cinematography

theory & practice

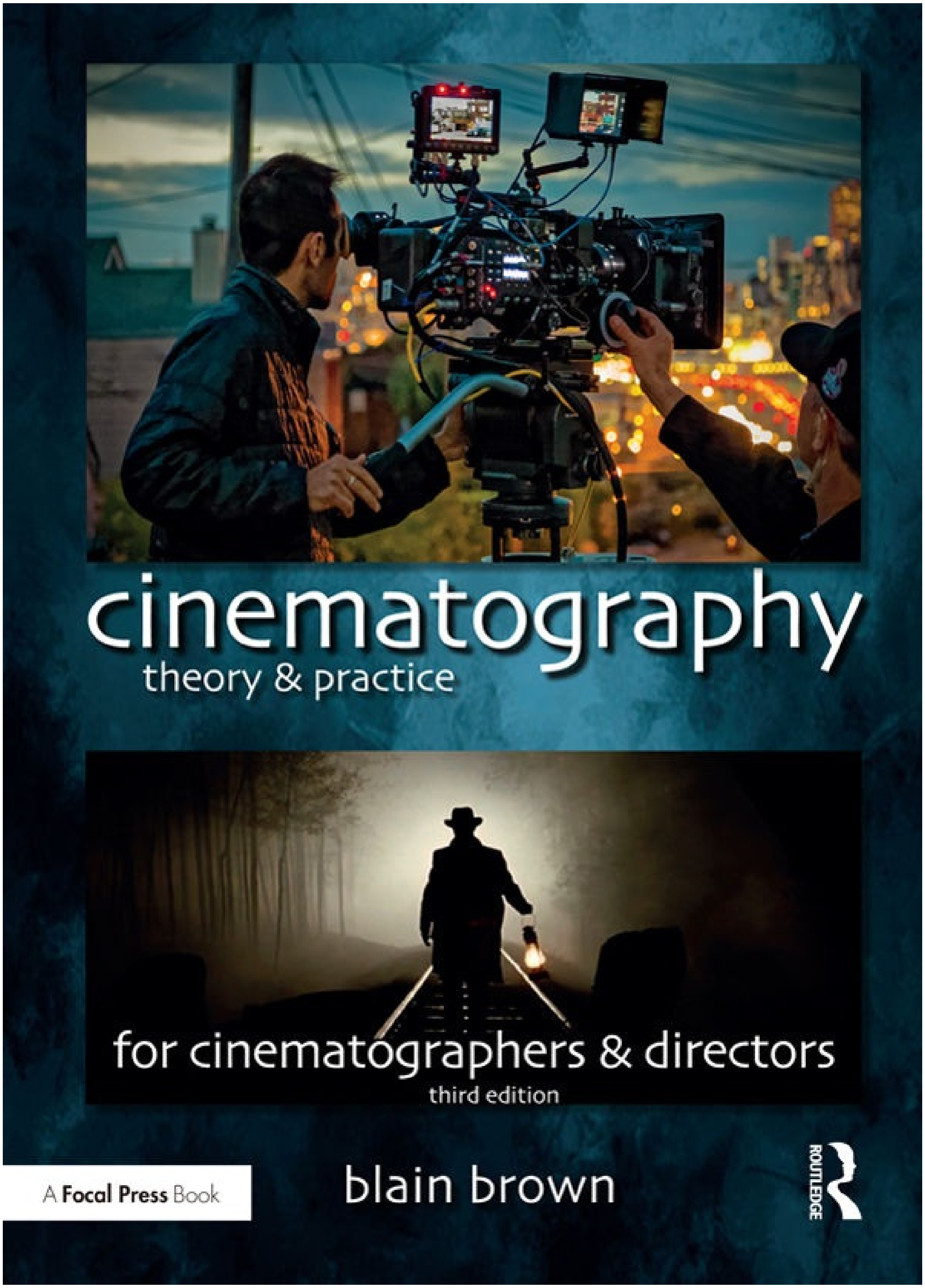
for cinematographers & directors

third edition

blain brown

A Focal Press Book

ROUTLEDGE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introduction

Film production has changed massively in the last few years. In many ways it has been as big a change as started in 1929 when the introduction of dialog recording forced the entire industry to alter the basic methods of shooting film.

Digital is, of course, the big change this time. Cinematographers, camera assistants, loaders, and operators have to learn new skills and methods. New job categories have been added—*Digital Imaging Technician* (*DIT*), *Digital Utility*, and *Digital Loader* and, importantly, the workflow from camera to distribution has been radically altered.

Using the new technology as a DP, director, editor, and postproduction artist is still evolving, and exciting new developments emerge regularly. For directors, the changes have been more subtle but they are there; the same applies to producers. In all cases, the changes create new opportunities and possibilities.

At the same time, most of the traditional skills are still critical to success in the camera department. For the DP, a deep understanding of the tools, techniques, and artistry of lighting is still essential. For the camera crew, the protocols of ensuring that everything is good and proper with the equipment is still critical. Focus and optics remain much the same and, of course, elements of visual storytelling such as composition, camera movement, color, and staging are as important to the overall success of a project as they have ever been.

New challenges, new technology, and new tools to learn — these are things the camera department has loved and embraced since the days of Thomas Edison. Let’s get started!

Figure 1.1. A frame from Orson Welles' *The Lady From Shanghai*.

writing with motion

WRITING WITH MOTION

The term cinematography is from the Greek roots meaning “writing with motion.” Cinematography is more than just photography; it is the process of taking ideas, words, actions, emotional subtext, tone, and all other forms of nonverbal communication and rendering them in visual terms. As we will use the term here, cinematic technique is the entire range of methods, and techniques that we use to add layers of meaning and subtext to the “content” of the film—the actors, sets, dialog, and action. The tools, the techniques, and the variations are wide ranging in scope; this is at the heart of the collaboration of the DP and the director.

BUILDING A VISUAL WORLD

When we create a film project, one of our primary tasks is to create a visual world for the characters to inhabit. This visual world is an important part of how the audience will perceive the story; how they will understand the characters and their motivations.

Think of films like *Blade Runner*, *Casablanca*, *Fight Club*, *O Brother*, *Where Art Thou?*, or *The Grand Budapest Hotel*. They all have a definite, identifiable universe in which they exist: it consists of the locations, the sets, the wardrobe, even the sounds, but to a large extent these visual worlds are created through the cinematography. All these elements work together, of course—everything in visual storytelling is interrelated: the sets might be fantastic, but if the lighting is terrible, then the end result will be substandard.

Let’s look at this sequence from early in *Blade Runner* (Figures 1.2 through 1.5). Without a single line of dialog, we know it is a hightech, futuristic world; giant electric signs and flying cars. The extravagant skyscrapers and squalid street life tell us a great deal about the social structure. In addition, it always seems to be raining, hinting at dramatic climate change. Picked up by the police, Deckard (the Harrison Ford character) is taken by flying car to police headquarters, landing on the roof.

Once inside, there is a sudden shift: the interior is not futuristic at all; in fact it is the inside of the Los Angeles train station—it is Mission Revival in its architectural style. Why an 18th-century looking building as a location choice? One thing you will learn as a filmmaker is that everything has to be for a reason—for every choice you make, whether in the story, the location, the props, whatever. Random choices do not help you tell your story. These choices may not always be conscious decisions (although all the major ones should be), but to simply "let things happen" will almost never result in a coherent, smooth-flowing story that conveys your original intentions in the way you wanted. The camera cranes down to the roof of an office and we discover… trash. It continues down to the captain's office. Its style and set dressing seem completely anachronistic: wood filing cabinets, a desk fan, an old TV. Why?

Then Deckard enters and his trench coat with the upturned collar provides the final clue: this could easily be a scene from a film noir detective story. The director is sending us a simple message: this may be the future with flying cars and replicants, but at the heart of it, this is an old-fashioned detective story with a hard-boiled sleuth and a femme fatale—all communicated entirely through visual means.

So how do we do it? As cinematographers, directors, production designers, and editors, how do we accomplish these goals? What are the essential elements we work with and manipulate to create this visual world?

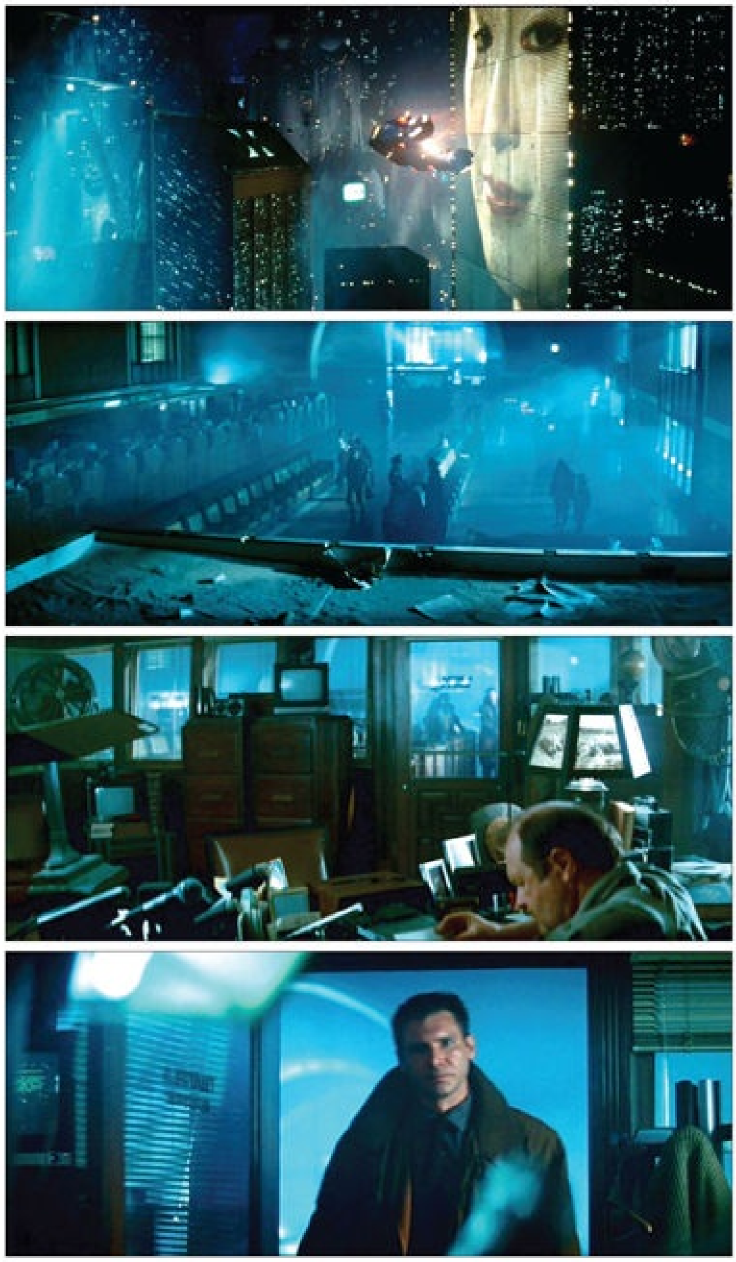


Figure 1.2 through **1.5.** Visual elements carry the story in this early scene from *Blade Runner*, but they also supply important visual cues about the subtext and tone of the narrative. This is the essence of visual storytelling: to convey meaning to the viewer in ways other than words—to add levels of meaning in addition to the dialog and action

If cinema is a language, then we must ask: what is the structure of that language? What is the vocabulary, what are the rules of grammar, the structure of this cinematic language? What are the tools of cinematography and filmmaking—the essential techniques, methods, and elements that we can use to tell our story visually?

THE VISUAL LANGUAGE OF CINEMATOGRAPHY

What we're talking about here is not the physical tools of filmmaking: the camera, dolly, the lights, cranes, and camera mounts, we are talking about the conceptual tools of the trade. So what are they? What are the conceptual tools of visual storytelling that we employ in all forms of visual storytelling? There are many, but we can roughly classify them into some general categories.

- The frame
- Light and color
- The lens
- Movement
- Texture
- Establishing
- POV

Figure 1.6. Strong visual elements tell us a great deal of the situation of the character in the opening frame of *Punch-Drunk Love*.

THE FRAME AS DEFINITION

Selecting the frame is the fundamental act of filmmaking; as filmmakers, we must direct the audience's attention: "look here, now look at this, now over here…" Choosing the frame is a matter of conveying the story, but it is also a question of composition, rhythm, and perspective.

Take this opening frame from *Punch-Drunk Love* (Figure 1.6). It gives us a great deal of information about the situation and the main character. Instantly, we know he is isolated, cut off from most of the world. The wide and distant shot emphasizes his isolation and loneliness reinforced by the color scheme and the lack of wall decoration. The dull, shapeless overhead fluorescent lighting underscores the mood and tone of the scene. Finally, the negative space on the right not only plays into the isolation and loneliness but into the possibility of something about to happen.

The strong lines of perspective, both horizontal and vertical, converge on him, “pinning” him in his hunched-over position. Without a word being said, we know a great deal about this person, his world, and social situation, all of which are fundamental to the story.

This frame from a beach scene in *Angel Heart* (Figure 1.12) also communicates a great deal: something is odd, out-of-balance. In unconventional framing, most of the frame is sky: negative space, we barely see the beach at all. One man is bundled in a coat, the other in a T-shirt, even though it hardly seems like good tanning conditions. The viewpoint is distant, observational. We know this is going to be no ordinary everyday conversation. Even when the dialog begins and you would normally expect the director to go in for close-ups, the camera hangs back, reinforcing the strangeness of the situation.

In this scene from *The Verdict* (Figures 1.8 and 1.9), the entire story is at a climactic point: the trial has reached the end, the lawyer (Paul Newman) has had his entire case thrown out, witnesses disqualified, evidence excluded. He has nothing left but his final summation, and everything depends on it. Even though the courtroom is crowded, he is surrounded by empty space: isolated and alone visually, this reflects his situation—he is utterly on his own at this point. Lines of perspective cut him off and lead the eye constantly back to him.

Figure 1.7. This frame from *The Dark Knight* uses strong color, lines of perspective, and movement to create a powerful image.

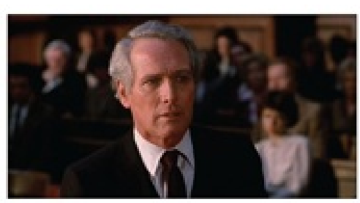


Figure 1.8 and **1.9.** This scene from *The Verdict* starts with a wide shot, then *pushes in* to a close-up.

A lamp hangs over his head like the sword of Damocles as if it might come crashing down any instant. All eyes are turned toward him at the almost exact center of the frame; clearly the weight of the world is on him at this instant.

Everything about the visuals tells us that this is his do-or-die moment—that everything about the case, and indeed about his entire life, depends on what he is about to say. As the scene builds in a continuous shot, the camera slowly pushes in to a medium shot, thus excluding nearly everything else in the courtroom and focusing the viewer's attention on him alone: other people still in the shot are out of focus. Perspective also plays a role in this frame from *The Dark Knight* (Figure 1.7), as does strong color and motion blurring.

THE VIEW OF THE LENS

Again, we are not talking about the physical lens, what concerns us here is how various lenses render images in different ways. This is a powerful tool of visual storytelling—the ability of optics to alter our perception of the physical world. Every lens has a "personality"—a flavor and an inflection it adds to the image. There are many factors involved: contrast and sharpness, for example, but by far the most influential aspect of a lens is the focal length: how wide or long it is. A short focal length lens has a wide field of view; a long focal length is like a telescope or binoculars, it has a narrow field of view.

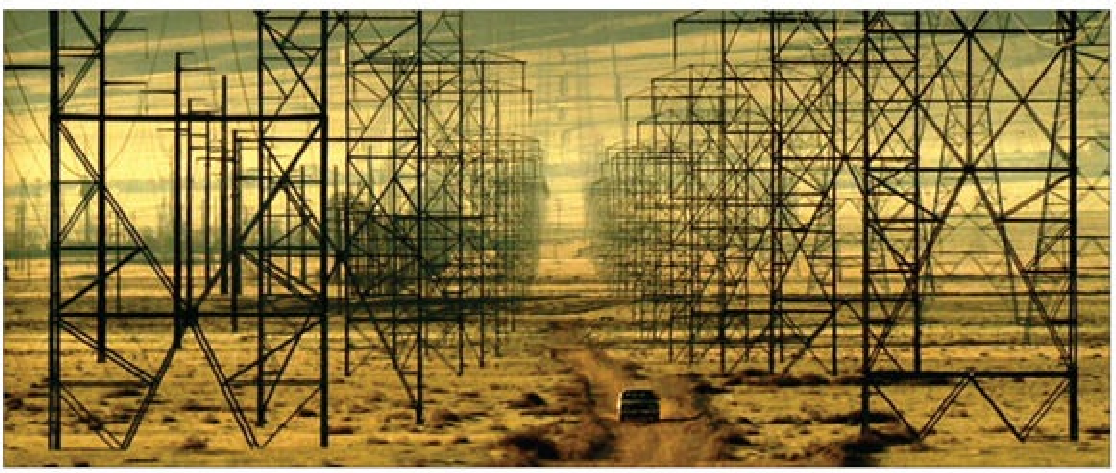


Figure 1.10. The compression ofspace created by a very long lens establishes the visual impression of a trap, a spider's web, in the final scene of *Seven*—an excellent example of *visual metaphor* in cinematography.

Figure 1.11. A very wideangle lens creates distortion for effect in this shot from *Delicatessen*.

A long lens compresses space and a wide lens expands and distorts space—these can be very powerful storytelling tools. Look at this frame from *Seven* (Figure 1.10). The extremely long lens compresses the space and makes the transmission towers seem like they are right on top of each other: the visual metaphor it establishes is a spider's web, a trap. It is a powerfully graphic and arresting image that precisely reinforces the story point at that moment. We see the opposite effect in the frame from *Delicatessen* (Figure 1.11). Here an extremely wide lens expands our perception of space and distorts the face—it has an effect that is both comedic and ominous.

COLOR AND LIGHT

Light and color are some of the most powerful and flexible tools in the cinematographer's arsenal. Lighting and controlling color are what takes up most of the director of photography's time on most sets and for good reason. They also have a special power that is shared only by a very few art forms such as music and dance: they have the ability to reach people at a gut, emotional level.

This is the very definition of cinematic language as we use the term here: visual tools that add additional layers of meaning to the content of the story. In a climactic frame from *Blade Runner* (Figure 1.13), the stabbing shafts of light and silhouetted bars on the window instantly communicate a man ensnared in a hightech nightmare world.

Figure 1.12. A frame from *Angel Heart* that is unbalanced frame both horizontally and vertically lends an air of tension and creates of sense of things being out of kilter in the world.

Figure 1.13. Stabbing shafts of light emphasize the danger and tension of this climactic scene from *Blade Runner*.

VISUAL TEXTURE

These days, we rarely shoot anything "straight"—meaning a scene where we merely record reality and attempt to reproduce it exactly as it appears in life. In most cases—particularly in feature films, commercials, and certainly in music videos—we manipulate the image in some way, we add some visual texture to it; this is not to be confused with the surface texture of objects. There are many devices we use to accomplish this: changing the color and contrast of the picture, desaturating the color of the image, filters, fog and smoke effects, rain, using unusual film stocks, various printing techniques, and of course, the whole range of image manipulation that can be accomplished with digital images on the computer—the list goes on and on. Some of these image manipulations are done with the camera, some are done with lighting, some are mechanical efx, and some are done in postproduction.

Figure 1.14. Desaturated sepia-toned color is the key texture element in *O Brother, Where Art Thou?*

Figure 1.15. Color and shadows, in addition to makeup effects, are central to this music video Come *To Daddy* (Aphex Twin) by Chris Cunningham.

A particularly dramatic example is the film *O Brother, Where Art Thou*? (Figure 1.14). Cinematographer Roger Deakins experimented with many camera and filter techniques to create the faded postcard sepia-toned look that he and the director envisioned. None of them proved satisfactory, and in the end, he turned to what was then an entirely new process: the digital intermediate (DI)—the original images are shot on film and ultimately will be projected on film in theaters. But in the intermediate stages, the image is manipulated electronically, in the digital world, with all the vast array of tools for imagemaking that computers afford us—and there are many.

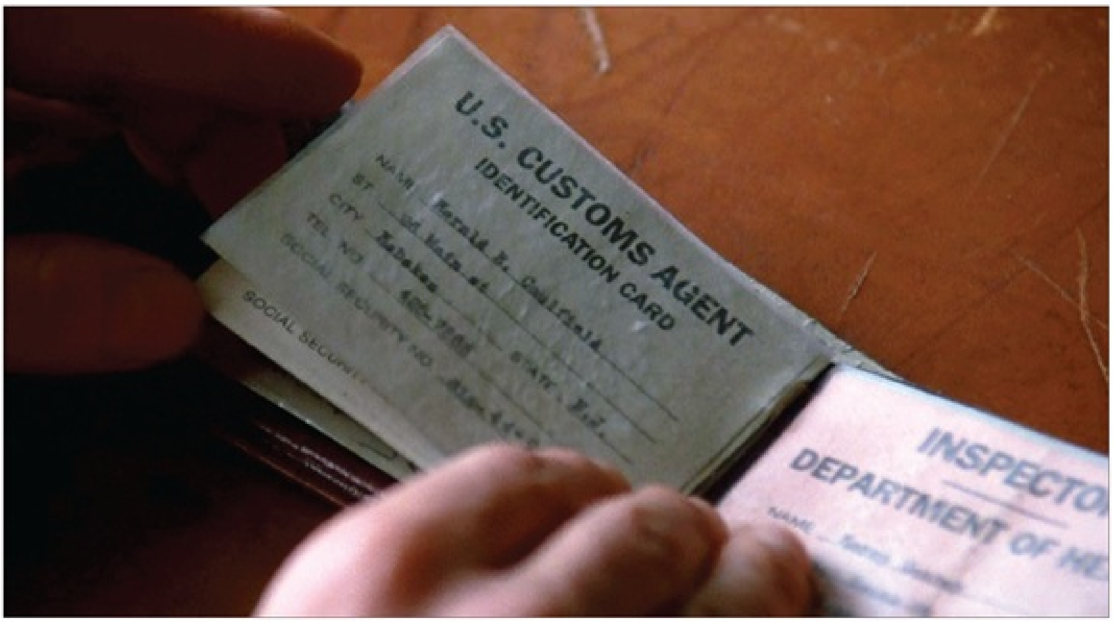


Figure 1.16. This shot from *Angel Heart is an insert*—a tighter shot of a detail from the larger scene. Here it is an *informational insert*; it establishes some point of information that the filmmaker needs the audience to know.

Figure 1.17. Highly saturated color and reflections make this shot from Wong Kar-wai's film *2046* memorable.

Some similar techniques are used in this music video *Come to Daddy* by English music video director Chris Cunningham (Figure 1.15) for Aphex Twin. In this video, Cunningham uses a wide variety of visual texture devices, including making film look like bad video, stutter frames, slow motion, and many more. Most visible in this frame are the shadowy lighting, contrasty look, and the green/cyan shift of the entire image, all of which reinforce the ghastly, surrealistic imagery of the content.

MOVEMENT

Movement is a powerful tool of filmmaking; in fact, movies are one of the few art forms that employ motion and time, dance obviously being another one. This opening sequence from *Working Girl* (Figures 1.18 through 1.24) is an excellent example of exciting, dynamic motion that serves an important storytelling purpose. It is a kinetic, whirling helicopter shot that begins by circling the head of the Statue of Liberty, then picks up the Staten Island ferry, and then ultimately goes inside (in a dissolve that simulates continuing the single moving shot) to find the main character, played by Melanie Griffith. This is far more than just a powerfully dynamic motion; it is also a clear visual metaphor. The story is about the main character's transition from a working girl secretary trapped in a dreary existence where every day starts with a ride on the ferry; on this day her birthday is celebrated with a single candle in a cupcake. By the end of the film, she is transformed into a strong, independent woman who stands proud and tall, not unlike the Statue of Liberty.

ESTABLISHING

Establishing is the ability of the camera to reveal or conceal information; think of it as a visual equivalent of exposition, which in verbal storytelling means conveying important information or background to the audience. It is really at the heart of telling a story visually—letting the camera reveal information is usually a more cinematic way of getting information across to the audience than is dialog or a voice-over narrator. In this frame from *Angel Heart* (Figure 1.16), a close-up of Mickey Rourke's wallet as he leafs through it conveys vital story information without words: clearly he carries fake IDs to assist him in his slightly sleazy work as a cut-rate private detective.

Establishing is accomplished primarily by a choice of the frame and the lens, but it can also be done with lighting that conceals or reveals certain details of the scene.

POINT-OF-VIEW

Point-of-view (POV) is a key tool of visual storytelling. We use the term in many different ways on a film set, but the most often used meaning is to have the camera see something in much the same way as one of the characters would see it: to view the scene from that character's point-of-view.

This is fundamental to cinema: the camera is the "eye" of the audience; how the camera takes in the scene is how the audience will perceive it. To a great extent, cinematography consists of showing the audience what we want them to know about the story; POV shots tend to make the audience more involved in the story for the simple reason that what they see and what the character sees are momentarily the same thing—in a sense, the audience inhabits the character's brain and experiences the world as that character is experiencing it.

There are many ways POV is used in filmmaking, and those will be discussed later, but these frames from *Chinatown* show a fundamental and frequently used application of the method. In Figures 1.25 through 1.27, we see over-the-shoulder as Jake Gittes follows someone he has been hired to investigate. He glances into his rear-view mirror, and the scene cuts to what he sees in the mirror

—his subjective POV.

Figure 1.18 through **1.24.** This opening scene from *Working Girl* is not only a dynamic helicopter move, it is also a powerful visual metaphor that introduces us to two main characters, establishes the tone and some key ideas of the film, some of the *backstory*, and even hints at some of the aspirations and destiny of the main character.

Figure 1.25. This scene from *Chinatown* employs POV to establish plot elements. The first shot is an *over-the-shoulder* which establishes the scene and the relationship between the two cars.

Figure 1.26. (middle) We see the detective looking; this establishes that what we see next will be his point-of-view.

Figure 1.27. (bottom) We see his *subjective POV* of what he sees in the mirror; this is the payoff of what has been established in the previous two shots.

DETECTIVE POV

Chinatown employs another layer of POV as well—called *detective POV*. It simply means that the audience does not know something until the detective knows it—we only discover clues when he discovers them. This means that the viewer is even more involved in how the main character is experiencing the events of the story. Polanski is a master of this story technique, and he makes it truly visual. For example, a large number of shots in *Chinatown* are over-the-shoulders of Jake Gittes.

