changes are re-conformed and timed before any subsequent previews.

Finishing Films Digitally

The digital preview is only one aspect of the dramatic and radical technological change in motion picture post production. The significant interest in finishing films using digital color timing and then creating film, digital cinema, and electronic delivery versions has touched an undeniable nerve in both the technology and creative community. This process, sometimes referred to as the *digital intermediate*, *digital film finishing*, or *digital mastering*, has been the focal point of many who look at this new post production workflow as the wave of the future.

There are some who predict that by 2007, it will be only the odd motion picture that will utilize the photochemical process that has defined the film workflow since its inception. There are some who feel that film itself will become threatened as an origination medium as new digital cinematography tools become increasingly powerful and accepted by the creative community. And without a doubt, there are others who feel that film will be part of our industry for many years to come. But there seems to be little doubt that the post production process will become digital and the transition will be as rapid as any technology adoption in motion picture history.

The origins of this digital pathway can be traced to a system of hardware and software developed by Eastman Kodak in the early 1990s. Practical digital film scanners coupled with Kodak's Cineon software allowed negative film to be digitally scanned, manipulated in digital workstations, and then recorded back to film on new digital film recorders. The significance of this systems approach was that the resulting digital images could be recorded back to film in a way that allowed the digital files to be seamlessly intercut with the adjacent film scenes. Cineon enabled digital

visual effects on a scale and at a quality level that revolutionized the industry. Theatregoers soon became connoisseurs of extraordinary images of amazing realism and scope. The new digital visual effects industry could quite literally make believable dinosaurs once again walk the earth as audiences eagerly anticipated releases of films that demonstrated this new digital artistic prowess.

In the early 1990s, digital editing devices were just beginning to make their inroads into the motion picture post production process. The early notion of complete digital post production workflow revolved around the very complex computer programming-intensive and almost secret society world of those who practiced the "black art" of visual effects. This was a world of Jolt Cola-imbibing young digital artists, code writers, and a few who made the transition from film opticals and effects to computers.

This digital community, with their powerful new tools and the images they produced, began to redefine the world of opticals and visual effects. Like the other electronic and digital workflow transitions that had taken place in sound, picture editing, and film and television post production, the photochemical optical and visual effects process was quickly becoming anachronistic.

In 1998, filmmaker Gary Ross explored the notion of using this digital visual effects technology to create whole scenes of his acclaimed *Pleasantville* in which color would subtly creep into the black and white world in which much of this film took place. This use of digital technology, and Ross's collaboration with Kodak's Cinesite, raised significant industry awareness of how these new tools might be used for something other than strictly visual effects. However, the model of this workflow was still very much visual effects-oriented, as *Pleasantville*'s digital scenes were still post produced and thought of as so many VFX shots, sort of an extended set of color opticals.

In 2000, the Coen brothers, stimulated by their cinematographer Roger Deakins, enlisted Cinesite's help and expertise to help create an entire film using a digital workflow. The result was the birth of a new digital methodology. The idea was to scan an entire film into digital files and then to use the tools to color-time the full picture in a way that simply was not possible in film timing. *Oh Brother, Where Art Thou?* was essentially entirely a color optical. Using the stylized look of the color-timed files, a Kodak laser film recorder digitally recorded the entire film onto the same intermediate film stock used for the creation of interpositives and internegatives. This digital intermediate element was now essentially a replacement for the cut

negative and could be used as the source for the printing elements for release. Originally meant to refer to the physical element that was the result of this digital scanning, color timing, and film recording, the term *digital intermediate* has become a colloquial reference for the entire new digital post production workflow.

The Digital Intermediate

This idea of the digital intermediate, born from visual effects workflow, was almost instantly acknowledged as a significant development. Cinematographers as well as directors hailed an expanded palette enabled by powerful digital color timing tools. The digital intermediate process was further popularized by the entry of EFILM, which had significant expertise in creating film from digital files for visual effects, as well as Technicolor, which made a significant investment in creating a new infrastructure for digital film finishing.

The process essentially consists of scanning the negative, conforming the negative digitally, importing and integrating visual effects elements, color timing, recording the finished timed movie to film, and creating various other delivery elements from the digital files.

In order to begin the digital intermediate process, the negative is scanned on a digital scanner. The early, very slow scanners required 6 seconds or more per frame for 4K resolution (4096×3072 pixels for the full 35mm frame), but the newest ones scan the negative at 2K resolution (2048 ×1536 pixels for the full 35mm frame) in real time at 24 fps and 4K resolution at 6 fps. Current scanners differ in speed, their ability to hold an image steady in "pin registration," their optical systems, their ability to scan at various resolutions, and their own imaging characteristics.