> When I meet a director, I try to first talk about emotions and what the story means for the director. What I want from a director is passion; I want to do projects that are important to the director. Because then it's personal and it matters. Every decision about a movie, about cinematography, about light, about camera placement, is emotionally important. And after all, what matters in life, I think, is what you feel. So movies are represented emotions. I try to put those emotions into images. For me, that's the main approach.
>
> Rodrigo Prieto (*Babel*, *The Wolf of Wall Street*)

PUTTING IT ALL TOGETHER

Filmmaking is a strange and mysterious enterprise—it involves mixing and coordinating many different elements, some of them artistic, some of them technical and businesslike. In particular, the cinematographer must be able to bridge that gap—to understand the practical side of dealing with the camera, lenses, digital aspects, file types, workflow, and so on, but also have their minds firmly planted in the artistic side of creating a visual world, visual metaphor, and storytelling. There is a third aspect as well: being an amateur psychologist. On a film set, there is no more fundamental collaboration than that of the cinematographer and director.

Many directors are adept at conveying their vision of the project either verbally or with drawings, metaphors, or photographic references. Some directors are not as good at this—they have a visual concept, but they are not able to communicate it well to their collaborators. In other cases, the director does not have a particular visual concept and wants help in developing one. In these instances, it is really up to the cinematographer to reach into the director's head and try to understand what it is he or she is trying to accomplish; if there are missing pieces in the visual puzzle that is a film project, then it is up to the DP to fill in those blank spots with artistic inspiration, collaboration, and leadership. Sometimes this brings into play another role the cinematographer must play—diplomat, which may call for a great deal of delicacy and being very careful about how one phrases a suggestion. In any case, it is up to the cinematographer to make the director's vision come alive. We are in the business of making things happen—taking artistic ideas and implementing them in the real world of the film set. Our job is to make dreams come alive, and it is a challenging and satisfying undertaking.

Figure 1.28. Moody, desaturated color plays a role, but the tilted angles and foreground object are also important in this shot from *Inside Llewyn Davis*.

Figure 1.29. Muted color and an extreme *dutch tilt* are the key visual elements from this scene in *Chungking Express*.

Figure 2.1. This frame from Rosemary's Baby demonstrates the power of framing and positioning of the camera as part of the overall composition.

Figure 2.2. This shot from the finale of *The Big Combo* is not only graphically strong in composition, but the many visual elements all work together to reinforce and add subtext to the story content of the scene.

MORE THAN JUST A PICTURE

Let’s think of the frame as more than just a picture—it is information. Clearly some parts of the information are more important than others, and we want the information organized in a particular way to be perceived by the viewer, in a certain order. Despite how it seems, we do not perceive an image all at once, which is why the order of perception is important.

Composition (and lighting, which can be part of composition) is how this is accomplished. Through composition we are telling the audience where to look, what to look at and in what order to look at it. The frame is fundamentally two-dimensional design (3-D films notwithstanding). Two-dimensional design is about guiding the eye and directing the attention of the viewer in an organized manner that conveys the meaning that you wish to impart. It is how we impose a point-of-view on the material that may be different from how others see it.

If all we did was simply photograph what is there in exactly the same way everyone else sees it, the job could be done by a robot camera; there would be no need for the cinematographer or editor. An image should convey meaning, mode, tone, atmosphere, and subtext on its own—without regard to voice-over, dialog, audio, or other explanation. This was in its purest essence in silent film, but the principle still applies: the images must stand on their own.

Good composition reinforces the way in which the mind organizes information. In some cases, it may deliberately run counter to how the eye/brain combination works in order to add a new layer of meaning or ironic comment. Composition selects and emphasizes elements such as size, shape, order, dominance, hierarchy, pattern, resonance, and discordance in ways that give meaning to the things being photographed that go beyond the simple: “here they are.” We will start with the very basic rules of visual organization then move on to more sophisticated concepts of design and visual language. The principles of design and visual communication are a vast subject; here we will just touch on the basics in order to lay the foundation for discussion.

Figure 2.3. The symmetrical *balance* created by the shadows and light on the floor is in *visual tension* with the off-center figure in the frame; *The Man Who Wasn't There*.

Figure 2.4. (bottom) The rhythm of repeated elements is an important component of this shot from *Eternal Sunshine of the Spotless Mind*. The position of the figure also adds some visual tension.

DESIGN PRINCIPLES

Certain basic principles pertain to all types of visual design, whether in film, photography, painting, or drawing. These techniques of basic design work interactively in various combinations to add depth, movement, and visual force to the elements of the frame. We can think of them as guidelines for visual organization.

- Unity
- Balance
- Visual tension
- Rhythm
- Proportion
- Contrast
- Texture
- Directionality

UNITY

Unity is the principle that the visual organization be a "whole," self-contained, and complete. This is true even if it is a deliberately chaotic or unorganized composition. In Figure 2.2, this climactic final shot from *The Big Combo* uses *frame-within-a-frame* composition to tell the story visually: having defeated the bad guys, the hero and femme fatale emerge from the darkness into the light of morning.

> The language of film is further and further away from the language of the theater and is closer to music. It's abstract but still narrative.
>
> Emmanuel Lubezki (*Birdman, The Revenant, Children of Men*)

Figure 2.5. Lighting, perspective, choice of lens, and camera position combine to give this Gregg Toland shot tremendous depth and threedimensionality in *Citizen Kane*.

BALANCE

Visual balance (or lack of balance) is an important part of composition. Every element in a visual composition has a visual weight. These may be organized into a balanced or unbalanced composition. The visual weight of an object is primarily determined by its size but is also affected by its position in the frame, its color, movement, and the subject matter itself.

VISUAL TENSION

The interplay of balanced and unbalanced elements and their placement in the frame can create *visual tension*, which is important in any composition that seeks to avoid boring complacency.

RHYTHM

Rhythm of repetitive or similar elements can create patterns of organization. Rhythm plays a key role in the visual field, sometimes in a very subtle way as in Figures 2.4, a frame from *Eternal Sunshine of the Spotless Mind*.

PROPORTION

Classical Greek philosophy expressed the idea that mathematics was the controlling force of the universe and that it was expressed in visual forces as the *Golden Mean*. The Golden Mean is just one way of looking at proportion and size relationships in general. Figure 2.7 shows the Golden Mean as applied to *The Great Wave Off Kanagawa* by Japanese ukiyo-e artist Hokusai. The outer rectangle defined by the Golden Mean is very close to 1.78:1, a widely used HD standard frame proportion.

Figure 2.6. Visual texture in a scene from *The Conformist*.

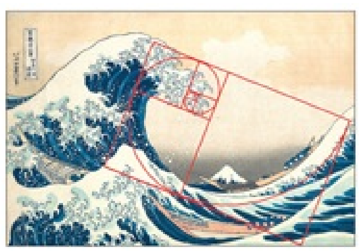


Figure 2.7. The *Golden Mean* as shown in *The Great Wave by Hokusai*.

CONTRAST

We know a thing by its opposite. Contrast is a function of the light/ dark value, the color and texture of the objects in the frame, and the lighting. It is an important visual component in defining depth, spatial relationships, and, of course, carries considerable emotional and storytelling weight as well.

TEXTURE

Based on our associations with physical objects and cultural factors, *texture* gives perceptual clues. Texture can be a function of the objects themselves, but usually requires lighting to bring it out, as in Figure 2.6. We also add texture in many different ways in filmmaking; see the chapter *Lighting Basics* where we will discuss adding visual texture to lighting as a way of shaping the light.

DIRECTIONALITY

One of the most fundamental of visual principles is directionality. With a few exceptions, everything has some element of directionality. This directionality is a key element of its visual weight, which determines how it will act in a visual field and how it will affect other elements. Anything that is not symmetrical is directional.

THE THREE-DIMENSIONAL FIELD

In any form of photography, we are taking a threedimensional world and projecting it onto a two-dimensional frame (although this is less true of 3-D filmmaking). A very big part of our work in directing and shooting visual stories is this essential idea of creating a threedimensional world out of two-dimensional images. It calls into play a vast array of techniques and methods, not all of them purely design-oriented: the lens, blocking of actors, lighting, and camera movement all come into play.

In reality, 3-D filmmaking is still two-dimensional, it just has an extra feature that makes it appear to be threedimensional—all the basic design principles still apply whether you are shooting 2-D or 3-D. There are, of course, times when we wish to make the frame more two-dimensional, even replicating the flat space of an animated cartoon, for example; in that case, the same visual design principles apply, they are just used in a different fashion to create that visual effect. Many visual forces contribute to the illusion of depth and dimension. For the most part, they relate to how the human eye/ brain combination perceives space, but some of them are cultural and historical as well—as film viewers, we all have a long history of visual education from everything we have seen before.

Figure 2.8. *Overlap* in a composition from the film noir classic *The Big Combo*.

DEPTH

In working toward establishing this sense of depth and threedimensionality, there are a number of ways to create the illusion—Figure 2.5 is a deep focus shot from *Citizen Kane*, photographed by Gregg Toland; it shows a great sense of depth in a visual field. In terms of the editing, it is useful to view a scene from more than one angle—shooting a scene entirely from a single angle creates what we call *flat space*. Elements that create a sense of visual depth include:

- Overlap
- Size change
- Vertical location
- Horizontal location
- Linear perspective
- Foreshortening
- Chiaroscuro
- Atmospheric perspective

OVERLAP

Overlap clearly establishes front/back relationships; something “in front of” another thing is clearly closer to the observer, as in this frame from the noir classic *The Big Combo* (Figure 2.8).

RELATIVE SIZE

Although the eye can be fooled, the relative size of an object is an important visual clue to depth, as in Figure 2.9. Relative size is a component of many optical illusions and a key compositional element in manipulating the viewer’s perception of the subject; it can be used to focus the viewer’s attention on important elements. There are many ways to manipulate relative size in the frame, using position or different lenses.

Figure 2.9. *Relative size* is key in this shot from *High Noon*, but clearly *linear perspective* and *overlap* also play a role.

Figure 2.10. Kubrick uses *linear perspective* to convey a sense of the rigid military and social structure in *Paths of Glory*.

VERTICAL LOCATION

Gravity is a factor in visual organization; the relative vertical position of objects is a depth cue. Perspective, as we know it now, was not understood by artists until the Renaissance; in Medieval paintings, for example, objects are generally only shown as above or below, left or right, not so much closer or farther away. This is also important in the art of Asia, which has not traditionally relied on linear perspective as it is practiced in Western art.

LEFT/RIGHT

The eye tends to scan from left to right or right to left. This has an ordering effect on the visual weight of elements in the field. It is also critical to how the eye scans a frame and thus the order of perception and movement in the composition. It can also relate to the staging of actors within the frame. In theater, the *downstage* (nearest the audience) right corner is considered to be the "hot" area of the stage.

Figure 2.11. *Chiaroscuro* lighting uses light and shadow to create depth and focus the attention of the audience, such as this frame from *Apocalypse Now*.

LINEAR PERSPECTIVE

Linear perspective was an invention of the Renaissance artist audience, such as this frame from Brunelleschi. In film and video photography, it is not necessary to know the rules of perspective, but it is important to recognize its importance in visual organization. Director Stanley Kubrick uses it to reinforce the rigid nature of French society in Figure 2.10, a frame from *Paths of Glory*; he uses strong geometry in *Dr. Strangelove* (Figure 2.23) for similar storytelling purposes.

FORESHORTENING

Foreshortening is a phenomenon of the optics of the eye. Since things that are closer to the eye appear larger than those farther away, when part of an object is much closer than the rest of it, the visual distortion gives us clues as to depth and size.

CHIAROSCURO

Italian for light (chiara) and shadow (scouro, same Latin root as obscure), chiaroscuro, or gradations of light and dark, establishes depth perception and creates visual focus. Since dealing with lighting is one of our major tasks, this is an important consideration in our work. Figure 2.11 is a shot from *Apocalypse Now*. See also Figure 4.1 at the beginning of the chapter *Visual Storytelling*: a masterpiece by the painter Caravaggio, one of the great old masters of the use of chiaroscuro.

ATMOSPHERIC PERSPECTIVE

Atmospheric perspective (sometimes called aerial perspective) is something of a special case as it is an entirely "real world" phenomenon. The term was coined by Leonardo da Vinci, who used it in his paintings. Objects that are a great distance away will have less detail, less saturated colors, and generally be less defined than those that are closer. This is a result of the image being filtered through more atmosphere, and the haze filters out some of the warmer wavelengths, leaving more of the shorter, bluer wavelengths. It can be re-created on set with haze effects or scrims (Figure 2.12).

Figure 2.12. *Atmospheric* perspective in the form of a heavy fog effect is an important element of this shot from *City of Lost Children*; not only for the sense of sadness and isolation but also because it is a set built in a studio. Without the sense of atmospheric perspective added by the smoke and backlight, it is doubtful the illusion would hold up so well.

Figure 2.13. The sinuous reverse S; a specialized type of line that has a long history in visual art.

Figure 2.14. Even a few simple lines can imply linear perspective.

FORCES OF VISUAL ORGANIZATION

All of these basic elements can then be deployed in various combinations to create a hierarchy of perception: they can create an organization of the visual field that makes the composition coherent and guides the eye and the brain as it puts the information together. It is important to remember that a viewer does not "see" an entire frame at the same time, the eye moves constantly as it "reads" the shot; our job is to guide that journey. The visual elements that help the eye/brain combination organize the scene include:

THE LINE

The line, either explicit or implied, is a constant in visual design. It is powerful in effect and multifaceted in its use. Just a few simple lines can organize a two-dimensional space in a way that is comprehensible by the eye/brain (Figures 2.14 and 2.15).

THE SINUOUS LINE

The sinuous line, which is sometimes referred to as the reverse *S*, (Figure 2.13) has been used extensively as a compositional principle by artists ever since the Renaissance era; it has a distinctive harmony and balance all its own, as seen in this example from *The Black Stallion* (Figure 2.16).

COMPOSITIONAL TRIANGLES

Triangles are a powerful compositional tool. Once you start looking for them, you will see compositional triangles everywhere. Figure 2.18 is a frame from *Citizen Kane*, an outstanding example of the strong visuals in filmmaking. The compositional triangles keep the frame active even through a fairly long expositional scene.

HORIZONTALS, VERTICALS, AND DIAGONALS

The basic lines are always a factor in almost any type of composition. Nearly infinite in variety, they always come back to the basics: horizontal, vertical, and diagonal. Lines may be explicit, as in this shotfrom *Seven Samurai* (Figure 2.15), or implied in the arrangement of objects and spaces.

Figure 2.15. Line as form and movement in this frame from *Seven Samurai*.

Figure 2.16. (bottom) The classic *sinuous S* in this shot from *The Black Stallion*.

THE POWER OF THE EDGE: THE FRAME

As we visually identify an object or group of objects in a frame, we are also subconsciously aware of the frame itself. The four edges of the frame have a visual force all their own. Objects that are close to the frame are visually associated with it and viewed in relation to it more than if they are farther away. The frame also plays an important role in making us aware of those spaces off-frame: left/right, up/down, and even the space behind the camera—all part of the visual space of the entire composition and crucial to making the visual experience more threedimensional. This power of the frame itself is also important in our choice of aspect ratio—which is the shape of the frame. It has changed over the history of film, generally from an almost square shape (Figure 2.10) to a wider, more horizontal rectangle (Figure 2.17) to an extreme wide frame as in this frame from *JFK* (Figure 2.21).

Figure 2.17. A full range of light and dark, bold color,and converging lines of perspective are compositional elements in this frame from *Kiss, Kiss, Bang, Bang*.

Figure 2.18. Compositional triangles in *Citizen Kane*.

OPEN AND CLOSED FRAME

An open frame is one in which one or more of the elements either pushes the edge or actually crosses the edge (Figure 2.22). A closed frame is one in which the elements are comfortably contained within the frame (Figure 2.23), which is associated with more formal composition. Although we look at the frames here as still photographs, most frames of a motion picture are dynamic.

FRAME WITHIN A FRAME

Sometimes the composition demands a frame that is different from the aspect ratio of the film. A solution is to use a frame within a frame—which means using framing elements within the shot. Figure 2.25 is an example from Jeunet's *Delicatessen*. It is particularly useful with very widescreen formats. Frame within a frame can be used not only to alter the aspect ratio of the shot but also to focus attention on important story elements.

Figure 2.19. Strong diagonal lines of linear perspective are crucial to this shot from *The Conformist*.

Figure 2.20. Diagonals in the film noir *Out of the Past*.

Figure 2.21. Verticals and horizontals in this shot from *JFK* are especially strong given the widescreen aspect ratio. Notice also how the unbalanced frame and negative space on the right side are especially important to the composition. Imagine if they had framed only the important elements on the left. It would not be nearly as strong a composition and would not work nearly so well for widescreen.

BALANCED AND UNBALANCED FRAME

> The edges of the frame are often more interesting than the center.
> Luciano Tovoli, ASC, AIC (*Suspiria, Bread and Chocolate*)

Any composition may be balanced or unbalanced. This shot from *Dr. Strangelove* (Figure 2.23) is both a closed frame and also a formal/balanced composition. Using formal geometry in the composition of the frame to comment on social structure is a constant in Kubrick's work. The frame from *JFK* (Figure 2.21) is an unbalanced frame. This is more than just composition: the graphic design of the frame also conveys story information about the situation.

Figure 2.22. An open frame composition from *Nightcrawler*.

Figure 2.23. A closed frame composition from *Dr. Strangelove*. This shot also shows Kubrick's use of strong geometry in visual storytelling.

POSITIVE AND NEGATIVE SPACE

The visual weight of objects or lines of force can create positive space, but their absence can create negative space, as in this frame from *Psycho* (Figure 2.24). The elements that are "not there" have a visual weight as well. It is important to remember that the space offscreen can be important also, especially if the character looks offscreen to the left, right, up, down, or even past the camera.

MOVEMENT IN THE VISUAL FIELD

All of these forces work in combination, of course—in ways that interact to create a sense of movement in the visual field. These factors combine to create a visual movement (eye scan) from front to back in a circular fashion as we see in *Seven Samurai* (Figure 2.27). This movement in the frame is important not only for the composition but also plays an important role in what order the viewer perceives and assimilates the subjects in the frame. This influences their perception of content. In analyzing frames in this way, remember that we are talking about the movement of the eye, not movement of the camera or movement of the actor or object within a shot.

Figure 2.24. *Negative space* and unbalanced composition in *Psycho*.

Figure 2.25. *Frame within a frame* in *Delicatessen*.

THE RULE OF THIRDS

The rule of thirds starts by dividing the frame into thirds (Figures 2.28 and 2.34). The rule of thirds proposes that a useful approximate starting point for any compositional grouping is to place major points of interest in the scene on any of the four intersections of the interior lines. It is a simple but effective rough principle for any frame composition. The rule of thirds has been used by artists for centuries; however, as Dr. Venkman says in *Ghostbusters*, “It’s really more of a guideline than a rule.”

RULES OF COMPOSITION FOR PEOPLE

If ever there were rules made to be broken, they are the rules of composition, but it is important to understand them before deviating or using them in a contrary style. Filmmakers often use a deliberate violation of these principles for a particular effect.

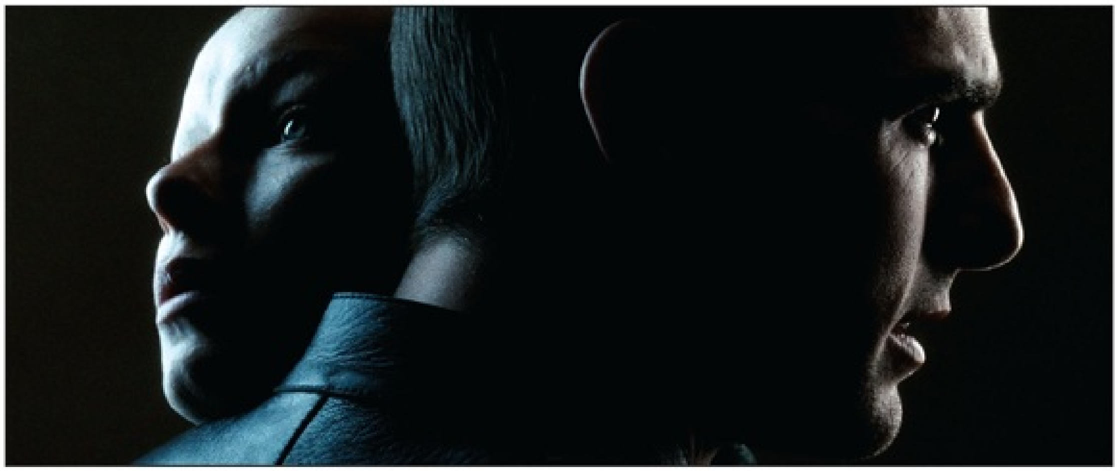


Figure 2.26. Strong directionality toward opposite sides in this tight two shot makes for powerful composition in *Minority Report*.

Figure 2.27. Visual movement in the frame reinforces character relationships and subtext in this shot from *Seven Samurai*.

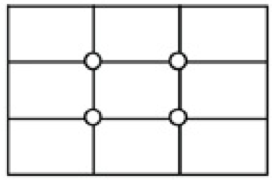


Figure 2.28. The basic concept of the *rule of thirds* is simple. View it as more of a general guideline than an actual rule.

HEADROOM

Headroom is a key issue in framing people. It is a natural human tendency to want to put a person's head in the center of the frame. This results in lots of wasted space above the person that serves no purpose and results in poor composition (Figure 2.31). Standard practice is to keep the top of the head fairly close to the top of the frame (Figure 2.33) without cutting them off. However, giving them a *haircut* is fine for close-ups, just not for wide shots (Figure 2.32).

NOSEROOM

A similar issue is *noseroom*, sometimes called *looking room*. Again, the tendency is to put the actor in the center of the frame. Think of it as the actor's eyeline or gaze as some visual weight—it needs some room. When the performer is looking off to left or right, move them over to the other side of the frame to make sure there is appropriate noseroom for the composition (Figures 2.29 and 2.30).

OTHER GUIDELINES

Don't cut off their feet. Typically, a frame should end somewhere around the knees or include the feet. Cutting them off at the ankles will look awkward; likewise, don't cut off their hands at the wrist. Naturally, a character's hand will often dart in and out of the frame as the actor moves and gestures, but for a long static shot, they should be clearly in or out.

Figure 2.29. Not enough *noseroom*.

Figure 2.30. Proper noseroom.

Figure 2.31. Too much *headroom*.

Figure 2.32. Too little *headroom*.

Figure 2.33. About the right amount of *headroom*.

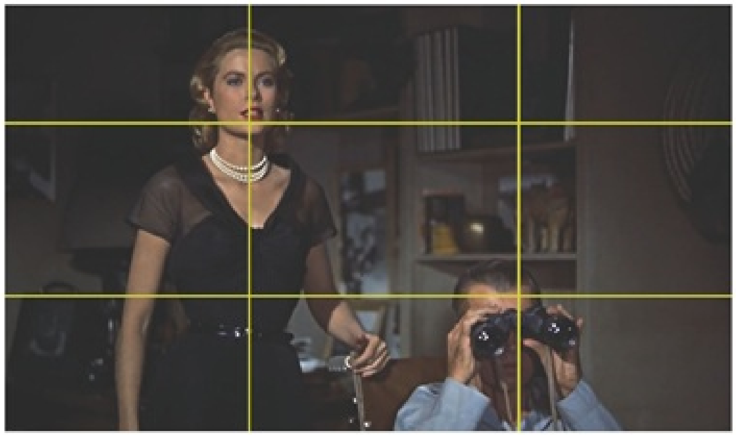


Figure 2.34. The rule of thirds as illustrated with a scene from Hitchcock's *Rear Window*.

Pay attention to the heads of people standing in the background. When framing for our important foreground subjects, whether or not to include the heads of background people is a judgment call. If they are prominent enough, it is best to include them compositionally. If there is enough emphasis on the foreground subjects and the background people are strictly incidental or perhaps largely out of focus, it is OK to cut them off wherever is necessary. If the situation does call for not showing their heads, you will probably want to avoid cutting through their heads at nose level.

Figure 3.1. A wide lens expands the space and helps form the composition and physical relationships in this shot from *Once Upon a Time in the West*.

language of the lens

Figure 3.2. An extremely long lens compresses space and brings the cloud-covered sun dramatically into this image from *Apocalypse Now*.

The *language of the lens* encompasses how the lens mediates and interprets the physical world for us; how it “renders” the image in different ways that can be used for effective visual storytelling. It is important for both the DP and the director to understand how lenses can be used and what effects can be achieved for particular visual purposes in the story. In this discussion, it includes also the placement of the lens which is an important directorial decision in framing up any shot—placement works together with the optical characteristics of the lens in creating the overall effect. The key optical aspects of a lens include:

- Perspective
- Compression or expansion
- Soft/hard
- Contrast

THE LENS AND THE FRAME

As we use the term in this book, *cinematic technique* means the methods and practices we use to add additional layers of meaning, nuance, and emotional context to shots and scenes in addition to their objective content. The lens is one of the prime tools in achieving these means. Together with selecting the frame, it is also the area of cinematography in which the director is most heavily involved.

FOREGROUND/MIDGROUND/BACKGROUND

As we discussed in *Visual Language*, one of the key elements of film is that we are projecting three-dimensional space onto a two-dimensional plane. Except where we want this flatness, it is a goal to recreate the depth that existed in the scene.

A big part of this is to create shots with a foreground, midground, and background. In the book *Hitchcock/Truffaut*, Hitchcock makes the point that a basic rule of camera position and staging is that the importance of an object in the story should equal its size in the frame.

Figure 3.3. The use of wide lenses to create *deep focus* was pioneered by cinematographer Gregg Toland on films like *The Long Voyage Home*, seen here.

LENS PERSPECTIVE

As we discussed in the previous chapter, the fundamental aspect of the frame is that it constitutes a selection of what the audience is going to see. Some things are included, and some are excluded. The first decision is always where the camera goes in relation to the subject, but this is only half of the job. Once the camera position is set, there is still a decision to be made as to how much of that view is to be included. This is the job of lens selection.

Human vision, including peripheral, extends to around 180°. *Foveal* (or central) vision, which is more able to perceive detail, is around 40°. In 35mm film, the 50mm is generally considered the normal lens. In fact, something around a 40mm is closer to typical vision. In video, the “normal” lens varies depending on the size of the video receptor—16mm film, 70mm, and all the others would have a different “normal,” as do all video sensor sizes and formats. A normal lens is considered to be one where the focal length equals the diagonal of the receptor (the film frame or the video sensor). The focal length is significant in another way in addition to its field of view. Remember that all optics (including the human eye) work by projecting the three-dimensional world onto a two-dimensional plane. Lenses in the normal range portray the depth relationships of objects in a way fairly close to human vision.

WIDE LENSES AND EXPANSION OF SPACE

With a wider than normal lens, depth perception is exaggerated: objects appear to be farther apart (front to back) than they are in reality. This exaggerated sense of depth has psychological implications. The perception of movement towards or away from the lens is heightened; space is expanded, and distant objects become much smaller. All this can give the viewer a greater sense of presence—a greater feeling of being in the scene—which is often a goal of the filmmaker. As the lens gets even wider, there is distortion of objects, particularly those near the lens. This is the fundamental reason why a longer focal length lens is considered essential for a portrait or head shot. It's a simple matter of perspective. If you are shooting a close-up and you want to fill the frame, the wider the lens, the closer the camera will have to be. As the camera gets closer, the percentage difference in distance from the nose to the eyes increases dramatically, which causes distortion (Figure 1.11 in *Writing with Motion*).

Figure 3.4. A *deep focus* shot from *Citizen Kane*. Three levels of the story are shown in the same frame.

For example, if the tip of the nose is 30 cm (centimeters) from the lens, then the eyes may be at 33 cm, a 10% difference. With a wide lens, this is enough to cause a mismatch in size: the nose is exaggerated in size compared to the face at the plane of the eyes. With a longer than normal lens, the camera will be much farther back to achieve the same image size. In this case, the tip of the nose might be at 300 cm, with the eyes at 303 cm. This is a percentage difference of only 1%: the nose would appear normal in relation to the rest of the face. The same fundamental principle applies to the perception of all objects with very wide lenses.

Another aspect of wide lenses is that at a given distance and f/stop, they have greater *depth-of-field*. Not to get too technical here (we'll do that in the chapter *Optics & Focus*), but suffice it to say that the depth-of-field of a lens is inversely proportional to the square of its focal length. We'll get into the details in later chapters, but perceptual ramifications are very much a part of the psychology of the lens. This greater depth-of-field allows more of the scene to be in focus. This was used to great effect in the 1930s by Gregg Toland, who used it to develop an entire look called deep focus, such as in the frame from *The Long Voyage Home* (Figure 3.3). In this film and others he shot in this period, Toland perfected deep focus as a visual system that he later introduced to Orson Welles (Figures 2.5 and 3.4).

DEEP FOCUS

The high point of deep focus as a storytelling tool is Citizen Kane. According to David Cook in *A History of Narrative Film*, "Welles planned to construct the film as a series of long takes, or sequence shots, scrupulously composed in depth to eliminate the necessity for narrative cutting within major dramatic scenes. To accomplish this, Toland developed for Welles a method of deep focus photography capable of achieving an unprecedented depth-of-field."

Figure 3.5. Very long lens perspective makes this shot from *Rain Man* abstract. It is reduced to the simple

idea of beginning a journey into the unknown future; the road seems to rise up into their unknown future. It is no accident that this frame is used on the poster for the film; it elegantly expresses the basic story of the film.

Figure 3.6. A wide lens is essential to this shot from a later scene in *Rain Man*. Trapped in the car with his extremely annoying brother, the wide shot in the emptiness of the prairie emphasizes how the car is like a lifeboat from which there is no escape.

This deep focus facilitates composition in depth to an unprecedented degree. Throughout the film we see action in the background that complements and amplifies what we are seeing in the foreground. For example, early in the film, we see Mrs. Kane in the foreground, signing the agreement for Mr. Thatcher to be the young Charles Foster Kane's guardian. Throughout the scene, we see the young man through a window, playing outside with his sled even as his future is being decided (Figure 3.4).

Welles also uses the distortion of wide-angle lenses for psychological effect. Frequently in the film we see Kane looming like a giant in the foreground, dwarfing others in the scene—a metaphor for his powerful, overbearing personality. Later, Welles uses the exaggerated distances of wide lenses to separate Kane from other characters in the scene, thus emphasizing his alienation.

Figure 3.7. This wide master from The *Lady from Shanghai* shows a normal perspective.

Figure 3.8. In the close-ups, Welles uses projections of the fish at ten times their normal size to introduce menace and a feeling of strangeness to the otherwise pleasant setting of the aquarium. The huge fish and the rippling motivated lighting from the water all work together to suggest that the character is “in over his head and out of his depth.”

COMPRESSION OF SPACE

At the other end of this spectrum are long focal length lenses, which you might hear referred to as *telephoto* lenses. They have effects that are opposite of wide lenses: they compress space, have less depth-of-field, and de-emphasize movement away from or toward the camera.

This compression of space can be used for many perceptual purposes: claustrophobic tightness of space, making distant objects seem closer, and heightening the intensity of action and movement. Their ability to decrease apparent distance has many uses both in composition but also in creating the psychological space (Figures 3.5, 3.12, and 1.10).

The effect of having objects seem closer together is often used for the very practical purpose of making stunts and fight scenes appear more dramatic and dangerous than they really are. With careful camera placement and a long lens, a speeding bus can seem to miss a child on a bicycle by inches, when in fact, there is a comfortably safe distance between them, a trick frequently used to enhance stunt shots and action sequences. The limited depth-of-field can be used to isolate a character in space. Even though foreground and background objects may seem closer, if they are drastically out of focus, the sense of separation is the same. This can result in a very detached, third-person point-of-view for the shot. This detachment is reinforced by the fact that the compression of space makes more tangible the feeling that the real world is being projected onto a flat space. We perceive it more as a two-dimensional representation—more abstract; this is used very effectively in Figure 3.10.

Figure 3.9. This wide shot comes at the end of a chase scene in *9 1/2 Weeks*; out on the town, the characters have been chased by a gang of violent thugs.

Figure 3.10. At the moment they realize they have lost their attacker, a severe lens change *punches* in to the scene. It is a high-energy cut that gets us closer so that we are experiencing the scene along with the characters rather than as an abstract, at-a-distance chase scene. We are drawn into their excitement and identify with their exuberance. The sudden loss of depth-of-field isolates them in the landscape and gives our attention nowhere else to go. The *punch-in* changes the visual texture to match the mood.

Another use of long lenses for compression of space is for beauty. Most faces are more attractive with longer lenses. They are known as *portrait lenses* for still photographers who do beauty and fashion or portraiture. Movement toward us with a long lens is not as dynamic and, therefore, is abstracted. It is more of a presentation of the idea of movement than perceived as actual movement of the subject. This is especially effective with shots of the actors running directly toward the camera; as they run toward us, there is very little change in their image size. We would normally think of this as decreasing the sense of movement, but in a way, it has the opposite effect. The same is true of slow motion. Although shooting at a high frame rate actually slows the movement down, our perceptual conditioning tells us that the people or objects are actually moving very fast—so fast that only high-speed shooting can capture them on film. Thus shooting something in slow motion and with a long lens has the ultimate effect of making the movement seem faster and more exaggerated than it really is. The brain interprets it in a way that contradicts the visual evidence.

Figure 3.11. A visually powerful *punch-in* from *Gladiator*, as the main characters rise into the arena from the underground space in a wide shot.

Figure 3.12. The switch to a very long lens (a *punch-in*) punctuates the moment and intensifies the drama as well as simply being dramatic and visually striking.

This is an excellent example of cultural conditioning as a factor in film perception. The convention is to show someone running very fast to shoot with a long lens and in slow motion. If you showed a long-lens, slow-motion shot of someone running to a person who had never seen film or video before, they might not understand at all that the person is running fast. More likely they would perceive the person as almost frozen in time through some sort of magic.

MANIPULATING PERSPECTIVE

There are many other tricks that can be used to alter the audience's perception of space. In *The Lady from Shanghai* (Figures 3.7 and 3.8), Welles uses a subtle and very clever trick to add subtext to the scene. In the film, Welles plays an ordinary seaman who is seduced into an affair and a murder plot by Rita Hayworth. There are double and triple crosses, and the Welles character is in way over his head. This scene is a meeting between him and the beautiful woman who is at the bottom of all the schemes and machinations. She asks him to meet her in an out-of-the-way public place: the aquarium. On the face of it, this seems like a perfect place for them to meet without attracting attention. In fact, she has a darker purpose.

Figure 3.13. *Rack Focus* is an essential part of the language of cinema. A sense of timing is critical to executing a proper rack focus that reinforces the scene and doesn't call attention to itself. You are guiding the audience's eye; it's not a purely mechanical thing. Like a dolly move, you don't want to arrive too early or too late. Another reason rehearsals are such a good idea.

The staging also seems perfectly straightforward. They meet and then talk while they stroll in front of the glass windows of the aquarium. Welles uses subtle tricks to make this happy, innocent place mysterious and foreboding. First, the motivated light from the aquarium backlights them dramatically in a classic film noir fashion. As the Welles character begins to realize the danger of the situation he is in, they move to a spot where they are completely in silhouette. When he goes in for coverage, the motivated lighting is also a water effect, so the ripples play across their faces.

The third trick is even more clever. In the wide shots, we see the fish in the aquarium: ordinary fish and turtles of one or two feet in length. In the close-ups, however, Welles had film of the fish back-projected at a greatly enlarged size. As a result, the fish are now gigantic. Although just barely seen behind their heads, the effect is mysterious and a little frightening. In combination with the silhouette and the rippling water effects, the subtext is clear: the character is out of his depth, his head is underwater, and he may not survive. It is a masterful stroke that is completely unnoticed by most of the audience. Like all of the best filmmaking techniques, it is seamless and invisible.

Figure 3.14. A normal lens keeps the background in focus; it can be distracting.

Figure 3.15. A very long lens throws the background out of focus and the viewer's entire attention is drawn to the character.

Figure 3.16. Deliberate lens flare is an essential part of the look of this scene from *9 1/2 Weeks*.

SELECTIVE FOCUS

The characteristic of relative lack of depth-of-field can be used for *selective focus shots* (Figures 3.14 and 3.15). As discussed above, shallow depth-of-field can isolate the subject. The essential point is that focus is a storytelling tool. This is a drawback of 16mm film and some HD/HD+ cameras. Because they often have smaller sensors, they have far more depth-of-field than 35mm film, thus making it more difficult to use focus in this way; however, many HD+ cameras now have sensors that are the same size as a 35mm film frame or even larger. Depth-of-field is a product of focal length, the aperture, and the sensor size, not whether it is film or video. See the chapter *Optics & Focus* for more on selective focus. If you want to reduce depth-of-field on a camera with a smaller sensor, some people will say "pull back and use a longer lens" or "shoot wide open." These are not always options, especially in a tight location.

Focus can also be shifted during the shot, thus leading the eye and the attention of the viewer. The term for the classic use of this is *rack focus* (Figure 3.13), in which the focus is on an object in the foreground, for example, and then, on cue, the camera assistant radically changes the focus so that it shifts dramatically to another subject either in front of or behind the original subject.

Not all shots lend themselves to the technique, especially when there is not enough of a focus change to make the effect noticeable. A downside of rack focusing is that some lenses *breathe* when changing focus; this means they appear to change focal length while shifting focus. Also with tracking shots that are very tight and close, we can watch as objects come into view, then slowly come into focus, then go soft again. Selective focus and out-of-focus can also be highly subjective visual metaphors for the influence of drugs or madness. The bottom line is that focus is an important storytelling tool as well as being crucial to the overall look of a particular production.

Another issue in selective focus is when two or more players are in the same shot but at different distances. If you don't have enough light to set the lens to a higher f/stop (and thus you don't have much depth-of-field), it may be necessary for the focus puller to choose one or the other to be in focus. This is up to the DP or director to decide, and they should consult before the shot—and don't forget to mood in No Country for Old Men. let the focus puller know. A few basic rules of thumb:

- Focus goes to the person speaking. It is permissible to rack focus back and forth as they speak.
- Focus goes to the person facing the camera or most prominent in the frame.
- Focus goes to the person experiencing the most dramatic or emotional moment. This may countermand the principle of focusing on the person speaking.
- If there is doubt about whom to focus on, most camera assistants put the focus on the actor who has the lower number on the *call sheet.*

Figure 3.17. A high-angle shot creates a graphic composition and helps establish the location and mood in *No Country for Old Men.*

This may sound frivolous but, it's not. Call sheets list the actors in numbered order of their characters. The lead is actor #1, and so on. If you are playing it on the fly, the safe bet is to go with the actor with the lower number on the call sheet.

If they are close enough, the focus puller may split the focus between them (if there is enough depth-of-field to keep both of them acceptably sharp) or by very subtly racking back and forth. Major focus racks need to be discussed in advance and rehearsed. This is true of all camera moves that are motivated by dialog or action. If the AC and the operator haven't seen what the actors are going to do, it is difficult to anticipate the move just enough to time it correctly. Rehearsal is a time saver, as it usually reduces the number of blown takes.

It is interesting to note that older books on cinematography barely mention focus at all. There is a reason for this. Until the sixties, it was the established orthodoxy that pretty much everything important in the frame should be in focus. The idea of having key elements in the frame that are deliberately out of focus really didn't fully take hold until it was popularized by fashion photographers in the eighties. It is now recognized by filmmakers as a key tool and is the reason that when evaluating and using HD/UHD cameras, a great deal of attention is paid to the size of the video sensor. There is more discussion of the other factors that affect focus and depth-of-field in the chapter *Optics & Focus*, later in this book.

Figure 3.18. This *god's eye shot* (a type of *high-angle* shot that is either directly overhead or nearly so) from *Life of Pi* is not merely graphic and beautiful, it is a powerful storytelling tool.

Figure 3.19. A wide lens and a centered camera position convey the sense of dependence and inter-connectedness of the characters in this scene from *The Grand Budapest Hotel*.

IMAGE CONTROL ATTHE LENS

Some techniques with the lens are discussed in the chapter on *Image Control & Grading*; in this chapter, we deal with altering the image quality with the lens and shutter only as they are relevant to this discussion of visual storytelling with the lens. There is a huge variety of visual effects that can be achieved with just the selection of lenses, filters, flare, and similar effects, many of which are difficult or impossible to achieve in other ways. One example—for some projects, DPs choose older lenses (even some that might be considered antiques) for their softer quality and characteristics such as flare.

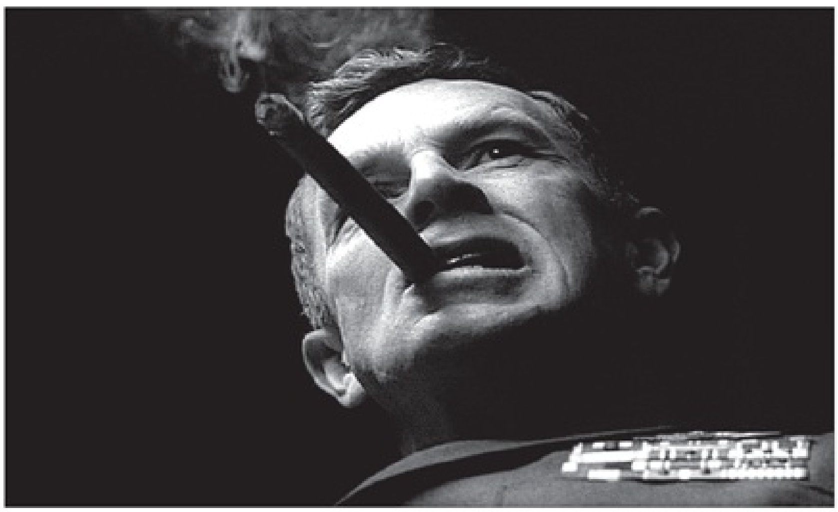


Figure 3.20. Kubrick is a master of choosing the right angle and lens to tell the story powerfully. In this shot, the lens height and angle make a clear statement about the state of mind of the character in *Dr. Strangelove: or How I Learned to Stop Worrying and Love the Bomb*.

FILTRATION

Modern lenses are remarkably sharp. In some cases, however, we are looking for a softer image. The most frequent reason is beauty. A softer image, especially of a woman's face, will generally be prettier. A soft image may also be more romantic, dreamlike, or, in a subjective shot, may translate to a state of mind less in touch with reality. Some cinematographers tend to think only of diffusion filters, but a softer image can be achieved in many different ways. More on this in the chapter *Image Control & Grading*.

SOFT LENSES

Some shooters use older lenses for an image that is subtly soft in a way that is difficult to achieve with filters. Soft lenses can give a slightly greater apparent depth-of-field. This is because the fall-off from critical sharpness is somewhat masked by the softness.

Besides not being made with the latest computer-aided optical design and manufacturing, older lenses also have less sophisticated optical coatings. The coating on lenses is there primarily to prevent internal flares and reflections, which slightly degrade and soften the image. Certainly the best-known recent use of this technique was the film *Saving Private Ryan*, where the filmmakers asked the Panavision camera company to remove the modern coatings off a set of lenses so that they would more closely resemble the types of lenses that were used in actual World War II combat photography.

FLARE/GLARE

A direct, specular beam of light that hits the lens will create a flare that creates *veiling glare*, which appears as a sort of milky whiteness over the whole image. This is why so much attention is paid to the matte box or lens shade and why the grips are often asked to set *lensers*—flags that keep direct light sources from hitting the lens. There are exceptions, such as in Figure 3.16, where deliberate flare is used as a visual device to set a certain tone for the shot.

Figure 3.21. *Optical point-of-view* is essential to the plot of *Rear Window*. Once we see a character looking through binoculars, telescope or camera lens, the *answering shot* is usually the subject as it would be seen through the optical device and in **Figure 3.22** below.

LENS HEIGHT

Variations in lens height can also be an effective tool for adding subtext to a shot. As a general rule, dialog and most ordinary people shots are done at the eye level of the actors involved; this is the standard default setting but you can vary it to achieve a variety of subtleties in lens point-of-view. Some filmmakers tend to avoid using straight-on eye-level shots, as they consider them boring. Variations from eye level can have story implications, psychological undertones and as a compositional device, such as in Figures 3.17 and 3.20.

Variations from eye level are not to be done casually, especially with dialog or reaction shots. Keep in mind that deviations from eye level are asking the viewer to participate in the scene in a mode that is very different from normal, so be sure that there is a good reason for it and that it is contributing in a way that helps the scene.

HIGH ANGLE

When the camera is above eye height, we seem to dominate the subject. The subject is reduced in stature and perhaps in importance. Its importance is not, however, diminished if the high angle reveals it to be a massive, extensive structure, for example. This reminds us that high angles looking down on the subject reveal overall layout and scope in the case of landscape, streets, or buildings.

This is useful if the intent is an establishing or expository shot where it is important for the audience to know something about the layout. As with subjective and objective camera views on the lateral plane, we can see camera angles that diverge from eye level as increasingly objective, more third person in terms of our literary analogy. This applies especially to higher angles. A very high angle is called a *god's eye shot* (Figure 3.18), suggesting its omniscient, removed point-of-view: distant, separate from the scene, a world view, philosophical, and contemplative.

Figure 3.23. A subtle *Dutch tilt* adds a sense of danger to this scene from *Die Hard*. Dutch tilt is frequently used to visually convey the sense of something being strange, off, or disoriented in the story.

LOW ANGLE

A low-angle shot can make a character seem ominous and foreboding, as in *Dr. Strangelove* (Figure 3.20). When a character is approaching something as seen from a low angle, little is revealed beyond what the character might see himself: we share the character's surprise or sense of mystery. If the shots of the character are low angle, we share his apprehension.

If these are then combined with high-angle shots that reveal what the character does not know, for example, we are aware of whatever surprise or ambush or revelation awaits him: this is the true nature of suspense. As Hitchcock brilliantly observed, there can be no real suspense unless the audience knows what is going to happen. His famous example is the bomb under the table. If two characters sit at a table and suddenly a bomb goes off, we have a moment of surprise that is quickly over, a cheap shock at best. If the audience knows that the bomb is under the table and is aware that the timer is clicking steadily toward exploding, then there is true suspense that engages and involves the audience in a way that simple shock never can. If the audience is on the edge of their seats knowing that the time on the clock is growing shorter, then the fact that the two characters at the table are chatting amiably is both maddening and engaging.

Although any time we get away from human eye level we are decreasing our subjective identification with the characters, low angles can become more subjective in other ways. Clearly a very low angle can be a dog's eye view, especially if it is cut in right after a shot of the dog and then the very low angle moves somewhat erratically and in the manner of a dog. This type of *doggie* POV is practically required for werewolf movies, of course. With low angles, the subject tends to dominate us. If the subject is a character, that actor will seem more powerful and dominant. Any time the actor being viewed is meant to be menacing or frightening to the character we are associating the POV with, a low angle is often appropriate.

Figure 3.24. The great film *The Third Man* is famous for its use of *Dutch tilt* to suggest that many of the characters are not "on the level."

DUTCH TILT

In most shooting we strive for the camera to be perfectly level. It is the job of the camera assistant and the dolly grip to recheck every time the camera is moved and ensure that it is still "on the bubble." This refers to the bulls-eye or transverse bubble levels that are standard on all camera mounts, heads, and dollies.

This is crucial because human perception is much more sensitive to off-level verticals than to off-level horizontals. If the camera is even a little off, walls, doorways, telephone poles, any vertical feature will be immediately seen as out of plumb. There are instances, however, where we want the visual tension of this off-level condition to work for us to create anxiety, paranoia, subjugation, or mystery. The term for this is "Dutch tilt" or "Dutch angle." See Figures 3.23 and 3.24.

Figure 4.1. Caravaggio's *The Calling of St. Matthew*. The lighting carries a great deal of the storytelling power of the image.

Figure 4.2. The transition from black-and-white to color in the film *Memento* is a visual metaphor for transitioning from the past (black-and-white) to the present (color). (top) The character picks up a developing Polaroid. (middle) His POV as the Polaroid develops and starts to show color. (bottom) Back on him, the scene has transitioned to color.

Figure 4.3. (top) Visual metaphor in *Apocalypse Now*—traveling up-river into darkness through clouds of green smoke of their own making—a doomed journey.

VISUAL METAPHOR

One of our most important tools as filmmakers is *visual metaphor*, which is the ability of images to convey a meaning in addition to their straightforward reality. Think of it as "reading between the lines" visually. In some films, things are simply what they are. In others, however, many images carry an implied meaning that can be a powerful storytelling tool. An example—in *Memento*, the extended flashback (which moves forward in time) is shown in black-and-white and the present (which moves backward in time) is told in color. Essentially, it is two parts of the same story with one part moving forward, and the other part told backward. At the point in time where they intersect, the black-and-white slowly changes to color. Director Christopher Nolan accomplishes this in a subtle and elegant way by showing a Polaroid photo develop (Figure 4.2). At the precise moment when these two timelines intersect, we watch as the Polaroid turns from no color to full color—a simple, elegant but expressive visual metaphor.

TELLING STORIES WITH PICTURES

In other chapters, we talk about the technical and practical aspects of lighting. In this chapter, we look at lighting and other aspects of the visual image as key elements of storytelling.

Let's divert our attention from film for a moment and look at a painting. Studying classical art is useful in that the painter must tell the whole story in a single frame (not to mention without dialog or subtitles). Thus, the painter must employ every aspect of visual language to tell the story of the painting as well as layer it with subtext, symbolism, and emotional content. As with the films of Kubrick, Welles, and Kurosawa, it is also useful to study the visual design because nothing in the frame is accidental. Every element, every color, every shadow is there for a purpose, and its part in the visual and storytelling scheme has been carefully thought out.

First, let's look at this beautiful painting that opens this chapter, *The Calling of St. Matthew* by Caravaggio (Figure 4.1). Light has enormous power to form space. In this case, the single source creates a pool of space that envelops the students. Outside it is another space, sharply delineated. Within this pool of light is knowledge and outside is darkness—ignorance. As Newton said, "What we know is a drop; what we don't know is an ocean." Clearly the light represents knowledge, the illuminating power of the great mystery of the universe, but it is not just a symbol—it is also a crucial part of the design. It carries a major portion of the storytelling as well.

Figure 4.4. A distinctive example of a simple but haunting use of the visual metaphor of light in storytelling from *The Exorcist*.

Figure 4.5. Use of lens, camera position, dark, moody color, converging lines of perspective, even the way the wide lens appears to make the characters lean toward each other—multiple factors combine to make this starkly graphic shot from *Seven*.

H.W. Janson discusses the painting in his book *The History of Art*: "Most decisive is the strong beam of light above Christ that illuminates his face and hand in the gloomy interior, thus carrying his call across to Matthew. Without this light, so natural yet so charged with symbolic meaning, the picture would lose its magic, its power to make us aware of the divine presence." The lighting is chiaroscuro at its best; not only does it create strong contrasts and clearly delineate the characters in sharp relief but the figures almost jump out at us. The strong directionality of the light guides the eye and unifies the composition. What is unimportant falls into shadow and thus does not distract the eye.

"In Baroque painting, light is an aggressive liberating force. A small amount of it is enough to reveal the spiritual opportunities that lie hidden." (Edmund Burke Feldman, *Varieties of Visual Experience*.). Here the strong beam of sunlight is the hand of God itself, reaching into the dusky tavern to pluck Matthew out of the darkness. The light coming from outside is clearly the presence of divine truth; it penetrates the dusty darkness of ignorance in the tavern, so the shadows are equally important—ignorance, lethargy, and wasted lives. As we discussed in Visual Language, they also form negative spaces that are important compositionally. It is a powerful painting that carries depths of meaning and content far beyond its mere visual beauty—the kind of thing we strive for every day on the set. All that is missing is a producer in the background saying, "It's awfully dark; couldn't we add some fill light?"

Figure 4.6. *Citizen Kane* employs techniques of visual storytelling with lighting that is expressive, visually striking, and makes specific story points. Here the reporter has come to the vault where Kane's memoirs are kept. As the guard brings forward the book that we hope will contain the ultimate secrets, the single beam of light represents knowledge reaching into the darkened space in much the same way that it does in the Caravaggio (Figure 4.1).

LIGHTING AS STORYTELLING

In visual storytelling, few elements are as effective and as powerful as light and color. They have the ability to reach viewers at a purely emotion gut level. This gives them the added advantage of being able to affect the audience on one level, while their conscious brain is interpreting the story at an entirely different plane of consciousness.