While those wishing to take advantage of the digital intermediate process have been driven by the flexibility in color timing, the importance of quality considerations also looms large. Much of the industry has focused on resolution as a key and important element in determining quality. An issue of hot debate has been the question of "How many Ks are OK?" with "Ks" referring to the thousands of pixels in the horizontal or vertical dimension that comprise a digital frame. There have been industry scientists, most notably Roger Morton and his team at Eastman Kodak, who have described a film system in which the negative has potential resolution of 6K or

more.[1] Others disagree, and claim that the negative through the film print process barely yields 2K resolution.[2] This issue of pixel resolution has also been hotly debated in the context of setting digital cinema standards of quality.

The most common practice today is a workflow in which color timing is done at 2K from files that may have been scanned at 2K, 4K, or 6K and then *down-rezed* or down-converted to 2K resolution. There is a general industry consensus that anticipates a 4K workflow when it becomes practical to do so. Computer processing power, digital storage, and network capacity need to undergo significant improvement in capability and cost effectiveness in order for the industry to move in that direction. Even though 4K is the goal of many in both the creative and technical community for digital cinema, as well for the digital post production process, there are some who feel that today's film lenses and film systems are just not capable of exhibiting moving images with that much resolution. That being said, everyone in the industry wants to be assured that the cinema of the future and the process by which it is made and exhibited are not compromised or hamstrung by setting the quality bar too low.

Initially, the negative for the digital film finishing process needed to be cut in order for it to be scanned. It was cumbersome to scan from unbroken-down camera or lab rolls, as the devices and software that ran them had no easy way to find the needed negative section from the edit decision list. Now, most of the devices and companies that offer these services can scan from the sometimes thousands of camera rolls and find the exact frames that need to be used for the timing and finishing process.

Once scanned, the individual frames need to be assembled into the film exactly as edited so that the film can be timed. If cut negative is scanned, the film is largely intact except for any visual effects shots or opticals, which may need to be inserted or created. If camera reels or uncut negative are scanned, most companies have devised a way to conform these individual files into the assembled picture. The task involves translating an edit decision list that specifies feet and frames, key numbers and time code into a

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[1] R. Morton, M. Maurer, and C. DuMont, "An Introduction to Aliasing and Sharpening in Digital Motion Picture Systems," *SMPTE Motion Imaging Journal*, May 2003, Vol. 112, No. 5, pp. 161–171; "Relationships between Pixel Count, Aliasing, and Limiting Resolution in Digital Motion Picture Systems," *SMPTE Motion Imaging Journal*, July 2003, Vol. 112, No. 7, pp. 217–224.

[2] V. Baroncini, H. Mahler, and M. Sintas, "The Image Resolution of 35mm Cinema Film in Theatrical Presentation," *SMPTE Motion Imaging Journal*, February/March 2004, Vol. 113, No. 2 & 3, pp. 60–66. But also see R. Morton, A. Cosgrove, and A. Masson, "Letter to the Editor Re: 'The Image Resolution of 35mm Cinema Film in Theatrical Presentation,' " *SMPTE Motion Imaging Journal*, April 2004, Vol. 113, No. 4, p. 102.

conforming list that assembles the 150,000 or more individual digital files into a movie.

One of the most daunting tasks in this new digital workflow is accounting for visual effects shots. Invariably last minute in nature, it is ironic that the visual effects workflow that spawned this new digital post production workflow has had a hard time integrating within it. That is because the digital visual effects workflow was created with film output as its target and cutting the output film into negative as its method. With a complete digital post production workflow, the calibration of scanners, displays, and color management becomes critical. In addition, finding efficient methods of inserting the "bushel baskets" of shots delivered on computer drives, data tape, film for scans, over the Internet, and in file formats different from the other data has made the integration process challenging. Of course, since the entire digital process gives the creative community the impression that anything can be changed instantly, it invariably is. While the tools might allow last-minute iterations and changes, the process of updating all the changes is certainly not currently efficient or painless.