FILM NOIR

Certainly, one of the highlights of lighting as storytelling is the era of *film noir*: American films of the forties and fifties, primarily in the mystery, suspense, and detective genres, nearly all of them in black-and-white. The noir genre is best known for its low-key lighting style: side light, chiaroscuro, shadowy (Figure 4.7). This was, of course, only one of the various elements of visual style: they also used angle, composition, lighting, montage, depth, and movement in expressive new ways. Many factors came together to influence this style: technical innovations such as more sensitive, finer-grained black-and-white negative film stock; lenses better suited to darker shooting conditions; smaller, more mobile camera dollies; cameras light enough to handhold; and portable power supplies, all perfected during World War II, alleviated many of the logistical problems previously connected with location filming.

Figure 4.7. The lamp, the phone, the clock and the character "pushed" to the edge of the frame all add up to tell the story in this shot from *The Maltese Falcon*.

These enabled filmmakers to get out to the dark, mean streets of the city with its shadowy alleys fraught with unknown dangers, blinking neon lights reflected on rain-soaked pavement, and all of the mystery and menace of the city after dark. Beyond just the gritty reality and groundedness that come with actual locations, the challenges and various difficulties of lighting in and around real structures tend to force cinematographers to experiment and be bolder with their lighting; there is less of a tendency to just do it the same old way it's always been done back in the studio.

But all of this is more than just visual style: it is inherently a part of the storytelling, an integral narrative device. “A side-lit close-up may reveal a face, half in shadow, half in light, at the precise moment of indecision.” (Silver and Ward, *Film Noir*.) Beyond narrative, it becomes part of character as well. Noir was the birth of the protagonist who is not so clearly defined as purely good or evil. As with Walter Neff in *Double Indemnity* or Johnny Clay in *The Killing* and so many others, they are characters full of contradiction and alienation. In their very being, they may be pulled between good and evil, light and dark, illumination and shadow. This reflects the confusion and sense of lost ideals that returned with the veterans and survivors of the war. It also reflects the “zeitgeist” of the times: the growing undercurrent that not all things can be known, “…the impossibility of a single, stable point of view, and thus the limits to all seeing and knowing.” (J.P. Tellotte, *Voices in the Dark*.)—that what is unseen in the shadows may be as significant as what is seen in the light.

My real job description is to light a set and the ideas all come from a 300–400 year period of painting during the Renaissance throughout the 15th, 16th, 17th centuries in northern Europe. All ideas about how to create images that are expressive and use light as the metaphor for understanding a meaning of what the painting or image is, all come from this one time period. The biggest influence on me was painting because of my background in theatre—lighting a stage or a set.

Robert Elswit

(There Will Be Blood, Nightcrawler)

LIGHT AS VISUAL METAPHOR

Let’s turn now to a more recent example, a film that uses light as a metaphor and as storytelling perhaps better than any other of the modern era: Barry Levinson’s *The Natural*. Masterfully photographed by Caleb Deschanel, the film is so visually unified and well thought out that it would be possible to comment on the metaphoric or narrative use of lighting in almost every scene; here we will examine only the high points. In the opening shot, we see the title character alone, dejected, and older, sitting at a railroad station. He is half in light and half in shadow, a metaphor for his uncertain future and his dark, unclear past. The train arrives and blacks out the screen. He gets on. End of title sequence. It is mysterious, suggestive, and supremely simple (Figure 4.9). *The Natural* is the tale of a talented young baseball player Roy Hobbes (Robert Redford) who is diverted from his career by a chance encounter with a dark and mysterious young lady but makes a comeback years later as he simultaneously finds love with his long-lost childhood sweetheart. It is a story of good versus evil in the classic sense, and Levinson and Deschanel use a wide variety of cinematic and narrative devices to tell it. More than anything, they use light as a visual metaphor—a key part of the visual storytelling.

Figure 4.8. The dead-center form in full silhouette, the haunting backlight in the fog, and the accent of the lantern all add up to convey the idea of a lonely, mysterious but powerful figure—*The Assassination of Jesse James by the Coward Robert Ford*.

As the story begins, Roy is a young farm boy full of energy, talent, promise, and infatuation for his sweetheart Iris (Glenn Close), who always wears white. This section is shot in bright afternoon sunlight: the vibrant energy of nature with just a hint of a soft filter. It is backlit with the sun, and everything is warm and golden.

His father dies of a heart attack in the shade of a tree, and that night there is a ferocious storm: inky blue punctuated with stabs of violent lightning. A bolt splits the tree, and Roy uses the heart of the tree to make his own bat, which he inscribes with a lightning bolt: a symbol of the power of nature—light in its most intense, primitive, and pure form. He gets a call from the majors and asks Iris out for a last meeting. They are silhouetted on a ridge against a glowing blue sky that represents night and the temptations of Eros (Figure 4.11). If you look closely, it is completely unnatural (it's day-for-night with a blue filter) but beautiful and perfectly portrays their mental state. In the barn, as they make love they are engulfed in stripes of moonlight alternating with darkness. It is a radiant moment, but there are hints of danger (we will learn much later in the film that she is made pregnant by this encounter). As he boards a train to travel to his major league tryout, things darken a bit. The only light source is the relatively small windows of the train, and while they admit plenty of light, it is low angle and somewhat shadowy and malevolent.

Figure 4.9. The opening shot from *The Natural*—a faceless character lost somewhere in between the light and the dark, suspended in time: the past is uncertain and the future is unclear. This purgatory of being caught between them establishes the mood and tone of uncertainty and conflict between two worlds that is carried through the rest of the film.

Figure 4.10. After years of foundering in the narrow darkness of obscurity, Roy emerges into the light of the one thing that gives him power—the bright sunny open space of a baseball field.

Figure 4.11. (top) Early in the film, Roy and his sweetheart Iris are young and innocent, but their purity is disrupted when they meet in the blue moonlight and make love. We will only find out at nearly the end of the film that this loss of innocence leads to a son, which Roy does not know about until he is redeemed and recovers this purity that is represented by the golden sunlight of a wheat field where he plays catch with his newly discovered son.

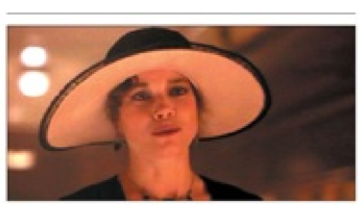


Figure 4.12. (bottom) The *Lady in Black*—the temptation that leads to Roy's downfall. She is always lit dimly and is somewhat shadowy—an ephemeral figure; in this shot under-lit for a mysterious look. DP Caleb Deschanel gave this scene a special treatment by *bi-packing* a slightly out-of-focus black-and-white negative with the color negative.

LIGHT AND SHADOW / GOOD AND EVIL

It is here that he first sees the woman who is to bring evil and temptation into his life—the *Lady in Black* (Figure. 4.12), who we first see in silhouette and from the back. Usually portrayed backlit or in shadow, as befits her evil nature, she invites him to her hotel room, shoots him, and then jumps to her death, ending his baseball hopes.

Sixteen years later, we see him arrive at the stadium of the New York Knights. He is in total darkness as he walks up the ramp, then emerges into sunlight as he enters the ballpark: he is home, where he belongs (Figure 4.10). Given his first chance to play, the sequence opens with a shot of what will become an important symbol: the lighting towers of the field. They are dark and silhouetted against black storm clouds. It is twilight, halfway between day and night. As he literally "knocks the cover off the ball," there is a bolt of lightning, and it begins to rain. Lightning, the most powerful form of light, is a recurring symbol throughout the film—light as pure energy, bringing the power of nature. Coming back into the dugout, we are introduced to a second visual theme: the flashbulbs of news photographers (Figures 4.15, 4.16, and 4.17). As one of his teammates adopts the lightning bolt as a shoulder insignia, the team takes off—a symbol of the power of light and energy that Roy has brought to the squad. Now they are on a hot streak. Now we meet the Judge, half-owner of the team. Slimy and evil, his office is completely dark, lit only by the dim light that seeps through the closed Venetian blinds (Figure 4.13). His face is obscured in shadow. After the Judge tries to get him to lose so he can buy the team, Roy rebuffs him, and on his way out he defiantly flips the room lights on. Then the bookie emerges from the shadows.

Figure 4.13. The Judge, who represents the most elemental evil in the film, claims to abhor sunlight—he stays always in the dark; only a few meager slits of light manage to seep into his darkened den.

Figure 4.14. As Roy begins to fall victim to the temptations of fame and the glamour of the big city, he once again is silhouetted in dark blue—even the car headlights seem to be glowering at him as he falls for the seductive Memo Paris.

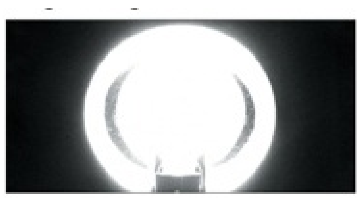


Figure 4.15. Throughout the film, flashbulbs represent the llare of fame, fortune, and celebrity. or Roy, as the new hero of the team, the newspaper photographers and flashbulbs are everywhere.

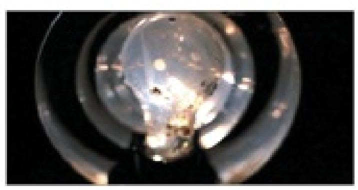


Figure 4.16. (below, top) They quickly become the flashbulbs of the paparazzi as he paints the town red with his glamorous girlfriend Memo.

Figure 4.17. (below, bottom) As the nonstop nightlife hurts Roy's performance on the field, a *slow-mo* shot of a flashbulb fading to black represents Roy's loss of power—the dimming of his light.

Their attempt at bribery having failed, they contrive to set him up with Memo (Kim Basinger, who always wears black) at a fancy restaurant, where the only illumination is the table lamps that cast an ominous under light on the characters, although fill is added for Roy (purity) and Memo (raw beauty). She takes him to the beach and in a reprise of the love scene between Roy and Iris they are bathed in blue moonlight. But this is a slightly different moonlight than we saw with his boyhood girl: colder and harsher; sensuous, but not romantic (Figure 4.14).

Figure 4.18. His long-lost love Iris comes to a game. Roy seems to sense her presence, but as he turns to look for her, he is blinded by the glare of the photographers' flashes.

Figure 4.19. As Roy's success on the field promises to rescue the team and spoil the Judge's plans, he watches from his shadowy lair.

Figure 4.20. As Roy is faltering on the field, near defeat, Iris stands up, and a single beam of light illuminates her so that she is visible in the crowd. It gives Roy the power to hit a home run and win the game. The angelic glow makes her hat a halo to supplement the white dress and the standing pose. To reinforce the lighting effect, she is surrounded by men, alfin dark clothes and hats.

FADING FLASHBULBS

Next comes a montage sequence of flashbulbs popping, symbolizing fame, celebrity, glamour, and the seduction of the fast life that will distract him from baseball. To emphasize the idea that fame and success have a corrupting influence on his focus on the game and his nightlife and partying with Memo Paris, many of the flashbulbs go off right in his face, thus affecting his vision—a perfect metaphor for the blinding influence of celebrity. Roy descends into a slump, bringing the team down with him. In his decline, the flashbulbs still go off, but in marvelous subtlety we see them in slow motion at the end of their burn cycle as they fade out. Iris comes to a game to watch, unbeknownst to Roy. As the team is losing and Roy is striking out, Iris stands up (Figure 4.20). Her translucent white hat is backlit by a single shaft of sunlight, making her appear angelic. Roy hits a home run that breaks the stadium clock—stopping time. Photographers' flashbulbs go off, and as Roy peers into the crowd looking for Iris, he is blinded by them and can't see her (Figure 4.18). Later, they meet and go for a walk. As he tells her the story of his dark past, they are in complete silhouette, in darkness even though it is midday. As he ends his confession, they emerge into full daylight. Later, the silver bullet that has been in his stomach since the Lady in Black shot him sends him to the hospital.

Figure 4.21. As a reporter comes close to uncovering Roy's dark secret, he sneaks onto the field to photograph him at batting practice. To stop him, Roy hits a ball with perfect aim that breaks the reporter's camera; the flashbulb fires as it falls to the ground: the glare of disclosure, of secrets being brought to light, is prevented by Roy's sheer talent with the bat.

Figure 4.22. As Roy lays ill in the hospital before the playoffs, the Judge comes to offer him a bribe. Rather than rendering the Judge in shadow as might be the obvious choice, Deschanel arranges for the warm glow of the otherwise benevolent hospital lamps to glare on the Judge's glasses—thus the light itself manages to obscure his eyes and partly disguise his evil. This is appropriate as he appears here not as the intimidating force of evil but as a silky-voiced cajoler.

Figure 4.23. (left, top) As Roy connects powerfully with the ball, he is framed so that the lights of the field

(representing the ennobling power of baseball) are in the shot with him.

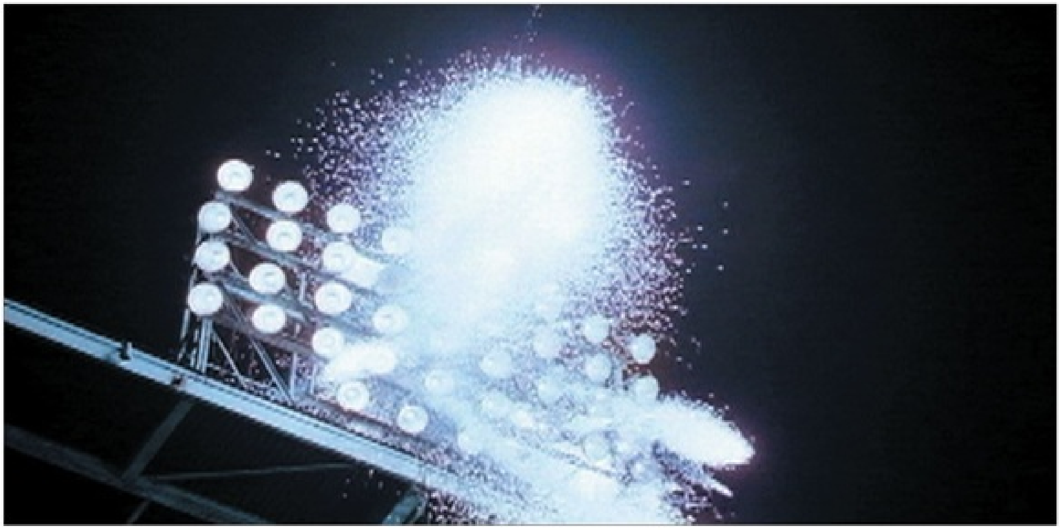


Figure 4.24. (left, bottom) Roy's home run strikes the lights of the field; one shatters, short-circuiting them all, and they explode in a shower of fireworks.

Against doctor's orders, he tries to practice in secret, but the reporter attempts to take a picture of him. Roy hits a ball that smashes his camera, which falls to the ground, and the flashbulb fires as it breaks: he is striking back at the glare of publicity that has nearly destroyed him (Figure 4.21).

The climactic final game is at night, and the stadium tower lights burn brightly. The Judge and the bookie watch the game from his skybox, which we see from below as just a pale yellow glow on the partially closed blinds: an image of evil and corruption hovering over the game (Figure 4.19). Roy is struggling as his injury plagues him, and it all comes down to one final pitch that will win or lose the pennant. Having it all rest on the final pitch is, of course, a given in any baseball movie, but the cinematography and the metaphor of lighting and lightning together with the mystical glow of the dying sparks, strongly reminiscent of triumphal fireworks, gives this scene a magical quality that makes it one of the most memorable final scenes in American cinema and visually one of the most moving.

Figure 4.25. As Roy rounds the bases, the sparks from the exploding bulbs surround him and his jubilant teammates in a soft, gentle wash of light. They are enveloped in an omnipresent glow of the power of good triumphant over evil—one of the most haunting images in modern cinema. The light is all around them, part of them, within them.

VISUAL POETRY

It all comes down to a 3–2 count and the last pitch—the ultimate moment. The pitch is thrown in slow motion; Roy swings and slams a home run right into the stadium lights (Figure 4.23), which shatter and short-circuit, sending a shower of sparks onto the field (Figures 4.24 and 4.25). This is a masterful touch, as drama, as storytelling, and as a truly motivated lighting effect. In one of the truly great images of contemporary cinema, as he rounds the bases in slow-motion triumph, Roy and his celebrating teammates are enveloped in these glowing fireworks, as if miniature stars of glory are raining on them. A soft, golden glow of light personified engulfs Roy and the entire team as the film ends. It is the light of pure good; Roy and the power of his raw talent as symbolized by the bat carved from the tree struck by lightning have transformed them and invigorated them with all that is good about baseball and all that it symbolizes about American democracy.

The firefly-like glow comes from the exploding lights of the field (the illuminating spirit of baseball), shattered by Roy's home run (his talent), that have just been struck by a bolt of lightning—the same lightning that has brought Roy the power of his unsullied talent when it struck the tree under which his father died and from which he took the wood to carve his almost magical bat. These are symbols, and they work, but there is a more subtle visual metaphor at work, and it is what makes the shot so hauntingly evocative. What is magical about this shot is that the light is everywhere: it is an omnipresent bathing glow, it is all around them, it almost seems to emanate from within them as they bask in the beauty of a pure and simple moment of triumph in baseball and the triumph of right over the insidious attempts of the Judge to infect and degrade baseball with his greed. With this elegantly simple but visceral and expressive visual image system, Levinson and Deschanel make the most of and add extra layers of meaning to a great story, a great script, and a superlative cast. In this particular film, light is used as a metaphor in a very clear and sustained way. In most films, lighting is a part of storytelling in more limited and less overtly metaphorical ways, but it can always be a factor in underlying story points, character, and particularly the perception of time and space. Filmmakers who take a dismissive attitude toward lighting are depriving themselves of one of the most important, subtle, and powerful tools of visual storytelling.

Figure 4.26. A stunning example of visual metaphor from *Empire of the Sun*—an extreme long lens magnifies the sun into the symbol of Japan at the moment the last few kamikaze pilots prepare to make a final desperate attempt.

Figure 5.1. This *establishing shot* from *Manhattan* shows us at a glance where the characters are anawhat the mood is.

Figure 5.2. The key establishing shot from Kubrick's *The Shining* gives information about the location, the terrain, and the layout of the hotel, as well as a vague sense of foreboding.

WHAT IS CINEMATIC?

It's easy to think of filmmaking as not much more than "We'll put the actors on the set and roll the camera." Obviously, there is much more involved, but it's important to understand that even if all you do is record what is in front of the camera, you are still making definite decisions about how the viewers are going to perceive the scene. This is the crucial point: ultimately, filmmaking is about what the audience "gets" from each scene, not only intellectually (such as the plot) but also emotionally and perhaps most importantly, how it contributes to their understanding of the story.

A QUESTION OF PERCEPTION

First of all, we have to recognize that how we perceive the world in a film is fundamentally different from how we perceive the world with our eyes and ears. Film only presents the illusion of the reality, and a big part of our job is to sell that illusion.

What do we mean when we say something is cinematic? Most of the time, when people say a novel or a play is "cinematic" they mean it is fast-paced and visual. Here, we use it in a different way; in this discussion we use the term to mean all the techniques and methods of filmmaking that we use to add layers of meaning to the content.

HOW FILM IS DIFFERENT FROM THEATER

Content means the things we are recording—the sets, the actors, the dialog, the props, and so on. In the theater, there is nothing between the eyes and ears of the audience and what is happening in front of them. In film, we have many methods of altering their perception of that reality.

In the early days of cinema, many practitioners were theatrical people. When they first saw the movie camera, they conceived it as a tool to extend their audience: they just put the camera where the audience would be and used it to record a performance. The upshot of this is that the entire performance is viewed from a single point-of-view, which is how a theatergoer sees a play. As a result, in early films the camera did not move, there were no close-ups, no shifting point-of-view—practically none of the tools and techniques of cinema as we know them now.

In short, these early films depend almost entirely on their content, just as theater does, but they lack the immediacy and personal experience of a live theater performance. The history of cinema can easily be studied as the introduction and addition of various techniques and methods that we call “cinematic”—in other words, the conceptual tools we referred to in the previous chapter: the frame, the lens, light and color, texture, movement, establishing, and point-of-view. In this chapter, we will deal primarily with the frame and another essential tool: editing. While editing is not the cinematographer’s job, it is critical to understand that the job of the DP and director working on the set is to provide the editor with footage that he or she can use creatively and effectively.

Figure 5.3. Kubrick often uses a static frame to convey basic ideas about the social structure of the situation, as in this shot from *Barry Lyndon*.

Figure 5.4. The Swedish film *Songs from the Second Floor* consists entirely of static frames. As a shooting method, this is called an *in-one*.

VISUAL SUBTEXT AND VISUAL METAPHOR

So cinematography has many purposes, some of them far beyond the simple act of “photographing” the action. Many of these methods are all about adding visual subtext to your scenes. In addition to visual subtext, visual metaphor can be a powerful tool as we saw in the last chapter.

THE FRAME

Setting the frame is a series of choices that decide what the viewer will see and not see. The first of these decisions is where to place the camera in relation to the scene. After that, there are choices concerning the field of vision and movement, all of which work together to influence how viewers will perceive the shot: both in outright content and in emotional undercurrent and subtext to the action and the dialog.

STATIC FRAME

A static frame is a proscenium. The action of the scene is presented as a stage show: we are a third-person observer. There is a proscenium wall between us and the action. This is especially true if everything else about the frame is also normal—that is, level, normal lens, no movement, and so on. This does not mean, however, that a static frame is not without value. It can be a useful tool that carries its own baggage and implications of POV and world view.

In Stanley Kubrick's film *Barry Lyndon*, the fixed, well-composed, balanced frames reflect the static, hierarchical society of the time (Figure 5.3). Everyone has his place; every social interaction is governed by well-defined rules. The actors move within this frame without being able to alter it. It is a reflection of the world they live in, and while it strongly implies a sense of order and tranquility, it also carries an overpowering lack of mobility: both social and physical. The world is static: the characters try to find their place in it. Each scene is played out completely within this fixed frame: without movement, cuts, or changes in perspective. This use of the frame conveys a wealth of information independent of the script or the actions of the characters. It adds layers of meaning.

A similar use of the static frame is the Swedish film *Songs from the Second Floor* (Figure 5.4) which also plays out every scene (with one exception) as a single long take within a completely immobile frame. Jim Jarmusch used the same technique in his second film, *Stranger Than Paradise*.

In both the examples, the distancing nature of the frame is used for its own purpose. The filmmakers are deliberately putting the audience in the position of the impersonal observer. This can either lend an observational, judgmental tone or much like objects in the foreground of the frame, make viewers work harder to put themselves into the scene, or a combination of both. As with almost all cinematic techniques they can be used in reverse to achieve a completely different effect than normal.

THE SHOTS: BUILDING BLOCKS OF A SCENE

It is useful to think of "building" a scene. Since we make scenes one shot at a time, we can consider that we are assembling the elements that will make the scene. If we think of a language of cinema, these shots are the vocabulary; how we edit them together would be the syntax of this language. These are the visual aspects of the language of film; there are, of course, other properties of this language that relate more to plot structure and narrative, but here we are concerned only with the visual side of this subject. In terminology, there are two general types of shots: *framing shots* (defined by how much is included) and *function shots*—defined by what purpose they serve in editing. In a by no means exhaustive list, they are:

Framing Shots

- Wide shot (or long shot)
- Full shot
- Cowboy
- Two shot
- Medium
- Close-ups
- Clean single
- Dirty single
- ECU
- Over-the-shoulder

Function Shots

- Establishing shots
- Cutaway
- Insert
- Connecting Shot
- Transitional Shot

With a few exceptions, most of these shots apply to people, but the terminology carries over to any subject. As they appear in the script, they are called *stage directions*. Let's look at them individually. As with many film terms, the definitions are somewhat loose and different people have slight variations in how they apply them, particularly as you travel from city to city or work in another country; they are just general guidelines. It is only when you are lining it up through the lens that the exact frame can be decided on.

As they appear in the script, stage directions are completely non-binding—it is entirely up to the director to decide what shots will be used to put the scene together. The screenwriter really has no say over what shots will be used, but they are helpful in visualizing the story as you read the script—especially if you are giving the script to people in order to secure financing for the project or to actors so they can decide if they want to be involved. These shots are the basic vocabulary we deal with—both in terms of editing and also in terms of the director communicating to the DP what it is they are trying to do. These basic elements and how they are combined in editorial continuity are the grammar of cinema.

An important function of choosing the shot is deciding what it is you want the audience to pay attention to; what you want them to mentally focus on or take in. An essential part of choosing the shot you want is what you want the frame to be: what you want to include but also what you don't want them to see.

> Angles tell us emotional things in ways that are mysterious—emotional things that I am often unaware of. I think a particular angle is going to do one thing, and it does something quite different often. I no longer have any sure sense that I have any grasp of it. Occasionally you will hit on an angle that is absolutely inevitable—it's just the right angle. It's puzzling and mysterious.
>
> Michael Chapman (*Taxi Driver*, *Raging Bull*)

Figure 5.5. Screen direction plays a major role in David Lean's directing of *Lawrence of Arabia*. To emphasize the inevitability of Lawrence's fate, all movement in the film is from left to right.

WIDE SHOT

The wide shot is any frame that encompasses the entire scene. This makes it all relative to the subject. For example, if the script designates "Wide shot—the English Countryside" we are clearly talking about a big panoramic scene done with a short focal length lens taking in all the eye can see. On the other hand, if the description is "Wide shot—Leo's room" this is clearly a much smaller shot but it still encompasses all or most of the room.

ESTABLISHING SHOTS

The establishing shot is normally a wide shot. It is the opening shot of a scene that tells us where we are. The scene heading in the script might be "Ext. Helen's office —Day." This might consist of a wide shot of an office building, so when we cut to a shot of Helen at her desk, we know where we are: in her office building. We've seen that it is a big, modern building, very upscale and expensive and that it is located in midtown Manhattan, and the bustling activity of streets indicate it's another hectic workday in New York. The establishing shot has given us a good deal of information.

ESTABLISHING THE GEOGRAPHY

A phrase that is often used is that we have to "establish the geography." In other words, we

The best professional advice I ever received was from Gordon have to give the audience some idea of where they are, what kind of place it is, where objects and people are in relation to each other. Other aspects of this were discussed earlier in this chapter.

Establishing the geography is helpful to viewers to let them know the "lay of the land" within a scene. It helps them orient themselves and prevents confusion that might divert their attention from the story. There are times when you want to keep the layout a mystery, of course. As we will see throughout the discussion of film grammar and editing, one of the primary purposes is to not confuse the audience. There will be times of course where you will want to confuse them, but if you don't give them information and they have to spend time trying to figure something out, however subconsciously, you have taken their minds away from the characters and the story. Figures 5.1 and 5.2 are examples of establishing shots that have value in ways beyond just showing the geography—they can also establish tone, mood, and time of day.

Willis. He stressed the importance of always having a point of view when approaching a scene. It's the first question I ask myself when I'm designing my coverage: what is the point of view, or whose? Once I've answered this question, everything falls into place with much more ease.

Ernest Dickerson, ASC (*Malcolm X, Do the Right Thing*)

An establishing shot, such as our office building example, might also include a tilt up to an upper floor. This indicates to viewers that we are not just seeing an office building, but that we are going inside. Shots of this type are sometimes considered old-fashioned and prosaic, but they can still be effective. Even though they give us a good deal of information, they are still a complete stop in the dramatic action.

Many filmmakers consider it more effective if the establishing shot can be combined with a piece of the story. One example: say we are looking down that same bustling street and our character Helen comes into view, rushing frantically and holding a big stack of documents; we pan or dolly with her as she runs into the lobby and dashes to catch a departing elevator. The same information has been conveyed, but we have told a piece of the story as well. Something is up with Helen; all those documents are obviously something important that has put her under a great deal of stress.

Of course, in the story, Helen may already be in her office. One of the classic solutions has been to combine a bit of foreground action with the establishing shot. For example, we start with a medium shot of a sidewalk newsstand. An anonymous man buys a paper and we can read the headline “Scandal Disclosed,” and we then tilt to the building. What we have done here is keep the audience in the story and combined it with showing the building and the context.

In a sense it is a bit of distraction such as a stage magician might use, but in another sense, it does convey some useful information. Certainly it’s a lot better than just cutting to Helen and have her do some hackneyed “on the nose” dialog such as, “Oh my god, what am I going to do about the big financial scandal?” Of course, there is one more level you can add: the guy who buys the newspaper is not an anonymous man but turns out to be the reporter who is going to uncover the real story. These are just examples, of course, but the point is to convey the location information in combination with a piece of the story or something that conveys a visual idea, a sound track inflection or anything that increases our understanding of the place, the mood, or anything that is useful to you as the storyteller.

A more elaborate establishing sequence is this one from *Goldfinger* (Figure 5.6). The opening shot is a flying banner that tells the audience they are in Miami Beach, and the helicopter shot closes in on a beach hotel and then into a tighter shot of a diver. We follow him down into the water and then cut to under the water where he swims away. A crossing female swimmer carries us back in the opposite direction where we discover Felix Leiter, who walks away to find… Bond, James Bond. The sequence elegantly establishes not only the location and circumstance but carries us in a continuous sweep of motion and action.

Figure 5.6. An elegant establishing sequence from *Goldfinger*.

CHARACTER SHOTS

There are a number of terms for different shots of a single character. Most movies and short films are about people, so shots of people are one of the fundamental building blocks of cinema.

FULL SHOT

Full shot indicates that we see the character from head to toe (Figure 5.10). It can refer to objects as well: a full shot of a car includes all of the car. A variation is the *cowboy* (Figure 5.12), which is from the top of the head to mid-thigh, originally in order to see the six-guns on his belt.

TWO SHOT

The two shot is any frame that includes two characters (Figure 5.7). The interaction between two characters in a scene is one of the most fundamental pieces of storytelling; thus, the two shot is one you will use frequently. The two characters don't have to be arranged symmetrically in the frame. They might be facing each other, both facing forward, both facing away from the camera, and so on, but the methods you use for dealing with this type of scene will be the same in any case.

MEDIUM SHOT

The medium shot, like the wide shot, is relative to the subject. Obviously, it is closer than a full shot. Medium shots might be people at a table in a restaurant, or someone buying a soda, shown from the waist up. By being closer in to the action, we can see people's expressions, details of how they are dressed, and so on. We thus become more involved in what they are saying and doing (Figure 5.13).

Figure 5.7. A *two shot*. This particular type of a medium shot, with both characters in full profile, is called a *50–50* and is normally something to be careful with as it is often used as a cheat to avoid having to shoot proper coverage of a dialog scene, however, no one would argue that this scene from *Casablanca* is anything less than great.

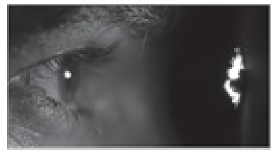


Figure 5.8. This *ECU* (*extreme close-up*) from Psycho not only shows us his intent gaze, it also manages to convey the madness of the character.

CLOSE-UPS

Close-ups are one of the most important shots in the vocabulary. There are a number of variations: a *medium close-up* (Figure 5.11) would typically be considered as something like from top of head to waist or something in that area.

A *close-up* (CU) would generally be from the top of the head to somewhere just below the shirt pockets. If the shot is cut just above the shirt pocket area, it is often called a *head and shoulders*. A *choker* would be from the top of the head down to just below the chin (Figure 5.14). A *tight close-up* would be slightly less: losing some of the forehead and perhaps some of the chin, framing the eyes, nose, and mouth. An *extreme close-up* or *ECU* might include the eyes and mouth only; this is sometimes called a *Sergio Leone* after the Italian director who used it frequently. Just as often, an ECU is an object: perhaps just a ring lying on a desktop, a watch, and so on. Any shot that includes only one character is called a *single*. Terminology for close-ups includes:

- *Medium CU*: Mid-chest up.
- *Choker*: From the throat up.
- *Big Head CU or tight CU*: Framed from just under the chin and giving a bit of "haircut." That is cutting off just a little bit of the head.
- *ECU*: Varies, but usually just mouth and eyes or eyes only.

A *close-up, medium*, or *full shot* might also be called *a clean single* whenever it's a shot of one actor alone, without anything else in the foreground. If we do include a little bit of the actor in front or even some other pieces of objects in the foreground, it's often called a *dirty single* (Figure 5.9). This is not to be confused with an *over-the-shoulder* (below), which includes more of the foreground actor.

Figure 5.9. A *dirty single* from *Zodiac*. Not quite an *over-the-shoulder* as it has out-of-focus elements in the foreground and very little of the foreground person.

OVER-THE-SHOULDER

A variation of the close-up is the *over-the-shoulder* or OTS (Figure 5.24), looking over the shoulder of one actor to a medium or CU of the other actor. It ties the two characters together and helps put us in the position of the person being addressed. The OTS is a useful part of the vocabulary of narrative filmmaking. Even when we are in close shot of the person talking, the OTS keeps the other actor in the scene. An OTS contains more of the foreground actor than a dirty single and their position in the frame is more deliberate.

Figure 5.10. A *full shot* from Kurosawa's classic *Seven Samurai*.

Figure 5.11. A loose *close-up* from *Casablanca*. Many directors will shoot two sizes of the *mediums* and *close-ups* in the coverage of a scene—this gives the editor tremendous flexibility in editing.

Figure 5.12. A *cowboy* framing from *The Good, the Bad and the Ugly*. A *cowboy* is from mid-thigh up, originally in order to show the six-guns. In Europe, it is sometimes called the *American shot*.

Figure 5.13. A loose *medium* from *The Grand Budapest Hotel*.

CUTAWAYS

A *cutaway* is any shot of some thing or person in the scene other than the main characters we are covering but that is still related to the scene (Figure 5.15). The definition of a cutaway is that it is something we did not see previously in the scene, particularly in the master or any wide shots. Examples would be a cutaway to a view out the window or to the cat sleeping on the floor. Cutaways may emphasize some action in the scene, provide additional information, or be something that the character looks at or points to. If it is a shot of an entirely different location or something unrelated to the scene, then it is not a cutaway, but is a different scene. An important use of cutaways is as safeties for the editor. If the editor is somehow having trouble cutting the scene, a cutaway to something else can be used to solve the problem. A good rule of thumb is in almost every scene you shoot, get some cutaways, even if they are not called for in the script or essential to the scene—a cutaway might save the scene in editing.

REACTION SHOTS

A specific type of close-up or medium is the *reaction* shot. Something happens or a character says something and we cut to another person reacting to what happened or what was said; it can be the other person in the dialog or someone elsewhere in the scene. Generally, the term refers to a facial expression or body language, not dialog. A reaction shot is a good way to get a safety cutaway for the editor. Sometimes the term just refers to the other side of the dialog, which is part of our normal coverage. Reaction shots are very important and many beginning filmmakers fail to shoot enough of them. Silent films were the apex of reaction shots as they understood that it is when you see the facial and body language reactions of the listener that you get the entire emotional content of the scene. Reaction shots may not seem important when you are shooting the scene, but they are invaluable in editing.

INSERTS

An *insert* is an isolated, self-contained piece of a larger scene. To be an insert instead of a cutaway, it has to be something we saw in the wider shots. Example: she is reading a book. We could just shoot the book over her shoulder, but it is usually hard to read from that distance. A closer shot will make it easy to read. Unlike cutaways, many inserts will not be of any help to the editor. The reason for this is that since an insert is a closer shot of the larger scene, its continuity must match the overall action. For example, if we see a wide shot of the cowboy going for his gun, a tight insert of the gun coming out the holster must match the action and timing of the wider shot; this means it can be used only in one place in the scene and won't help the editor if they need to solve a problem elsewhere in the scene. There is no need to be specific about the terminology when setting up a shot; however, inserts tend to fit into a few general categories:

- Informational inserts: a shot of a clock on the wall is a practical insert, as is reading the headlines on the newspaper or the name of the file being pulled from the drawer. These are mostly about giving the audience some essential piece of information we want them to know (Figure 1.16).
- Emphasis inserts: the tires skid to a halt, the coffee cup jolts as he pounds the table, the windows rattle in the wind. Emphasis inserts are normally closely connected to the main action but not absolutely essential to it.
- Atmosphere inserts: these are little touches that contribute to the mood, pacing, or tone of a scene (Figures 5.22 and 5.23).

Figure 5.14. A *tight close-up* from *Apocalypse Now*; sometimes called a *Big Head close-up* or a *choker*. In all tighter close-ups, it's OK to give them a "hair cut."

Figure 5.15. A *cutaway* from *91/2 Weeks*. A shot of the cat is not really part of the scene, but it add mood and tone to the scene.

CONNECTING SHOTS

Most scenes involving two people can be adequately edited with singles of each person; whether are talking to each other or one is viewing the other from a distance, such as a shot of a sniper taking aim at someone. This is sometimes called separation. There is always a danger, however, that it will seem a bit cheap and easy and the fact that it is an editing trick might somehow undermine the scene. Any time the scene includes people or objects that cannot be framed in the same shot at some point in the scene, a connecting shot may be a good idea although it is by no means absolutely necessary. This applies especially to point-of-view shots where the character looks at something, then in a separate shot, we see what she is looking at; but it also applies to any scene where two or more people are in the same general space, whether they are aware of each other or not. A connecting shot is one that shows both of the characters in one shot; often it is in the form of an over-the-shoulder or wide angle that includes both of them (Figures 5.16 through 5.19).

Figure 5.16. This scene from *Skyfall* consists of Bond and a villain on top of a train and Moneypenny on a nearby hilltop—the first three frames above are sometimes called *separation*—individual parts of a scene such as a close-up or medium shot showing only one side of the action.

Figure 5.17. A *choker* (*tight CU*) of Moneypenny aiming.

Figure 5.18. Combining the close-up on Moneypenny with her *optical POV* of the men on the train would make the scene play fine—no need to have her and the actors on the train in the same location or even the same country while shooting, the audience will accept it.

Figure 5.19. Shooting a *connecting shot* really ties the scene together and makes it more real and more effective than using separation shots only.

PICKUPS

A pickup can be any type of shot, master or coverage, where you are starting in the middle of the scene (different from previous takes where you started at the beginning as it is written in the script). You can pick it up only if you are sure you have coverage to cut to along the way. A “PU” is added to the scene number on the slate so the editor will know why they don’t have a complete take of the shot.

Another use of the term is a pickup day. This is one or several days of shooting after the film is already in editing. At this point, the director and editor may realize that there are just a few shots here and there that they have absolutely must have in order to make a good edit.

TRANSITIONAL SHOTS

Some shots are not parts of a scene themselves but instead serve to connect two scenes together. We can think of these as transitional shots. They might come at the end of a scene, at the beginning, or between scenes. Some are simple cutaways: a scene ends, cut to a shot of a sunset and then into the next scene. There are many other types of transitional shots as well, they are a sort of visual code to viewers that the scene is ending. Scenes of the city or landscape are frequently used as transitional devices as they also add to the mood or pace and are generically visual—meaning they don’t need to make a specific point in order to be interesting.

INVISIBLE TECHNIQUE

In almost all cases, we want our methods to be transparent—we don't want the audience to be aware of them. We are striving for invisible technique.

Camera movement, lighting, set design, even actor's behavior that makes viewers aware that they are watching a movie all distract from their following the story, just as seeing a Starbucks cup on the table in an 18th-century drama would. There are a few obvious exceptions such as when a character talks directly to the camera, but these are deliberate and are called "breaking the fourth wall," which we'll talk about in a bit.

THE SHOOTING METHODS

There are many different ways to shoot a scene, but some basic methods are used most often. The following summaries are some of the most fundamental and frequently used techniques for shooting a scene. The master scene method is by far the most often used method of shooting a scene, especially for dialog scenes.

THE MASTER SCENE METHOD

In principle, the *master scene method* is quite simple: first, you shoot the entire scene as one shot from beginning to end—this is the master. Once you have the master, you move on to the coverage. Except in rare cases, it is always best to shoot the master first, as all the rest of the shots must match what was done in the master. Not shooting the master first will frequently lead to continuity problems.

The master does not have to be a wide shot but it generally is. Nor does it have to be static; a *moving master* (sometimes called a *developing master*) is fine too. The important thing is that it is the entire scene from beginning to end. For complex scenes, we sometimes break it into *mini-masters* within the scene, just use common sense to plan how to best get the scene covered.

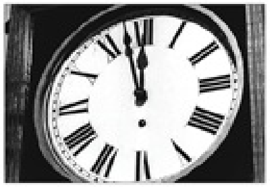


Figure 5.20. An insert of the clock conveys important story information ana emphasis in this shot from *High Noon*.

Figure 5.21. This scene from *Barton Fink* is an excellent use of *inserts* to give us not only basic information but a feel for how run down and creepy the hotel is. This *two shot* establishes the scene.

Figure 5.22. An insert reveals his dirty fingernails and the rusted bell.

Figure 5.23. (left, bottom) An insert ofthe book adds to the texture of the scene.

COVERAGE

The coverage consists of the over-the-shoulders, medium shots, and close-ups that will be used to complete the scene. Think of the master as a framework for the whole scene—coverage is the pieces that fit into that framework to make it all work together. This is why you should always shoot the master first. It establishes the continuity for the scene—everything you shoot after that has to match what was established in the master. After you have shot the master, you will have to pick one side (one of the actors) to begin with. It is important to do all of their shots before you turn around and do the coverage of the other actor because changing the camera position from one side to another often involves changing the lighting and moving other equipment. It is a huge waste of time to do some shots of one side, move to the other side and then come back to the original side. The shots you do on the second actor are called the answering shots, and it is important for editing that they match the coverage of the first actor in their lens size and focus distance: this is to keep them a consistent size as you cut back and forth between them. Some basic common sense principles apply when shooting with the master scene method:

- Shoot the master first; if you try to shoot coverage first and the master later, it will likely cause problems in continuity. This is a very important rule!
- Get the whole scene from beginning to end.
- If characters enter, start with a clean frame and have them enter after a *beat* (a short time)—so the editor has some leeway in finding the *cutting point*.
- If characters leave, make sure they exit entirely, leaving a clean frame. Continue to shoot for a *beat* after that.
- Consider using *transitional shots* to get into or out of the scene.
- Shoot all the shots on one side before moving to the other side of the scene. This is called *shooting out* that side.

Figure 5.24. An *over-the-shoulder* shot from *Casablanca*.

Figure 5.25. An *over-the-shoulder* from a more extreme angle in *Touch of Evil*.

If you know you are going to use mostly the coverage when you edit, you may be able to live with some minor mistakes in a master. It is easy to get carried away with dozens of takes of the master.

OVERLAPPING OR TRIPLE-TAKE METHOD

The *overlapping* method is sometimes called the *triple-take* method. It is not used as much as other ways of shooting a scene, but it is important and it is especially useful in understanding the concepts of continuity. Let's take an example of how it might be used—say you are filming the manufacture of a large axle on a big industrial lathe. It's a real factory, and you are doing an industrial video for the company. The metal piece is expensive, and they are only making one today. The point is that you are not going to be able to repeat the action. You can ask the machinist to pause for a few minutes, but there is no going back to repeat.

On the other hand, you don't want to show a 10 or 20-minute process all from the same angle—that would be incredibly boring. You need different angles. If you were using the *master scene method*, you would film the scene from one angle, then set up the camera for a different angle and repeat the entire scene, for over-the-shoulders, close-ups, and so on. The triple-take method is useful for scenes where the action cannot be repeated.

OVERLAPPING

So here's what we do: as they bring in the metal piece to be cut, you shoot that in a wide shot to establish the scene; at that point you ask the workmen to pause for a moment. Then you quickly move in for a close-up as they put the piece on the lathe. For this shot, the machinists back up a few steps and bring the metal piece in again and carry on with the action, all the way up to securing it in the lathe. You then quickly move to another angle and get more of the action, again with the machinists backing up a few movements before starting again. In the end, you will have different angles that should cut together smoothly because the *overlapping* action gives the editor several choices of where to find the cutting point.

> Learn the rules before you try to bend or break them. You need a foundation on which to build.
>
> Douglas Slocombe (*The Italian Job, Raiders of the Lost Ark, The Servant*)

Let's take another example: a lecturer walks into a room, sets his notes on the lectern, then pulls up a chair and sits down. This is where the overlapping part comes in. You could get a wide shot of him coming in, then ask him to freeze while you set up for a closer shot of him putting the notes on the lectern, then have him freeze again while you set up another shot of him pulling up the chair.

What you will discover is that the shots probably won't cut together smoothly. The chance of finding a good, clean cutting point is a long shot. It is the overlapping that helps you find smooth cut points. Here is what will work much better: you get a wide shot of him walking in and let him take the action all the way through to putting the notes on the lectern. Then set up a different angle and ask the actor to back up a few steps. Once you roll the camera, the actor comes up to the lectern again (repeating the last part of his walk). You then shoot the action all the way through to pulling up the chair.

Again you halt to set up a different angle, and have the actor back up from the lectern, and repeat the action of putting down the notes and then carrying it on through to the end of the scene. All this overlapping will enable you to cut the action together smoothly with good continuity cuts. The most important principle to take from this is to *always overlap all action*, no matter what shooting method you are using. Giving the editor some extra overlap at the beginning or end of any shot will prevent many potential problems when editing the scene. Again, it is important to remember that this is one of our primary responsibilities—making sure all the footage is *cuttable*.

Figure 5.26. A *reveal* that turns into a *close-up* from *Titanic*. There is a considerable amount of story information in this shot—how elegantly she is dressed, how beautiful, and fragile she is and perhaps how she has some trepidation at undertaking this voyage. The reveal can be a useful and stylistic storytelling tool. This shot also functions as a stylish and elegant *character introduction*.

IN-ONE

Of all the methods of shooting a scene, by far the simplest is the *in-one*, sometimes called a oner or a *developing master*, or the French term *plan-scene* or *plan-sequence*. This just means the entire scene in one continuous shot. A scene might be simple as "she picks up the phone and talks" in which case a single shot is probably plenty. Some in-ones can be vastly more complicated: such as the famous four-minute opening shot of *Touch of Evil* or the long Steadicam shot of entering the Copacabana in Martin Scorsese's *Goodfellas*.

A caution, however: when these shots work, they can be magnificent, but if they don't work—for example, if you find in editing that the scene drags on much too slowly—your choices are limited. If all you did was several takes of the long in-one, you really don't have much choice in editing. Play it safe—shoot some coverage and cutaways just in case. Another useful tactic is when the director has one they like, do another one at a 10% quicker pace.

FREEFORM METHOD

Many scenes theses days (and even entire movies) are shot in what is commonly called *documentary style*—the camera is handheld, loose, and the actor's movements don't seem pre-planned. It seems like documentary style and many people call it that, but it is not really. When shooting a real documentary, we can almost never do second takes, or have them repeat an action. Our aim in shooting fiction scenes like this is to make it seem like a documentary. In most cases, scenes like this are shot several times with the actors repeating the scene for several takes. Since the camera is handheld, the camera operator typically does their best to follow the dialog: they pan the camera back and forth to always be on the person who is speaking. This can be a disaster for the editor. Imagine that you shoot a scene three times like this. You end up with three takes that are almost the same and the camera is only on the actor who is talking.

Imagine trying to edit these three takes together—almost impossible. Editing is all about having different angles to cut to. If all you have is three almost identical takes, there are not really any different angles to cut to. Also, you have no reaction shots of the person listening; as we discussed before, reaction shots are important to the storytelling and the editing. So what to do?

SHOOTING THE FREEEORM METHOD

Here is a method that works well for providing the editor with lots of cuttable material and is also very efficient in shooting—we call it the *freeform method*:

- On the first take, follow the dialog. Do your best to stay with the actor who is speaking. This is the *dialog pass*.
- On the next take, pan back and forth to stay with the person who is not talking. This will give you lots of good reaction shots, which are important. It will also give the editor lots of things to cut away to. This is the *reaction pass*.
- For the third take (if you do one) improvise: follow the dialog sometimes, go to the nonspeaking actor sometimes, occasionally back up to get a wide shot—whatever seems appropriate. This is the *freeform pass*.

All these together will give you a scene you can cut together smoothly and give the editor lots of flexibility to cut the scene in various ways and to tighten up parts that seem to be dragging.

Figure 5.27. Frames from the opening sequence of *Midnight in Paris*, shot in soft warm tones by Darius Khondji. It is a *montage* because it is a series of shots connected only by a common theme.

MONTAGE

There is a special form of editing used in dramatic narrative filmmaking that does not aim for continuity at all; this is called *montage* (Figure 5.27). A montage is simply a series of shots related by theme. Say the theme is "Springtime in the city"—you might have a series of shots of the flowers blooming, gentle rain showers, the sun breaking through the clouds, that sort of thing.

Some kinds of montage advance the story but without linear continuity. For example, Rocky prepares for the big fight: we see him working out, punching the bag, running on the streets of Philly, then finally running up the stairs to triumph. It is not real-time continuity but we see the story develop. It's a series of related shots, not scenes with linear continuity. All of these methods share one common goal: to be invisible. We don't want the viewers to be aware they are a movie because this would distract them from the story.

INVOLVING THE AUDIENCE: POV

Recall the three forms of literary voice: *first person*, *second person*, and *third person*. In first-person storytelling (whether in a short story, novel, or in a film), a character in the story is describing the events. He can only describe things that he himself sees. First person speaks as "I." Such as "I went to the zoo." Second person speaks as "you," as in "You went to the zoo." It is someone who is not the speaker but who is part of the conversation. Third person, on the other hand, speaks about "they," as in "They went to the zoo." Third person is completely objective, and first person is completely subjective.

Figure 5.28. The noir film *Lady in the Lake* is shot entirely from the detective's *subjective POV*—the only time we see him is when he is reflected in a mirror.

Figure 5.29. *84 Charlie Mopic* is shot with a documentary-style look, meaning that the entire film is shown from the cameraman's subjective POV—84 Charlie Mopic is the Army designation for a combat cinematographer.

In this context, objective means merely showing or stating what is happening without getting involved. Imagine we are watching some people arguing from 20 feet away. In this case, we are just watching "those people over there" and we can see them arguing—there is not much motivation for us to get deeply involved physically or emotionally. The complete opposite is when we are one of the people involved in the argument: we are completely engaged in every way.

Second person is somewhere in between. Let's think of it as if we are standing right behind one of the people arguing, right over their shoulder. We are not directly in the argument, but clearly it is much more involving and engaging than viewing it from a distance.

There are few clear-cut lines of delineation between subjective and objective—only gradations. We have previously talked about giving the scene a narrative point-of-view. Each camera angle has a point-of-view as well, and there are several variations to that meaning. Our two people are talking; the camera stands off to one side of them. The camera is essentially part of the scene, since it sees the people but it is not involved in the scene in any way. It is a neutral observer. It is completely objective—third person.

This is like the *omniscient* narrator in a novel or story. An omniscient narrator or POV is a voice that tells the story but is not a character in the story and can "see" everything that is going on. The voice can tell us what each and every character is doing at any time. What is a completely subjective shot? It is when the camera takes the place of one of the characters. In the case of our two people talking, if the other character is talking, she would look directly into the lens as if she were looking into the eyes of the man. In actual practice, this is almost never done in narrative filmmaking, although it is used on very rare occasions. Probably the most famous example is the noir film *The Lady in the Lake* (Figure 5.28). In this case, the story is seen in an entirely first-person, purely subjective fashion as if the camera is the detective. When other characters speak to the detective they look directly into the lens. As a result, we can never see the detective because the camera is the detective—the lens becomes his eyes. The only time we see him is when he looks into a mirror.

A fascinating and very successful modern variation of this is a film titled *84 Charlie Mopic*, a Vietnam war film (Figure 5.29). The premise is that a cameraman together with a journalist/interviewer are sent along with a long-range reconnaissance team to record everything they do. Throughout the entire film, everything we see is only what is photographed by Mopic's camera. It's a terrific conceit and is executed beautifully. We see Mopic only briefly three times in the entire film. At the very end, they are under fire and are being evacuated by helicopter. Mopic is just about to get into the chopper and he is shot. He tosses the camera into the chopper and it lands on the floor facing him. It records his death as the chopper takes off without him. The fact that his death affects us so much illustrates the power of subjective POV as a device to involve the audience both visually and emotionally.

Other forms of POV are things like *doggie cam*. If there is a dog in the scene and the camera is placed low to the ground and moves along in a fashion resembling how a dog moves, we are seeing the scene from a dog's point-of-view.

Figure 5.30. This *master* establishes the background group and that the man with the mustache is looking to the left of the camera in this scene from *High Noon*.

Figure 5.31. In the *cutaway* to the background group, the directional relationships are maintained and most importantly the man with the mustache is still looking to camera left. There can be no question but that he is looking toward the foreground group.