Once conformed, the digital timing process begins (although conforming and changes also take place during the timing process). Timing environments initially resembled the telecine suites that were familiar to the directors and cinematographers who had used video color correction tools for creating commercials or home video releases. Currently more of these environments are being built to simulate theatres, with large screens and digital projection so that the scope of the film can be taken into account during timing. The tools are also evolving as software-based color correction devices, more powerful than today's telecine-type color correction tools, are augmenting hardware color correction. Remember that LUTs have several capabilities: they alter the display device to emulate film, take the digital data to film, alter the data to play on television, and create images for digital cinema. Modeling the complex digital-to-film process so that the images viewed in the digital environment can be delivered on film has become the "secret sauce" that differentiates competitors within the service business. In what only can be described as the "Battle of the LUTs," these proprietary approaches yield a "my LUT is better than your LUT" pitch to potential customers. As there are no standardized approaches to color management in the workflow, many facilities have created "home brew" LUTs.

Color management and look management that allow for consistency and predictability are topics that echo loud in discussions of the new digital work-

flow. A management process that accounts for different display devices and media and accurately emulates the look of the image in these differing environments is a key goal to both digital motion picture creation and distribution. Digital cinema would simply not be possible without the assurance of color management. The digital post production workflow must include processes whereby images intended for film, digital cinema, and home video distribution can be created and viewed with the assurance that they will be correctly displayed.

Post Production Evolves

Indeed, much of this new digital workflow is evolving as are the roles of industry professionals. The digital timing medium allows directors and cinematographers to extend production beyond the limitations of principal photography. The ability to alter expectations in production, such as knowing that *magic hour* (the time before the sun has risen or after the sun has set, but the sky is bright enough for good tonal rendition) can be achieved in post production with significantly more control than for a crew waiting for the sunrise or the sunset to be "just right." The knowledge that certain parts of a scene might be "lit" in a digital timing environment more efficiently and cost effectively might lead cinematographers to light differently. These emerging powerful tools will allow for new kinds of lighting and looks.

One of the issues that burns the midnight oil in the venerable clubhouse of the American Society of Cinematographers is the question of who will be responsible for creating and utilizing this new palette. In an era when everyone, even amateurs, has access to powerful image manipulation tools such as Photoshop, cinematographers are very concerned that they not play secondary roles to other collaborators in the process. The ascendant colorist who commands attention and remuneration has been a linchpin in many decisions to try these new post production paths. The visual effects supervisor is increasingly playing a role in creating the look and lighting feel of a film. Digitally mastered movies such as *The Lord of the Rings* point to a new type of film in which the cinematographer might photograph a scene in a very straightforward way, but the post production teams of visual effects, colorists, and directors might actually realize the ultimate creative vision.

This evolution of the digital workflow process, directly descendant from the visual effects workflow, might very well diverge into a VFX path

and a more production-oriented path. With evolving look management and color management tools, it will be possible to track the creative look intent from the earliest pre-visualizations through the dailies, preview, and final timing process. In this way, all the color and look decisions in production could follow along and inform the post production process of the color choices that were made in dailies and previews. Of course any of these choices could be changed in the film digital mastering for film recording and other distribution. Today's digital intermediate workflow, in which the negative is scanned and the color decisions happen at the end of the process, could be made more efficient if the color workflow and management were part of the process from the beginning.

This new workflow will encompass a process by which many forms of distribution elements will be created. It will surely be influenced by the Digital Cinema specifications being articulated by *Digital Cinema Initiatives* (DCI), the consortium formed and funded by the seven major Hollywood studios, and by standards created by SMPTE (Society of Motion Picture and Television Engineers). At the junction of these new post production pathways, there must be color management that will allow the creative community to take advantage of new digital methods and tools in a transparent and seamless way. This workflow must allow for the creation of 35mm film that will be part of the distribution chain for quite some time as well as ensure that digital elements embodying the creative intent can easily be generated.

An important question the industry needs to address in the new digital era is, with increasing amounts of images no longer represented by physical film but by data and files, how will motion picture elements be archived? The notions of digital archiving and digital asset management, which seem to so easily roll off tongues of vendors, especially at industry technical conferences, are illusory at best. Many industry professionals who are charged with the task of maintaining the libraries and archives of the major studios remain unconvinced that there are good current long-term and deep archive solutions to store digital data. This issue remains high on the list of tasks that need to be accomplished before these new digital ways will be considered robust.

This new post production workflow, which may very well allow filmmakers to exhibit and distribute the most pristine, highest quality cinematic images ever, is still a work in progress. But it is progress itself, and the dedication of countless industry professionals, that feel a calling to create the infrastructure for a future cinema that can be truly worthy of its past.