THE FOURTH WALL AND POV

Subjective POV is often used to represent someone observing a scene from hiding; however, it is rarely carried all the way through. For example, if the "victim" were to see the stalker and walk over to confront him, logically he would look directly into the camera. There are two problems with this. First, it would break the illusion of the film. The audience would be made jarringly aware that they are watching the movie. In the theater, it would be called *breaking the fourth wall*. This is when an actor in the play talks directly to the audience. To take it to its most extreme and ridiculous logical end, if the man were to ask the stalker a question and he agreed, we would have to nod the camera up and down. Breaking the fourth wall is something we avoid but there are exceptions to this, such as when Ferris Bueller addresses viewers directly; at times such as this, all conventions are tossed aside, generally for comic effect.

The most frequently used type of character POV is the *POV look*. An example of this is when we see someone looks up, and then the next shot is a view of an airplane. It is often used as a device to cheat a location or establish a physical relationship that didn't really exist on the set or location. For example, if we want to establish that the character has a view of the city, but the location you are using doesn't really have one, it is a simple matter to get a shot of the character looking and then cut to a long shot of the city. To take it to the next step, it would also be possible to take the actor (or even a standin) to another location and get an over-the-shoulder of a view of the city. This is a cheated connecting shot and only requires that the two windows (or at least what they see of them) match visually.

In their book *Film Art: An Introduction*, David Bordwell and Kristin Thompson call this the *Kuleshov effect*. This refers to Lev Kuleshov, one of the early Russian formalist filmmakers in the 1920s. He performed an experiment in which is used the same shot of a famous Russian actor with a completely neutral look intercut (at various times) with shots of nature, some soup, a baby, and a dead woman. When asked about what emotions the actor was expressing, the audience said he was either showing tranquility, hunger, joy, or great sorrow. On the set, it is normally just called a *POV cut*, which we'll talk about more later (Figures 5.70 and 5.71)

This illustrates the storytelling power of simply putting two shots together. When we show someone tilt his head up and his eyes turn toward something offscreen, then cut to a clock tower or an airplane, viewers will always make the connection that our character is looking at that tower or plane. It also reminds us that we are almost never doing shots that will be used in isolation: ultimately shots are used in combination with other shots. This is really the essence of filmmaking: doing shots that are good on their own is important, but in the end what really counts is how the shots work when they are put together in editing.

Figure 5.32. A simple and purely visual establishing sequence opens *The Maltese Falcon*. It starts on the Golden Gate Bridge (top), so we know we're in San Francisco; pulls back to reveal the window (middle) and sign, so we know we're in an office, and then down to the shadow on the floor (bottom) that introduces the name of detective agency and the name of the main character. It is an elegant visual introduction.

Maintaining correct eyeline is important to continuity but also directs the audience's attention by showing where the character is directing their attention. In a sense the perception of the viewer "follows" the eyeline of the characters, as in the POV Look; where eyeline literally creates a continuity that did not exist in real life.

CONTINUITY

Continuity is perhaps the most important element of invisible technique: it's all about maintaining the illusion by avoiding jarring cuts that will take the audience out of the flow of the story.

Without continuity, a film becomes a series of unnatural jarring moments that takes a viewer out of the illusion and distracts them from the story. A planned lack of continuity can be a useful technique to create tension and confusion in a scene but be very careful not to overdo it.

Again, it's about organizing the material for the brain—to make it understandable, but understandable in the way we want it to be understood—this is the primary goal of editing a narrative film and thus it has to be a primary goal of how we go about shooting the original material.

SHOOTING FOR EDITING

Filming is ultimately shooting for editorial. The primary purpose of shooting is not merely to get some "great shots"—in the end it must serve the purpose of the film by giving the editor and the director what they need to actually piece together completed scenes and sequences that add up to a finished product that makes sense, has emotional impact, and accomplishes its purpose.

THINKING ABOUT CONTINUITY

Movies get made one scene at a time, and scenes get made one shot at a time. No matter how large and complex a production is, you are always still doing it one shot at a time. As you do each shot, you have to keep the overall purpose in mind: that this shot must fit in with all the other shots that will make up the final scene. Continuity is a big issue in filmmaking. It's something we have to be aware of at all times. Continuity mistakes can easily render several hours of shooting worthless or can create huge problems in editing. So what is continuity? Basically, continuity means a logical consistency of the story, dialog, and picture so that it presents the appearance of reality. Here's a simple example: in a wide shot, he is not wearing a hat. Then we immediately cut to a close-up and he is wearing a hat. It appears to the viewer as if a magic hat suddenly appeared on his head. This would be a serious continuity error—moviegoers would surely notice it. When the audience is aware of continuity errors, it makes them aware they are watching a movie; it breaks the illusion.

Although continuity is primarily the job of the director and the script supervisor, it is very important that the director of photography has a thorough understanding of the principles of continuity and how to go about making sure the footage is “cuttable,” meaning that it is material that the editor can use to put together the best scenes possible.

Figure 5.33. A well-known example ofan error in continuity—in this shot from *Pulp Fiction*, the bullet holes are already in the wall, although the guy hiding in the bathroom has not yet fired at them. This is the kind of thing the general public thinks of when they hear the term continuity, but as we’ll see there is much more to it than this. This particular example is the type that the audience is almost never going to notice, but this is not to say that continuity isn’t important, just that you can get away with some small mistakes.

TYPES OF CONTINUITY

There are several categories of continuity and each has its own challenges and possibilities. They are:

- Content
- Movement
- Position
- Time

CONTINUITY OF CONTENT

Continuity of content applies to anything visible in the scene: wardrobe, hairstyle, props, the actors, cars in the background, the time set on the clock. As discussed in the chapter *Set Operations*, it is the script supervisor in conjunction with the various department heads who must ensure that all of these items match from shot to shot.

These kinds of problems extend from the very obvious—she was wearing a red hat in the master, but now it is a green hat in the close-up—to the very subtle—he was smoking a cigar that was almost finished when he entered and now he has a cigar that is just started. While the script supervisor, on-set wardrobe, and prop master are the first line of defense in these matters, it is still up to the director and camera person to always be watchful for problems.

As with almost anything in film there is a certain amount of cheating that is possible; filmgoers can be very accepting of minor glitches. Absolutely perfect continuity is never possible, and there is a large gray area.

HEAD POSITION

One type of continuity that plays a large role in the editor’s decision about choosing the edit point between two shots of an actor is head position. Whether the actor’s head is up or down, turned left or right is something the audience is likely to notice. In theory, actors should always try to make their movements in coverage match what they did in the master and then to repeat their movements for each successive take. That’s theory, but reality is not so simple, especially in scenes that involve a lot of movement by the characters or very emotional scenes. Understandably, directors tend to be much more concerned about the performance and the development of the scene than they are about the actor's head and hand movements. This is one reason why doing more than one take of a shot that is part of the coverage of a scene is always a good idea. It is also one of the reasons why we shoot the coverage (mediums, close-ups, etc.) all the way from the beginning to the end of the scene on every take.

Figure 5.34. We see the Sheriff turn his heaaand look, which *sets up* the *subjective POV*(*High Noon*).

Figure 5.35. His subjective POV of the clock. From an editorial point-of-view three things are important: the POV is properly set up, the screen direction is consistent between the two shots, and his eyeline is correct. He is looking up and to the left and the clock is on the wall and facing right.

CONTINUITY OF MOVEMENT

Anything that is moving in a shot must have a movement in the next shot that is a seamless continuation of what was begun. Whether it be opening a door, picking up a book, or parking a car, the movement must have no gaps from one shot to the next. This is where it is so critical to be aware of how the shots might be cut together.

As discussed in *Shooting Methods*, to play it safe in shooting any type of movement and be sure that the editor is not constricted in choices, it is important to *overlap* all movement. Even if the script calls for the scene to cut away before she fully opens the door, for example, it is best to go ahead and let the camera roll for a few seconds until the action is complete. Never start a shot exactly at the beginning of a movement—back up a bit and roll into it, then let it run out at the end. One prime example of this is the *rock in*. Say you shot a master of a character walking up to the bank teller. He is there and is talking to the teller in the master. You then set up for a close-up of him. You may know that the edit will pick up with the character already in place, but the safe way to do it is to have the character do the final step or two of walking up as shot in the close-up OTS position.

There are times, however, when focus or position is critical. It is difficult to guarantee that the actor will hit the mark with the precision necessary to get the shot in focus. In this case, a *rock in* is the way to go. The technique is simple—instead of actually taking a full step back, the actor keeps one foot firmly planted and steps back with the other: then when action is called, she can hit her mark again with great precision.

CONTINUITY OF POSITION

Continuity of position is most often problematic with props. Props that are used in the scene are going to be moved in almost every take. Everyone must watch that they start and end in the same place, or it can be an editor's nightmare. This is often the dividing line between a professional performer and a beginner: it is up to the actor to place them exactly the same in every take. If there is a mismatch in placement of a prop between the master and an element of coverage, it is up to the director to either reshoot one or the other or to shoot some sort of coverage that will allow the editor to solve the problem.

This can be done in a variety of ways. One simple example: if the actor put the glass down on the left side of the table in the master, but it is on the right side in the medium, one solution is to do a shot where the actor slides it across the table. This solves the problem, but there is one drawback: the editor has to use that shot, whether it helps the scene or not. This may end up creating more problems than it solves.

Figure 5.36. *Screen direction* is established by where the camera is in relation to the subjects. Once it is established in the scene (usually by the master shot) it should be maintained for all shots in the scene—otherwise the audience will be confused as characters suddenly jump from one side of the screen to the other.

Figure 5.37. With the camera on his left/her right as in Figure 5.36, we see her on the left side of the screen and him on the right side.

Figure 5.38. The characters stay where they are, but the camera moves to the other side of *the line*.

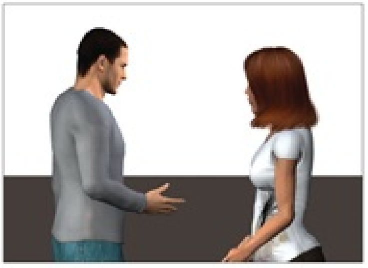


Figure 5.39. With the camera now on the other side, their screen positions are reversed.

CONTINUITY OF TIME

This does not refer to the problem of resetting the clock for each take so that it always reads the same time (that is *prop continuity* and comes under *continuity of content*), rather it has to do with the flow of time within a scene. If Dave North is walking away from Sam South in the wide shot, then you cut to a close-up of Sam South; by the time you cut back to Dave North, his action must be logical time wise. If the close-up of Sam South was for one second, when cutting back to the wide shot, Dave North can’t have walked fifty yards away.

THE PRIME DIRECTIVE

Most of the techniques and rules of continuity are based on one principle: to not create confusion in the mind of the audience and thus distract them from the story. To a great extent, the methods we use to shoot scenes and coverage is aimed toward this end.

SCREEN DIRECTION

Let’s take this simple two shot (Figure 5.36). From our first camera position, Lucy is on the left and Ralph is on the right—Figure 5.37. Then, in Figure 5.38, the camera position is shifted to the other side. In Figure 5.39, the audience will see, for no reason they can understand, that Ralph is on the left side facing right and Lucy is on the right side facing left. It will confuse the audience. While their brains try to sort it out, their attention will be drawn away from the story. Not only will they be distracted from the story, but if it happens often enough, it will annoy and frustrate them. What is it that dictates where we can put the camera to maintain continuity?

Another example: two people are standing on opposite sides of the street (Figure 5.40). The woman sees the car going right (Figure 5.41). The man sees the car going left (Figure 5.42). If we move them to the same side of the street, they will both see the car going in the same direction in relation to their own sense of orientation (left/right): their perception of the car will be the same. The movement of the car establishes direction, but there is another aspect: where they are viewing the movement from is also important; this is defined by *the line*, sometimes called the *180° line* or the *action axis*.

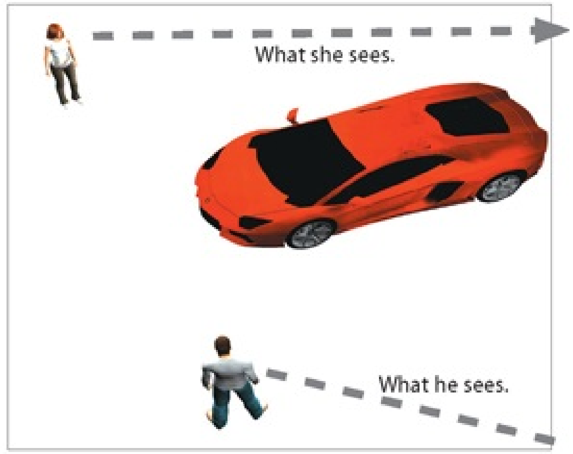


Figure 5.40. The position of the viewer (or camera) establishes *the line*, sometimes called *the 180° line* or the *action axis*.

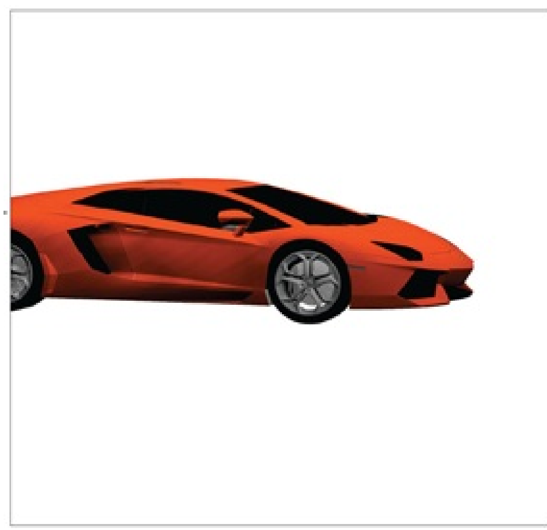


Figure 5.41. The man at the bottom will see the car moving to his left.

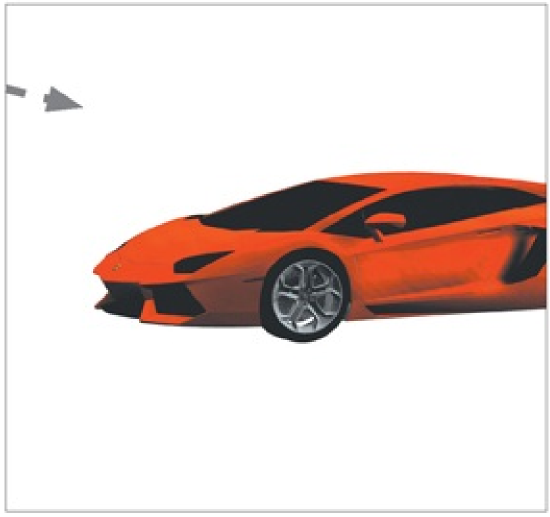


Figure 5.42. The woman at the top will see the car moving to her right.

Figure 5.43. If both of them are viewing the car from the same side of its movement of direction, then they will both see it moving in the same direction.

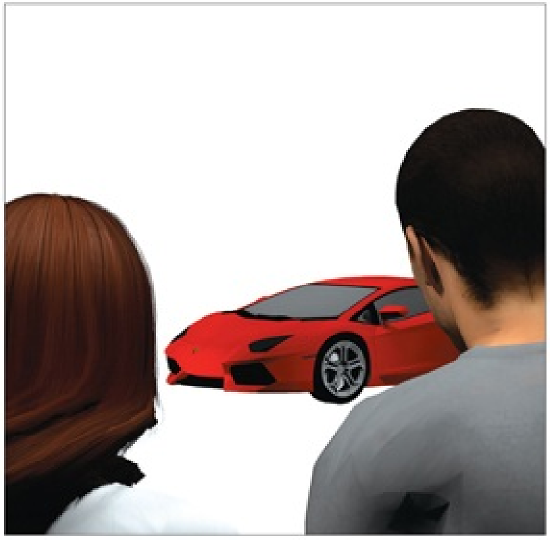


Figure 5.44. Their POV when both are on the same side of the line. This is the basic principle of screen direction—if we cross over to the other side of the line of action, it will reverse the screen direction.

THE ACTION AXIS

There is an imaginary axis between these two characters. In our first example of the car, the movement direction of the car establishes what we call the line. In all of these diagrams, it is represented by the large dashed line. The line is referred to by several terms; some people call it the *action axis* or the *action line* but most commonly, just *the line*. If we stay on one side of it for all our shots—everything cuts together perfectly (Figure 5.45). If we cross over to the other side—the characters will jump to opposite sides of the screen (Figures 5.38 and 5.39). In practice the camera can go nearer or farther, higher and lower, in relation to the subjects; the lens focal length can change, and so on—what is important is that by keeping the camera on the same side of the line, the screen direction does not change.

Figure 5.45. As long as you stay on the same side of *the line*, any camera position, any framing, any lens height, any focal length will be OK in terms of screen direction.

THESE ARE THE RULES—BUT WHY?

The basic rules of not crossing the line are well known to all working filmmakers, but many do not stop to consider the fundamental theory and perceptual issues that underlie this principle. It is important to understand it at a deeper level if you are to be able to solve the trickier issues that do not conveniently fall into one of the basic categories of this system. More importantly, it is only when we understand the whole theoretical system that we can truly understand when it is permissible to break the rules.

First, we have to consider directionality. What do we mean by that? What is something that's not directional? Not much, really. A featureless cylinder or a globe painted all the same color are non-directional, but just about everything else is. A woman looking at a building is directional. More importantly, her *look* is directional. Movement is also directional. Say we took that featureless globe and rolled it down the sidewalk. Its line of movement is the line. If we see it from one side of the line, it's going to our left, and if we see it from the other side of the line, it is going right.

WHAT ESTABLISHES THE LINE?

The line is established by the first view of the scene the audience sees. Frequently, this will be the master, but whatever is the first shot of the scene the audience sees, the line is established. If Louis is on the left and Rene is on the right in that first shot, they should remain consistent for the rest of the scene unless you deliberately change it. Once the physical relationship of the scene has been established, it must remain consistent in order to avoid confusing the audience. As we saw in the example of the man and woman and the car (Figures 5.40 through 5.44), your first camera setup in the series of shots establishes the line, but it works in conjunction with specific visual elements of the scene itself. Several things can establish the line for a particular scene. They are:

- A look
- Movement
- A specific action
- Exiting frame
- Physical geography

THE PURPOSE OF SCREEN DIRECTION

Screen direction serves two important purposes: it gives the audience clues about the story and it helps keep the audience from getting confused about where someone is or what they are doing. Avoiding confusion is the fundamental reason for all film continuity.

Figure 5.46. In this sequence from *High Noon*, leaving town is clearly established as going left.

Figure 5.47. When the marshall decides he must stand and fight, we clearly see him turn the carriage around and head back the other way. When the carriage is moving to the right, we know that they are going back toward town. If we didnt see him turning around, the fact that the carriage is now going the opposite way would be confusing.

DIRECTIONAL CONVENTIONS

The classic example of this is in low-budget cowboy movies of the fifties. In these films it was always well established that one direction on screen was toward town and the opposite direction was away from town (Figures 5.46 and 5.47). Once we knew that we could tell if the good guys or the bad guys were heading toward town or away, any deviation from this would have been very confusing. Another convention applies to trains, planes, and automobiles. If someone is leaving the east and going to the west, the plane or vehicle should be traveling left in the frame and vice versa. This is derived from the fact that most maps have north on top, so west is left and east is right.

One of the aims of editing is to not confuse the audience. If a character is walking toward the left of the screen in one shot and without explanation in the next shot he is walking toward the right, the audience will (even if only subconsciously) wonder why he changed direction. Their attention will be momentarily drawn away from the story as they try to sort it out.

This is the basic principle of all continuity in film shooting and editing. For example, she was just wearing a red dress outside the restaurant, but once she stepped through the door she is wearing a blue dress. Is this a different day? A dream sequence? What happened?

EXCEPTIONS TO THE RULE

There are several important exceptions to the 180° rule and the line.

- If we see things change position in the shot, then we understand that things have changed position. If a car is moving right in the shot, and then we see it turn around so that it's going left, then there's no problem (Figures 5.46 and 5.47).
- When the camera position moves during the shot.
- If you cut away to something completely different, when you cut back, you can change the line.
- In the case of something that is moving, you can cut to a neutral axis shot, then go back to either side of the line.

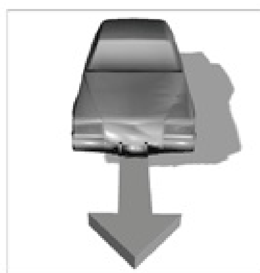


Figure 5.48. To be *truly neutral*, the object or character must be angled to exit the top or bottom of the frame. This is also an example of a shot that is on the neutral axis. Shots of this type can be useful in editorially switching the scene from one side of the line to the other—once you cut to a neutral axis shot, you are free to cut back to shots on the other side of the line.

A *neutral axis shot* is one where the movement is either directly toward or away from the camera (Figure 5.48). In essence, the line itself has moved. Some people tend to think of the line as very rigid and static, that once the line is established it can never move the whole rest of the time you are shooting the scene, but actually it is fluid and can change throughout the scene, as we will see later.

There is another exception, although it must be applied with caution. Remember, the whole point of the rule is to not confuse the audience. That means that if we can cross the line *without* confusing the audience, then you're still OK.

Example—a courtroom—its layout is very clear and visually strong. At the front of the room is the bench, a large identifiable object with the judge sitting at it. On one side is the jury, and facing the judge are the counsel tables. It is familiar and understandable. In a situation like this, you have a great deal of leeway in crossing the line without creating confusion. Another example would be rock climbers ascending a cliff. You can jump to the other side and no one is going to misunderstand what happened.

Figure 5.49. A *true reverse* from *Rear Window*. At the top, the scene as it plays out at the start.

Figure 5.50. A *true reverse* involves moving the camera to the "wrong" side (in terms of *screen direction*) but because it is a big, obvious move, the audience is not confused. This frame is a fairly common use of the reverse shot—to show what it is the actors are looking at. It can also be used to *reveal* new information,

such as the alien lurking right behind the character.

REVERSE

The *reverse* is a simple technique that turns out to be difficult to understand conceptually. A *reverse* is when you deliberately move the camera to the other side of the line. But wait, we just learned that this is a big mistake, right? Well, you can do it, but you have to understand how it works in order for it not to be perceived as just an error in screen direction continuity (Figures 5.49 and 5.50). To oversimplify—if you go just a little bit over the line, the audience is going to see it as a mistake, confusing. If you go a lot over the line, even all the way to the complete opposite of what you have established, the audience is going to be able to understand what has happened—the camera is just on the other side of the room, no big deal. Just crossing the line slightly is a problem. It is when you definitively and unquestionably are on the other side of the line that a reverse is understandable. It is also helpful if the background behind the characters is noticeably different. The audience does have to do some mental reorientation but given the proper clues they can do so easily. Another way to cross the line is to see the camera move to the other side of the line, as in a dolly move. Then there is no confusion.

TURNAROUND

Obviously, you would never do the over-the-shoulder on one actor, then move the camera to do the OTS on the other actor, then go back to the first for the close-up, and so on. This would be very inefficient and time-consuming. So naturally you do all the coverage on one side, then move the camera and reset the lighting. The term for this is that you shoot out one side before you move to the other side, which is called the *turnaround*. Many beginning directors call it the reverse, as in “We’re done with her shots, now let’s shoot the reverse on him.” Technically, this is wrong, but as long as everyone understands what is meant, it doesn’t matter. It’s also why many people refer to it as a *true reverse*, to distinguish it from a mere turnaround.

ANSWERING SHOTS

The group of mediums, over-the-shoulders, and close-ups (the *coverage*) on the second actor that match the ones done on the first actor are called the *answering* *shots*. Every shot you do in the first setup should have an *answering shot*. In cases where some physical obstacle precludes a good camera position for the turnaround, or perhaps the sun is at a bad angle, or there isn't time to relight for the turnaround, it is possible to cheat.

CHEATING THE TURNAROUND

In any of these cases, it is possible to move the camera and lights only a little and just move the actors. This is a last-ditch measure and is only used in cases where the background for one part of the coverage is not usable or there is an emergency in terms of the schedule—if, for example, the sun is going down. The idea is that once we're in tight shots, we really don't see much of the background.

It is not correct, however, to just have them switch places. In cheating a turnaround, you have to either move the camera a couple of feet, or even better, just slide the foreground actor over so you are over the correct shoulder. (Fortunately, moving the foreground actor usually involves moving the key only a little to make sure it is on the correct side of the face.) The key to a successful cheat is that the background either be neutral or similar for both actors as established in any previous wide shots. In some cases, moving props can help establish the cheat. Also, be sure the actor's eyelines are correct: if she was looking camera right on the previous shot, she should be looking camera right for the cheated turnaround.

PLANNING COVERAGE

Which brings us to another key point that is easily overlooked: whenever you are setting up a master, take a moment to think about the coverage—this is a job for the director but also the cinematographer as the director is not likely to be thinking about the problems of lighting or camera positions. Make sure that there is some way to position the camera for proper answering shots. Particularly if one character's coverage is more dramatic or more crucial to the story than the other, it is very easy to get yourself backed into a corner or up against an obstruction that makes it difficult or impossible to position the camera for a proper answering shot.

An answering shot should be the same focal length, focus distance, and angle as the shot it is paired with. In a pinch, if you can't get quite far back enough (or close enough), you can cheat a bit with a different focal length to end up with the same image size, which is by far the most important issue. As with all issues of continuity, anything that the audience won't notice is OK.

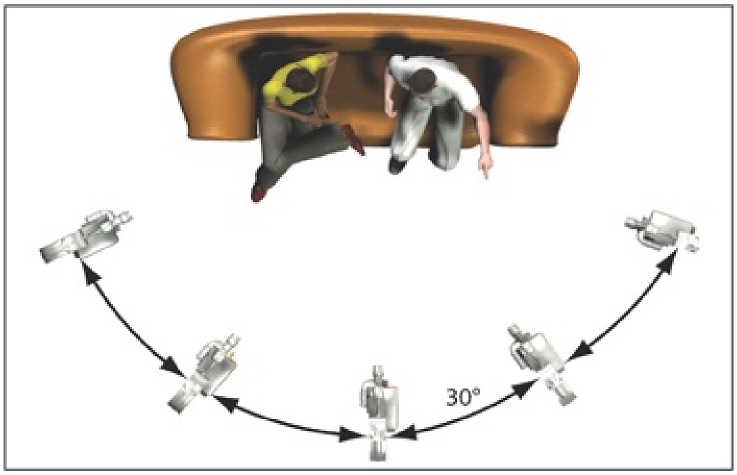


Figure 5.51. The *20% rule* and the *30° rule* are pretty much the same thing. What is important is not some exact figure, but the crucial element is that the two shots appear *different enough* to the audience so that they cut together smoothly. You should consider these guidelines an absolute minimum. Often they are not enough of a change. It is best to combine the 30° move with another change, such as a different focal length to ensure cuttability.

CUTTABILITY

So that's the 180° rule, and we can shoot anywhere in the 180° circle, right? Well, not quite. First, let's define what makes shots cuttable. When we put a sequence together, it is important that when one shot follows another, it does so smoothly, not jarringly. An example: our two people are on the sofa. We are doing a shot from the side that includes both of them and the arms of the sofa. Then we move in just a bit and get a similar shot of the two of them but without the sofa arms. How would it look if we cut these two together? Suddenly the image size changes just slightly, as if maybe the film broke and some frames are missing—sometimes called a jump cut. For two shots to be cuttable, there needs to be a more substantial change. If instead of moving in just slightly, for example, we moved in a lot so that the shot is just a close-up shot of one of the characters. Then the two shots would be cuttable.

THE 20% AND 30 DEGREE RULES

How do we know how much we have to change to make two similar shots cuttable? It's called the *20% rule*. In general, a shot must change by at least 20% to be cuttable (Figure 5.51). That can be a 20% change in angle, in lens size, or camera position. It's a very rough guideline, of course. Many people find that 20% just isn't enough of a change for a smooth cut. At best, it is an absolute minimum—it is wise to make more of a change to ensure a good edit. Another rough guideline is the *30° rule*. This is just a variation of the 20% rule. Let's go back to our 180° circle. Without changing the lens, or moving closer or farther away, and as long as we move 30° to the left or right along that circle, we're OK (sort of). With lens changes, it is more subjective. Depending on other factors in the shot, moving up or down one prime lens size—say from a 50mm to a 35mm —may or may not be enough. Frequently, it is necessary to change two lens sizes: say, from a 50mm to a 25mm. In the end, it comes down to a judgment call. All of these are based on the same basic principle—two shots that are going to be cut together need to be different enough that the audience easily perceives that they are two different shots, not just one shot with some frames missing in the middle—a jump cut.

OTHER ISSUES OF CONTINUITY

Some additional general principles apply when the subjects are in motion during the scene or when shooting groups of people larger than a two shot.

Figure 5.52. Maintaining the same direction while going through a door is usually desirable, but not always necessary. There is a continuity error in this scene. Can you spot it? See the text for the answer. It is the type of continuity error that no one is ever going to notice as they watch the film and thus is of little consequence. *The Maltese Falcon*.

MOVING SHOTS

Two types of shots predominate in moving shots: the driving shot, and walk and talk. The same rules apply to both. At first glance, we would think that the direction of the car or the walk is the major axis, but in fact, it is only a secondary axis. The major axis for screen direction is between the two people, not the direction of their walk or the movement of the car.

GOING THROUGH A DOOR

There are two schools of thought on door entrances and exits. Some will say that if a character goes through a door going to the right (in an exterior shot), they have to emerge on the other side, also going right (in the interior shot). Others maintain that once someone goes through a door it is a new deal, and anything goes. Again, it is a subjective call. If there is a very clear connection between the two, and the directionality and continuity of movement are very strong, then it is a good idea to maintain directional continuity between the two. If there is a great deal of difference between the interior and exterior and there is a greater change in angle, camera position, or lens size between the two, it is possible to go to the other side when the character comes through the other side of the door (Figures 5.52 and 5.53). However, there is a small continuity problem in this scene when Bogie enters the office. Can you spot the mistake? Take a very close look before you read the next paragraph.

He is using a different hand opening the door: right hand in the hallway shot and left hand on the shot inside the office. Similarly, when a character takes a turn around a building, if the camera cuts when the character disappears around the corner, when we pick him up on the other side, the screen direction should be maintained.

ENTERING AND EXITING FRAME

Once a character exits either frame left or right, they should enter the next from the opposite side (Figures 5.54, 5.55, and 5.56). You can think of it as an imaginary pan. As the character exits frame, you mentally pan with her: this positions you correctly for the next shot of entering frame. Of course, there will be times when you do an actual pan as characters pass the camera, but there are just as many occasions when you will want to cut, either because the pan is awkward, would reveal parts of the location you don't want to see, or even when the two shots are in very different locations even though you want the audience to perceive the two parts of the walk to be in the same place. This is called location stitching (for an example see Figures 5.76 through 5.78). As with all continuity sequences, if something else comes in between the exit and the entrance, anything goes when you cut back to the original scene.

NEUTRAL AXIS TO EXIT FRAME

If the character or a moving vehicle exits the frame on a completely neutral axis, then you are free to go anywhere you want on the next cut. For something to exit on a truly neutral axis, however, it has to exit either above or below the frame (Figure 5.48). A neutral axis resets screen direction; once you go to a neutral axis shot of any type, you are free to come back to the scene with a new screen direction established for the scene. This can be used as an editorial device and also as a way to save the scene in editing, just as you would with a cutaway.

THREE SHOTS

Three shots can be difficult—once you get a third person into a shot, the coverage and continuity issues increase dramatically. Screen direction is basically the same in three shots (or when there are more characters in the scene), but one thing to watch out for is overlapping the person in the center. If you break it up as a pair of two shots, the person in the center will appear in both shots and there will be unavoidable continuity problems as it's impossible for even a skilled actor to exactly repeat every movement. The center character will tend to "pop" as you cut from shot to shot.

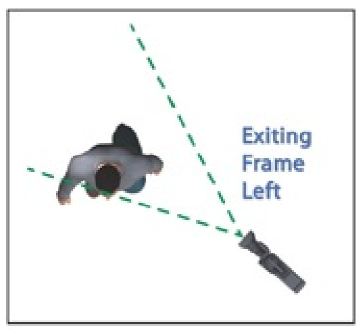


Figure 5.54. When a character exits the frame, this establishes a direction. In this example, he is exiting *Screen Left*.

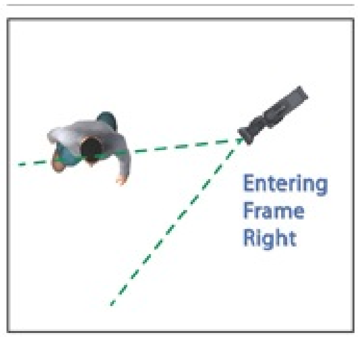


Figure 5.55. The screen direction established by the exit must be observed when the character re-enters in the next shot. To match his exit in Figure 5.53, he must enter the frame *Screen Right*.

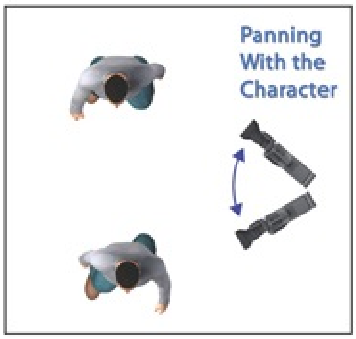


Figure 5.56. Think of it as if you were panning the camera.

KEEP THE NOSE OUT

For the same reason, it is important to avoid getting a part of the foreground person in the shot when doing a clean single over the shoulder of the second character. When two characters are fairly close to each other in the master, it is often difficult to completely frame the second person out, especially if they move around a lot. Often their nose, or a hand, or some small piece of them will creep into the single. This is not only compositionally annoying but will cause continuity problems. It will often be necessary to shift the offscreen character back a bit, so they don't creep in. You don't want to do it so much that you "miss" their presence in the coverage. If there is a large shift, be sure to set a new eyeline for the onscreen character so that their head doesn't shift too much from the master.

Figure 5.57. The basic principles of an *over-the-shoulder* shot apply even if the angle is more extreme than normal—the head and shoulders of the foreground person are clearly visible; the main subject is in focus and the eyelines match. From Kubrick's *The Killing*.

PROP CONTINUITY IN COVERAGE

Mistakes in prop continuity are easy to make, especially on small productions where you may not have a full prop crew on the set or when you don't have an experienced continuity supervisor. It is important to stay vigilant for even the smallest details, as bad continuity is something that will mark your project as "amateurish." On the other hand, there is such a thing as "too much continuity." Sometimes, script supervisors can become so obsessed with tiny details, which won't really be apparent to the audience, that they can start to get in the way of the production. Figures 5.52 and 5.53 are an example of this. It is important to find a balance.

EYE SWEEPS

When an offscreen character walks behind the camera, the onscreen character may follow with her eyes. It's perfectly OK as long as the eye sweep is slightly above or below the lens. As always, it is important that the actor not look directly into the lens, even for just a moment. The most important thing about eye sweeps is that they match the direction and speed of the crossing character. This means that the onscreen actor will move their head in the opposite direction of the movement of the crossing.

CHASE SCENES

Chase scenes can be problematic for screen direction. As a general rule of thumb you want to maintain an overall direction within the scene, but there is considerable room for variation. For car chases especially, some directors prefer to mix it up more to slightly disorient the audience and emphasize the kinetic nature of the chase.

CUTAWAY EYELINE CONTINUITY

Since cutaways are not part of the main scene but are physically related to it, directional continuity must be maintained between the location of the scene and the cutaway element. This is especially important for cutaways that involve a look from the additional character, which they often do (Figures 5.30 and 5.31). Since you are moving away from the main scene and it is usually for a quick pickup shot, often you will be up against limitations of the set or other problems that will make it necessary for you to cheat the additional character a bit. Because the audience is acutely aware of where an actor's eyes are directed, wrong eyelines are something they will always be aware of—it is very easy to get them wrong.

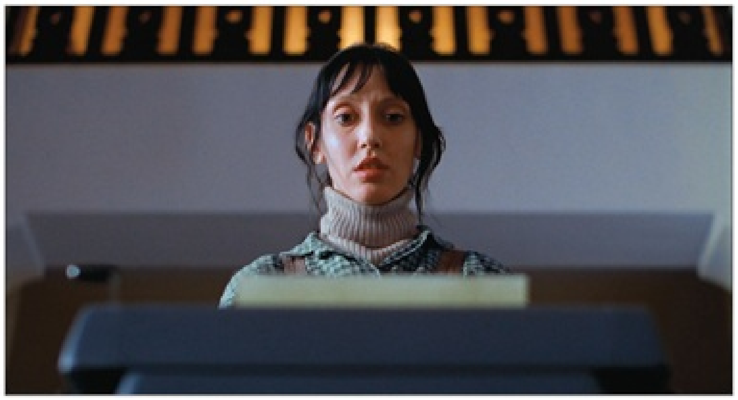


Figure 5.58. Her look down at the typewriter establishes her eyeline for her POV in this scene From *The Shining*.

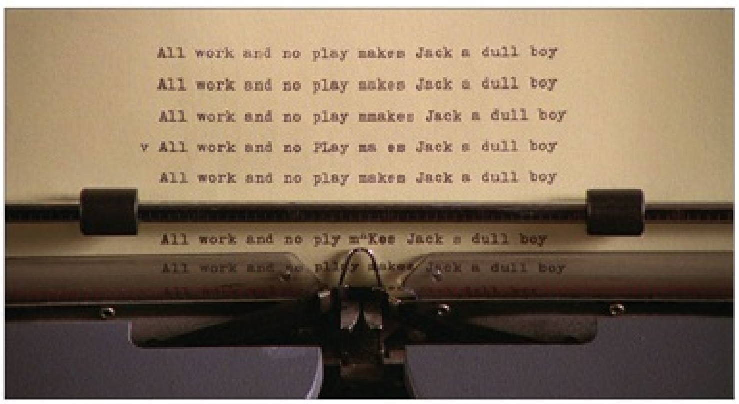


Figure 5.59. The POV insert matches the eyeline that has been established.

EYELINES IN OVER-THE-SHOULDER COVERAGE

When shooting over-the-shoulder coverage, the camera height will generally be at eye level for the characters. If the two performers are of unequal height, some modification may be necessary. In this case, the camera height will approximately match that of the character over whose shoulder you are shooting.

EYELINES FOR A SEATED CHARACTER

The same principle applies when one or more of the characters is seated or on the floor (Figure 5.57), but with an important exception. Since shooting over the shoulder of the standing character might be an extreme angle, it also works to keep the camera at the eye level of the seated performer, which makes it sort of a past-the-hips shot.

In situations like this, for the clean singles, when there is a difference in height or level of the characters in coverage, the eyelines may also need some adjustment. This does not apply to over-the-shoulders, as we can see the offscreen performer's head and thus we know the actual eye-level.

OTS AND INSERTS

Inserts often are not critical in terms of screen direction except in a general way. One instance where they are important is reading inserts. This type of insert is quite common as the master scene, or even an over-the-shoulder, is normally not tight enough to allow the audience to actually read what the character is looking at. In these cases, it is important to conform to the eyeline and screen direction of the character reading the material, even if they are not holding it (Figures 5.58 and 5.59).

Figure 5.60. This master from *Ronin* (**A**) establishes the main group and their places around the table. The next cut (**B**) reveals the woman at the head of the table (separate from the group) in a way that shows her relationship to them; it orients us to the overall arrangement. This is a *reverse*. (**C**) This cut to a three shot maintains the screen direction established in the master (**A**). This is a good example of how seeing a piece of the table helps to keep us grounded in the scene. If it wasn't there, we would definitely miss it. (**D**) This shot of the girl is outside of the group so that we are seeing her from over a different shoulder of the foreground actor than we saw in (**B**) but it's not a problem as the screen direction is maintained. (**E**) This single on the man in the suit also benefits from seeing a piece of the table. If it was necessary to move the

table to get the shot, the set dressers will often have something smaller that can stand in for it. (**F**) This shot is from the POV of the man in the suit, but we don't see any of him in the foreground. In this case we are said to be "inside" him—not inside his body, but inside his field-of-vision.

MOVING ACTION

Once you thoroughly understand the underlying principles and the cognitive reasons for these rules, it is easier to see when there can be exceptions and flexibility. Most importantly, in a scene with moving action, such as a fight scene, the line will be shifting constantly. In fight scenes photographed to be edited in a rapid fire sequence, the director and editor might want to ignore the line to add a sense of action and disorientation to the scene.

GROUP SHOTS

Scenes with more than three characters generally require a good deal of coverage. If there is a dominant direction to the arrangement of the group, that will most likely dictate a screen direction line based on where you shoot the master from. In practice, it may be possible to shoot from almost anywhere as long as you get the proper answering shots and coverage. However, it may be better to pick a line and stick to it. If there is a dominant character standing apart from the group, this will often establish the line. These frames from a group scene in *Ronin* illustrates some of these principles (Figure 5.60). Notice in particular the slight difference between B and F. Both are shots down the middle of the axis; B, however, is an over-the-shoulder past the man in the suit, while F does not include him, and is more of his POV.

INTRODUCTIONS

When you are bringing the viewer into a scene, you can think of it as bringing a stranger into a party. Some of the concepts have been mentioned before, but now let's consider them in the context of narrative continuity. There are four basic introductions that need to be made: place, time, geography, and the main characters. Many aspects of introductions and transitions are in the script, but they must be actualized by the director and the cinematographer on the set. Some are improvised at the time of shooting because they may be based on some prop or aspect of the set or location that has not been apparent before, such as a perfect full moon just above the frame—an invitation to start on the moon and tilt down to the scene.

Figure 5.61. The opening frame of a very long, slow, deliberate zoom out from *Barry Lyndon*.

Figure 5.62. The last frame from that same zoom. Kubrick uses this type of *slow disclosure* thematically

throughout the film, always ending in a perfectly balanced formal composition, often based on a painting of the period. The slow zoom out works on many levels, both visually and storywise. It is an example of a scene as an in-one—the whole scene played out in one continuous shot.

THE PLACE & THE GEOGRAPHY

This was discussed previously, but it deserves mention here as there are several aspects to establishing the geography that relate to actual shooting on the set. Establishing the place generally just serves the purpose of showing us where the scene will take place (Figures 5.1 and 5.2). This is just called the *establishing shot*. Establishing the *geography* is a bit different than just letting the viewer know where the action takes place. Where an establishing shot is generally an exterior view of the building, establishing the geography relates to the scene itself. In many scenes, it is also important that they have a general comprehension of the layout of the place—the overall geography.

Most of the time we start wide on a scene, and successive shots move in closer. An important exception to this is called *slow disclosure*. In this technique, instead of opening with a wide shot, the scene begins with a tight shot of a character or another scene element. Only as the scene progresses does the camera pull back to reveal where we are and what is going on. This is a variation of the basic reveal where the camera starts on something that either moves or the camera moves past it to show some other scene element. Stanley Kubrick uses slow disclosure masterfully in *Barry Lyndon* (Figures 5.61 and 5.62). Throughout the film, one of the key formal devices is the very long, very slow zoom back. He starts with a telling detail of the scene and then very deliberately pulls back to reveal more and more. As with so many other aspects of the film (perfectly composed fixed frames based on paintings of the period, the emphasis on formal geometry), this slow pull back underlines the rigid formalism of society and culture at that time as well as the inevitability of Lyndon’s decline. These long pullbacks also serve as editorial punctuation between sequences and contribute to the deliberate pace of the film. For these shots, Angenieux created a special lens—the Cine-Pro T/9 24–480mm with a far greater zoom range than any other lens available at the time. Famously, he also had an ultra-fast Zeiss F/0.7 still photo lens converted for use on a motion picture camera to shoot almost entirely with natural light and period sources such as candelabras and windows—which is an integral element of his overall plan to faithfully re-create the sense of life in the 18 th century, when the only lighting available was windows, fires, and candles.

Figure 5.63. Devices to convey a short passage of time are often more difficult than demonstrating a long passage of time between cuts. In *Ronin*, the director uses the fact that the Christmas tree is being decorated in one shot. The bellhops enter with a box of decorations for the tree.

Figure 5.64. (above, bottom) In the next shot, the tree is fully decorated. It is very subtle but the audience will subconsciously register that some short amount of time has passed between the two shots.

Figure 5.65. A dramatic and suspenseful introduction of the antagonist in *High Noon*. His arrival has been talked about and dreaded for the entire movie up until this point, but when he arrives on the noon train, the director delays showing his face until the most dramatic story moment. As he gets off the train, we see him only from the back.

Figure 5.66. (right, middle) As his former girlfriend is boarding the train to escape the coming violence, she turns to see him and their eyes meet.

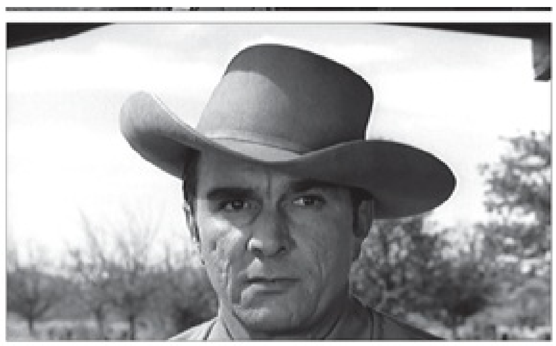


Figure 5.67. (right, bottom) Our first view of him is both a dramatic *reveal* and her subjective *POV*: it makes for a powerful moment. Notice how their eyelines *match*; if they did not, it would not seem like they were looking at each other. In order to match, they need to be *opposite*: she is looking toward the left of the frame and he is looking toward the right side of frame.

THE TIME

Beyond establishing where we are, the viewer must know when we are. Internally within the scene, this is either a function of a transition shot or other types of temporal clues. In Figures 5.20, 5.34, and 5.35 we saw it done with cutaways and inserts of clocks in High Noon. In these two frames from Ronin (Figures 5.63 and 5.64) the director needed to find a way to establish that fifteen or twenty minutes had passed.

This can be much more difficult than conveying that days have passed or that it was summer and now it's winter—that can be accomplished by a simple exterior shot of the green trees which dissolves to a shot of the same tree barren of leaves and a layer of new-fallen snow on the ground. Here he has done something very subtle. In the first shot we see the bellhops starting to put decorations on a tree in the hotel lobby. In the second shot, as the camera pans to follow the character's exit, we see that the decorations have been completed. For the audience, this is completely subconscious, but it conveys the passage of time in a subliminal way.

THE CHARACTERS

Introducing the characters is of course mostly a function of the script and the actors, but a general principle is to introduce key characters in some way that visually underlines some aspect of their importance, their nature, and their story function. Also, making this introduction visually interesting helps the audience remember the character: a form of visual punctuation. We already saw a particularly elegant character introduction in Figure 5.26 from *Titanic*.

For the entire first half of *High Noon*, we have been waiting for the arrival of the bad guy on the noon train. He has been discussed, feared, even run away from. When we finally meet him (Figures 5.65 through 5.67), Zinnemann handles his introduction cleverly. As the bad guy first gets off the train, we do not see his face. Then for an entire sequence of shots, we see him being greeted, strapping on his guns, and still we do not see his face. Finally, his former lover is getting onto the train; she is leaving town only because he has come back. She turns to look at him, and it is only then that we first see his face. It is a dramatic and distinctive way to introduce the character.

OTHER EDITORIAL ISSUES IN SHOOTING

In the course of shooting the scene, it is important to not be so focused on the essential action and storytelling that there is no thought of the small shots that will help the editor put the scene together in a way that is seamless, logical, and also suits the tone, pacing, and mood of the sequence. These include cutaways, inserts, and character shots that contribute to the overall ambiance.

JUMP CUTS

Disruptions of continuity can result in a jump cut. Although clearly an error in methodology, jump cuts can be used as an editorial technique. Truffaut and others of the *nouvelle vague* in France in the early sixties were among the first to employ jump cuts effectively. Jump cuts as a stylistic device stem from Jean-Luc Goddard's first feature, *Breathless*. Film lore is that he just shot the scenes in such a way that they could not be edited conventionally (such as running the camera for long periods as the characters drive around Paris) and simply had to come up with a stylish way of covering up his error. True or not, it made jump cuts a stylistic device, which just goes to show, if you spin it right, even your mistakes can become legendary.

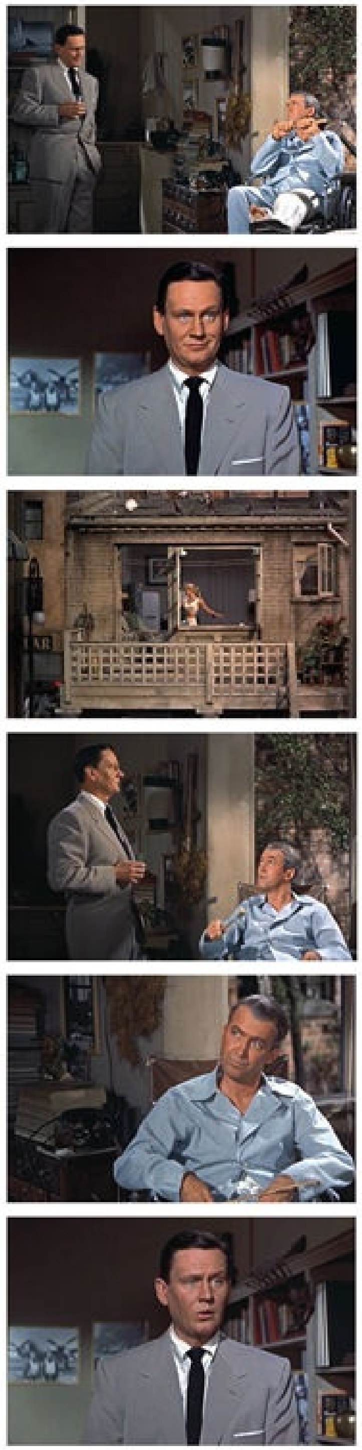


Figure 5.68. An excellent use of eyelines for story purposes from *Rear Window*. The top frame establishes his eyeline toward Jimmy Stewart. The next three establish his eyeline to Miss Body so that in the bottom frame we can see he is really looking at her while talking to the seated Stewart.

Figure 5.69. *Jump cuts* in *Breathless*, in this case, created by editing together different clips from a long continuous take.

THE SIX TYPES OF CUTS

Some aspects of editing are beyond the scope of what we deal with in day-to-day production on the set, but directors and cinematographers must know most of the major concepts of editorial cutting in order to avoid mistakes and to provide the editor with the material she needs to not only cut the film together seamlessly, but also to control pacing and flow, delineate overall structure, and give the scenes and the whole piece unity and cohesion. There are six basic types of cuts, some of which have been discussed. They are:

- The content cut
- The action cut
- The POV cut
- The match cut
- The conceptual cut
- The zero cut

THE CONTENT CUT

The content cut applies to whenever we cut to a new shot within a scene only to add new information or carry the story forward. In its simplest form, content cutting is used in the coverage of a conversation. We cut from the master to the over-the-shoulder, to the close-up. Nothing changes in these shots except the content. We were seeing both of them, and now we see one of them, and so on.

The content cut is just a part of the overall forward progression of the narrative. As with all cuts, it must obey the basic rules of the line and the 20% rule in order to be cuttable.

THE ACTION CUT

The action cut, sometimes called a *continuity cut* or a *movement cut*, is employed whenever action is started in one shot and finished in the next. For example, in the first shot we see him opening the door, and in the next shot we see him emerging from the other side of the door. Or she reaches across the table, then cut to her hand picking up the cup of coffee. Shooting for the action cut must be done properly if it is to work in editing.

First of all, you should always *overlap* the action. In this example, it would be a mistake to have her reach for the cup, then call “cut” as soon as her arm extends, then proceed to a close-up of her arm coming in to pick up the shot. There is a grave danger that there will be a piece missing, which will result in a jump cut.

As discussed in *Shooting Methods*, shooting the overlap also gives the editor the choice of exactly when to time the cut. If the editor has some freedom to time the cut, small problems in continuity can be smoothed over. In this small example, the overlapping action is fairly small. In the case of entering and exiting doors, getting in and out of vehicles, and so on, fairly substantial overlaps should be shot. This is especially true if there is important action or dialog going on during the move. In that case, the editor needs the ability to adjust for performance and narrative flow as well as simple continuity. In shooting close shots that continue the action in a larger shot, it is also important to match the speed of the action. In the case of picking up coffee, the actor may have been in the middle of a big speech as she reached for the coffee and thus did it slowly and deliberately. If a good deal of time has passed between shooting the wide shot and picking up an insert of the hand picking up the coffee, it is possible that she will not be doing the dialog, and all she is doing is sticking her hand in the frame to grab the cup. In this case, it is very easy for her to forget the pacing of the original shot.

Figure 5.70. These frames from *Rear Window* show the *POV cut* in use. The turn of his head and his eyeline let us know that the lady in the window is what he is looking at as seen in Figure 5.71 (bottom). We know this because the geography of the location has been previously established so we understand where her window is in relation to the main character.

While shooting for an action cut, it is important to always be aware of the possibilities of the *cut point*. It is always best to cut “on the action.” If someone is seated at a desk and rises to go to the door, you want to shoot while he is rising from the chair. If the phone rings, you want to cut to the next shot while he is reaching for the phone, and so on. Cutting on action makes for a smoother cut and a more invisible one. The audience is a bit distracted by the action and less likely to notice the cut. Take the example of answering the phone: in the medium shot, the phone rings, he picks it up and starts talking. Then we cut to a close-up of him talking. In this case, it is critical that his head be in the same position and that he is holding the phone in the same way. If any of these fail, it will be bad continuity and will be distracting. Cutting as he reaches for the phone helps avoid these problems.

THE POV CUT

> I learned from a great editor: ‘Cut out all the comin’s and goin’s.’
>
> Jack Couffer, ASC

The POV cut is sometimes called “the look” and we briefly discussed it in *Shooting Methods*. It is one of the most fundamental building blocks of continuity and is especially valuable in cheating shots and establishing physical relationships. A POV cut occurs anytime a look offscreen in the first shot motivates a view of something in the next shot (Figures 5.70 and 5.71). The simplest case:

- Shot 1: A character looks offscreen and up.
- Shot 2: A view of a clock tower.

Figure 5.72. In *2001: A Space Odyssey*, Kubrick uses an edit that is both a *conceptual cut* and a *match cut*. In the first frame the ape has discovered the bone as a weapon and tool and throws it into the air. In the next frame (Figure 5.73, middle) we see the bone traveling through the air. Then there is a match cut (Figure 5.74, bottom) to a spaceship. Kubrick has not only communicated that the original tool (a bone) has led to a world where space travel is possible, but he has also moved the story forward from the past to the future in an elegant way; no need for a clumsy title card that says “10,000 Years Later” or some other obvious device—the conceptual cut says it all.

There will be no question in the mind of the viewer that we are seeing the tower as he would see it—that is, from his point-of-view. In order to do this, the POV shot must satisfy certain conditions.

- Direction of look. If it is to a shot of the clock tower, clearly, he has to look up. Further, he must look up at approximately the right angle. If his gaze only rises about 10°, for example, and the clock tower is ten stories high, it won't work. Similarly, if we have seen in a wide shot that the clock tower is on his right side, then his look must go to the right as well.

- Angle of the POV. The shot of the clock tower must bear some logical relationship to where the viewer is. If we have seen that he is standing on the plaza right under the tower, then we cannot cut in a shot of it as seen from a hundred yards away over the trees.

The POV cut is a classic means of cheating locations. For example, our story is based on him seeing a murder in the building opposite him, but unfortunately, the building opposite our location is unavailable for use. In this case, the POV cut from him looking out the window to a POV of his view through the window of the building across the street will sell the concept that he can see the murder.

Figure 5.75. Alfred Hitchcock's film *Rope* appears to be one long, continuous take but, of course, it consists of segments no longer than 10 minutes as that was the maximum length of film stock available. The cuts between segments are hidden by various devices that are examples of the *zero cut*—a cut that is meant to be invisible.

EXECUTING A SUBJECTIVE POV

In order to make the *Subjective POV* cut work, it is essential to execute the shots properly. A subjective POV consists of several pieces. First, you must establish the person looking, or the audience will not know whose POV it is. Second, it is necessary to see that person "look"—often this is done by showing them turn their head or in some other way obviously appear to be looking at something (Figure 5.70). This part of the setup is essential in letting the audience know that the next shot will be the character's POV. Third is the actual POV itself, their view of the thing they are looking at (Figure 5.71). Generally, this needs to be a somewhat normal lens because an extremely long lens or very wide lens would not represent normal human vision and wouldn't look like someone's point-of-view. To finish it off, many editors also use the shot of the character returning their head to the position they were in before the POV, but this is not absolutely essential.

THE MATCH CUT

The *match cut* is often used as a transitional device between scenes. An example from a western: the telegrapher sends the message that the governor has not granted a pardon; the hanging will go on as scheduled. From the telegrapher, we go to a shot of the telegraph pole (with audio of the clicking of the telegraph). Then from the shot of the telegraph pole we cut to a shot of the gallows: a vertical pole the same size, shape, and in the same position as the telegraph pole. One image exactly replaces the other on screen.

One of the most effective uses of a match cut is in *2001: A Space Odyssey* as shown in Figures 5.72, 5.73, and 5.74. Another famous example is at the beginning of *Apocalypse* Now where Coppola cuts from helicopter blades to the ceiling fan in a Saigon hotel room. Great care must be taken in shooting both sides of a match cut. It is not enough that the objects be similar in shape: the screen size (as determined by focal length) and the position in the frame must also match. One method is to have a video of the previously shot scene and play it back on the director's monitor. For scenes requiring greater precision, a monitor with an A/B switch allows the image to be quickly switched back and forth from the freeze frame of the video to the live picture feed from the camera.

Figure 5.76. This scene from Ronin appears to be one continuous pan, but in fact, when a passing pedestrian wipes the frame, there is a cut that enables the filmmaker to use two entirely different locations

as the beginning and end of the same shot. This is called *location stitching or location splicing*.

THE ZERO CUT

The *zero cut* is a type of match cut that rarely gets mentioned in discussions of shooting and editing. A variation of this technique is used by John Frankenheimer in *Ronin* (Figures 5.76 through 5.78). In this case, the camera tracks with a man as he walks down a street An extra *wipes* the frame (blocking it entirely for a frame or two) and the character walks on. There is nothing especially remarkable about the shot. The trick is that it is actually two shots that were done thousands of miles and weeks apart. The first part of the shot was done on location in Europe, and the second part of the shot is on a studio lot in Los Angeles. This gives the director the opportunity to use the strong points of two locations combined into one continuous shot. This is actually a form of location stitching (also called location splicing) where footage shot in two or more locations is edited to make it look like the whole scene was filmed in one place. This technique is the same one Hitchcock used in his "one shot" film *Rope* (Figure 5.75). It is what made it possible for him to shoot the entire film so it appears to be one long continuous take, even though a roll of film in the camera lasts only 10 minutes. Although *Rope* gives the impression of one long take, it is a myth that there are no cuts at all, in fact, there are a few, most of them at the reel changes.

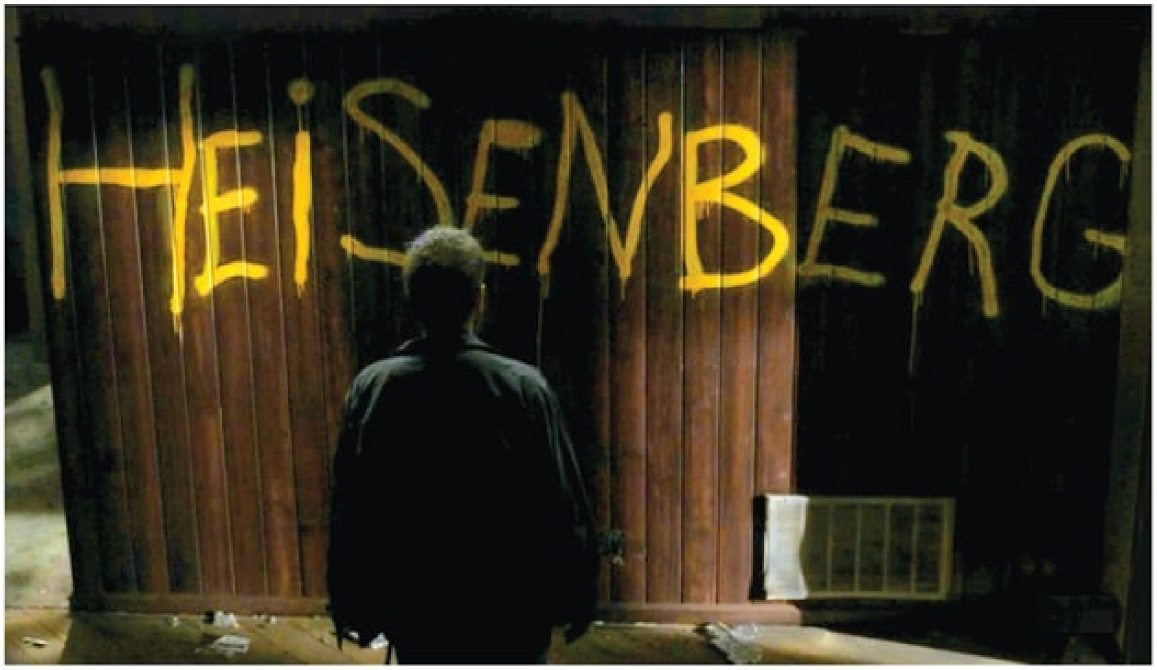


Figure 6.1. Dramatic color makes this shot from *Breaking Bad* especially powerful.

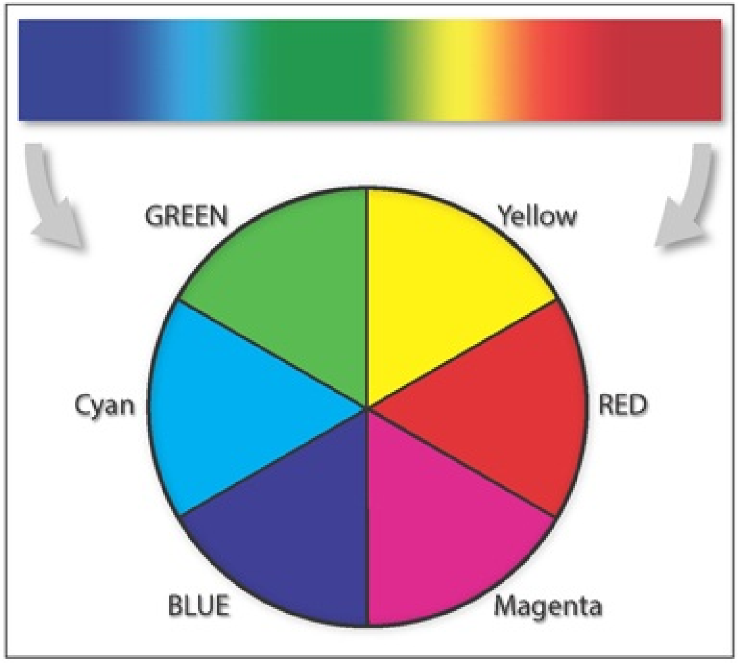


Figure 6.2. Newton's innovation was to take the spectrum and bend it into a circle. Note that the color wheel has magenta even though it does not appear on the spectrum. The secondaries Cyan and Yellow are mixtures of the primaries on either side of them on the spectrum, but Magenta is a mixture of Red and Blue, which are at opposite ends of the spectrum.

Color is both a powerful artistic and storytelling tool and a complex technical subject. As with most artistic tools, the better you understand the technical side, the better equipped you will be to use it to serve your creative purposes. Although we'll be delving into the science and technology of color, it is important to never lose sight of the fact that it all comes down to human perception—the eye/brain combination and how it interprets the light waves that come in is the basis of everything we do in this area. As for technology, never forget that when it comes to achieving your artistic and crafts person goals—anything goes; you are never constrained by some "techie" requirement, unless, of course, ignoring that technical aspect is going to interfere with what you finally want to achieve.

COLOR TERMINOLOGY

As we will see later in the chapter *Measurement*, what we commonly call color is more properly termed *hue*. *Value* is how light or dark a color is and *saturation* is how "colorful" it is; in video we more commonly call it *chroma saturation* or just *chroma*. A desaturated color in everyday terms might be called a *pastel*. These terms are the basis for two color models: *Hue/Saturation/Value* (*HSV*) and *Hue/Saturation/Lightness* (*HSL*). These systems are widely used in computer graphics and sometimes show up in applications used in dealing with video streams or individual frames (such as when adjusting a frame or frames in *Photoshop*, for example); they are widely used in *color pickers* which are almost always a part of visual software.

Derived from the color wheel, it is easy to conceptualize hue as a circle and saturation as its distance from neutral white in the center. This is shown in Figure 6.5; this is a simple visualization of hue, color mixing, and chroma saturation decreasing to white (no saturation). However, it does not show value/lightness decreasing to black. This is a pervasive problem with illustrating and graphing color models since there are usually three important axes; it is hard to do it in on the two-dimensional space of paper.

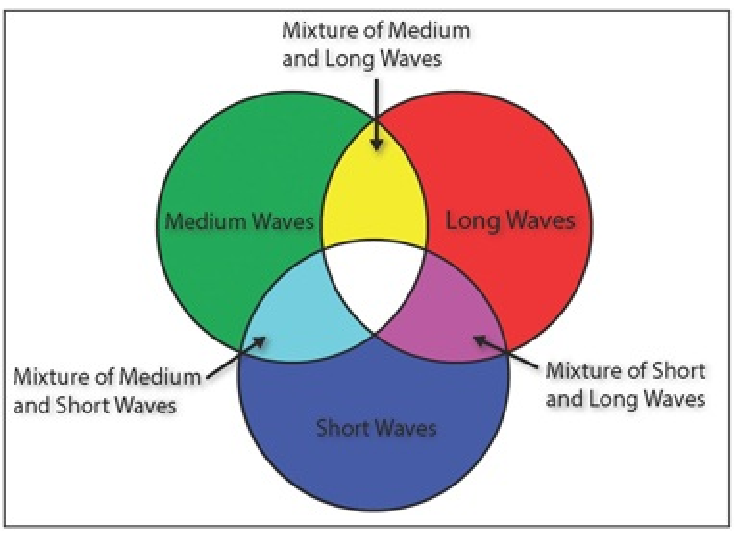


Figure 6.3. The basic color wheel shows the primary colors: Long wavelengths (Red), Medium wavelengths (Green) and short wavelengths (Blue) and the secondary colors that result from mixing two primaries equally.

COLOR TEMPERATURE: THE BALANCES

Even simple consumer cameras can be set to “daylight,” but what is daylight? It’s not sunlight, which tends to be warmer due to the yellow sun of Earth; it’s not skylight, which is very blue, it’s a combination of the two. It is a somewhat arbitrary standard, established back in the fifties when someone went out on the front lawn of the *Bureau of National Standards* in Washington at noon with a color meter. They determined that daylight was 5600K. The units are K, for *degrees Kelvin* and this is called *color temperature*. The ° symbol is not used with the Kelvin scale. (Some cameras use 5500K.)

If you heat a *black body radiator* (such as a piece of metal) to 3200K it will be the same orange color as the light bulbs we use in filmmaking; in other words, the Kelvin scale is sort of a common sense application of the terms “red hot,” “white hot,” *etc*. Here’s the funny part: a lower temperature makes the color “warmer,” where logic would imply that making it hotter makes it “warmer” in color. On this scale the average color temperature of daylight is 5600K—5500K and 6500K are also sometimes used as the average “daylight.” Consumer cameras (and most DSLRs) have other preset white balances in addition to daylight and tungsten. These usually include *open shade*, which is much cooler because it is mostly skylight which is much bluer; the same applies to overcast days, where warmer direct sunlight is not a factor.

WARM AND COOL

On the warmer end of the scale are things like household light bulbs, candles, and other smaller sources which are in the 2000K to 3000K range. All this brings us to the question: what do we mean when we say “warm” or “cool” colors? Clearly it doesn’t relate to the color temperature; in fact, it works in the opposite direction (Figure 6.4).

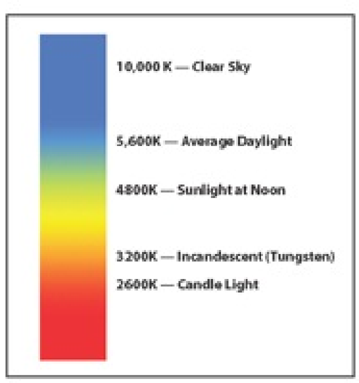


Figure 6.4. Color temperature in degrees Kelvin. Lower color temperature is Red/Orange; higher color

temperature is bluer.

Color temperatures above 5000K are commonly called *cool* colors (blueish), while lower color temperatures (roughly 2,700–3,500K) are called *warm* colors (yellow through red). Their relation on the color wheel is shown in Figure 6.11. The color temperatures of black body radiators are also shown in Figure 6.13; it is called the *black body locus*, meaning that it is a collection of points, not a single instance. Color temperature is a useful tool but it doesn't tell us everything about the color of a light source; specifically, it doesn't tell us anything about how much green or magenta is in a light's radiation. This is a problem because many modern light sources have a lot of green in them, usually a very unpleasant amount, especially for skin tone; these sources include fluorescent tubes, *CFLs* (*Compact Florescent Lights*) and even some *HMIs* (which we'll talk about in the chapter *Lighting Sources*). All of these produce light by electrically exciting a gas (LEDs work by a process called *electroluminescence*).

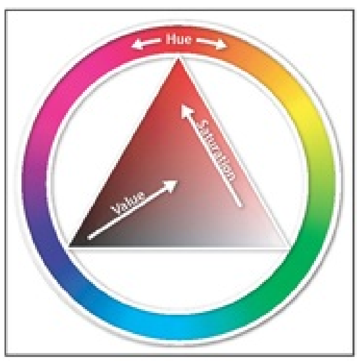


Figure 6.5. Hue, what most people think of as "color" is measured around the color wheel. Value goes from dark to light (Red is used as the example here), and Saturation is the "colorfulness"—high saturation is the color as very intense and low saturation is the color as a pale tint.

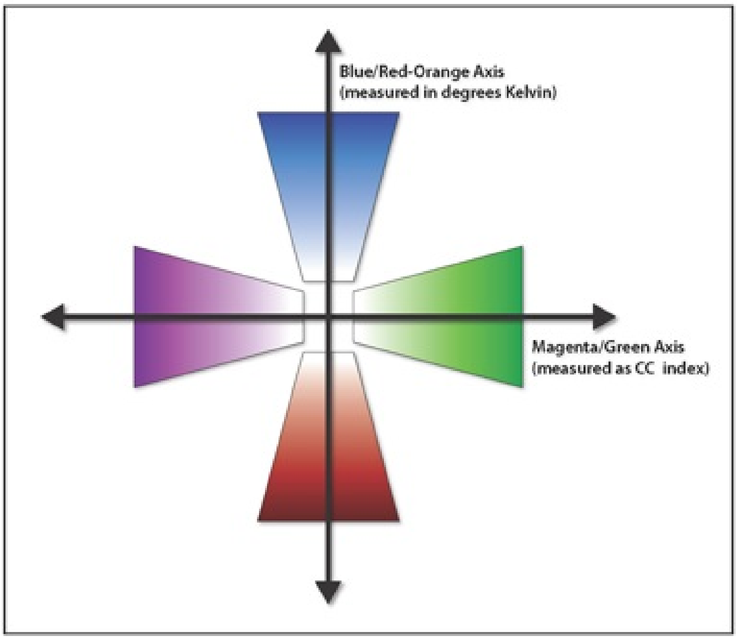


Figure 6.6. The two axes of color: Red/Orange-to-Blue and Magenta-to-Green. They are completely separate and have to be measured separately, which is why all color meters have two different measurements: *Degrees Kelvin* and *CC (Color Correction) Index*

Because color temperature and green (and its opposite magenta) are two different aspects of light, they have to be measured separately. For this reason, color meters will have two scales and output two measurements: one in *degrees Kelvin* (color temperature) and the other in *Color Compensation* (*CC*) units (the magenta/green scale, sometimes called *tint*). Cameras will have similar controls.

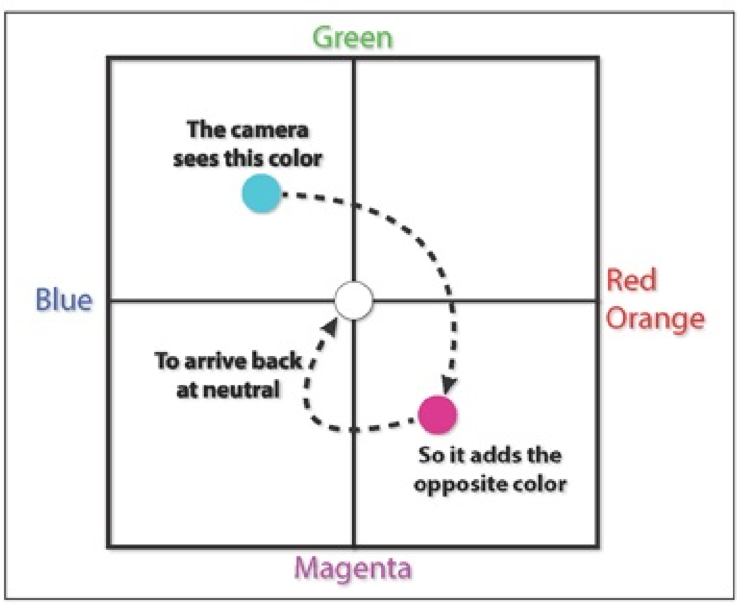


Figure 6.7. A conceptual diagram of how a camera does white balance. Notice that it operates on the two color axes: Green-to-Magenta and Blue-to-Red-Orange. In this example, the camera "sees" the scene as being lit with blue/green (cyan) lighting, which might be typical of some types of daylight fluorescent tubes. This is why it is important to use a truly neutral white or photo gray card as the target while white balancing—you want the camera to be analyzing *only* the color of the lighting of the scene, not the color of objects within the scene. As we will see later, the actual adjustment is made by varying the balance of red and blue in relation to green.

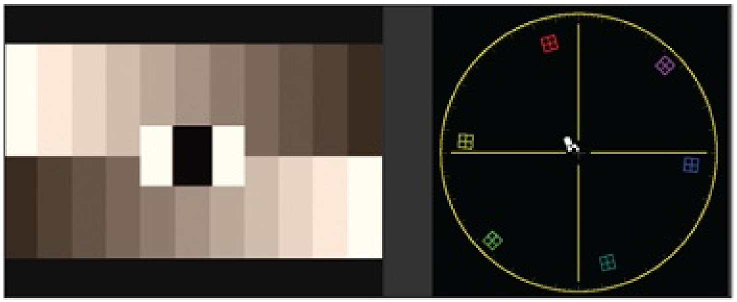


Figure 6.8. A neutral gray scale with the color balance skewed toward warm light. Notice how the trace on the vectorscope is pulled toward red/orange.

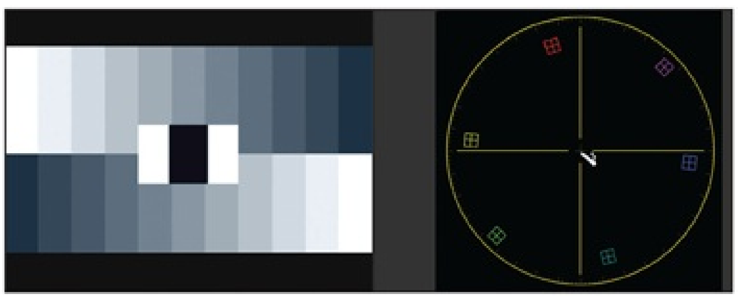


Figure 6.9. The same chart with color balance skewed toward blue—the vectorscope trace is pulled toward blue.

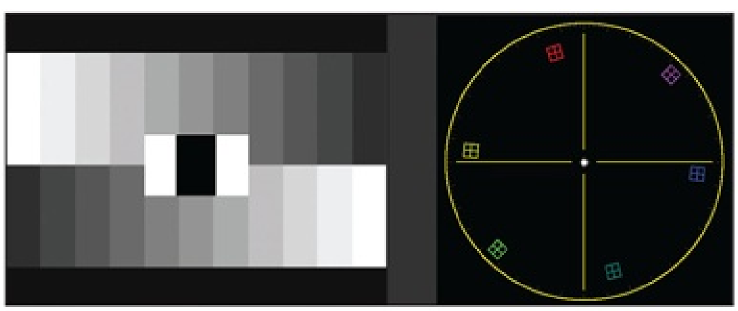


Figure 6.10. The gray scale with neutral color balance—the vectorscope shows a small dot right in the center, indicating that there is no color at all—zero saturation.

WHITE BALANCE, BLACK BALANCE, AND BLACK

SHADING

A white piece of paper will appear white to us whether it's in a fluorescent-lit office, a tungsten-lit living room, or outdoors in the noon day sun. This is because our brain "knows" that it's white so it just interprets it as white. This can accommodate a wide range of color sources but, of course, in extreme conditions under a single color source such as pure red or blue, it does break down and we see the paper as taking on the color of the source. Cameras don't have the ability to adapt in this way: they will record the color of light reflected off the paper just as it is. This is why we have to *white balance* cameras. In older HD cameras, this white balance is *baked in*; with cameras that shoot RAW, it is recorded in the metadata. Figures 6.12 and 6.14 show incorrect and adjusted color balance.

Most cameras will have preset color balances but it is usually more accurate to do an active white balance on the set. The VFX people will appreciate this as well, as they frequently have to artificially re-create the lighting conditions. It is helpful to understand how a camera accomplishes this (Figure 6.7). Conceptually, it is a process of sensing what light is in the scene and "adding" the opposite so that they balance back to neutral white. Technically, cameras achieve this by adjusting red and blue in relation to green. In traditional HD cameras (and even in a few RAW cameras) this is done by adjusting the gain on the three color channels. In cameras that shoot RAW, the gain of the color channels is not changed in the camera (except on some Canon and Sony cameras), the color balance adjustments are recorded in the camera and the actual changes occur in color grading. *Black Balance* is also extremely important; most cameras will perform a black balance automatically, usually with the lens capped for complete darkness. Without proper black balance, some colors won't reproduce properly—see *Measurement. Black Shading* is different. The Red company explains it like this: "Noise in any digital image is the result of both 'fixed pattern' and random noise. The former is caused by persistent variations in light sensitivity between pixels, whereas the latter is caused by thermal fluctuation, photon arrival statistics, and other non-repeatable sources. Everything else being equal, fixed pattern noise is, therefore, the same for every image, whereas random noise is not.

Figure 6.11. Warm and cool colors. This is a psychological phenomenon; in terms of physics, the color temperature of Blue is "hotter" (higher in degrees Kelvin) than Red but this has little to do with our perceptual reaction to colors.

Figure 6.12. This shot was lit entirely by skylight, which is blue. On the left, the camera is set to *Tungsten balance* and the resulting shot is very blue, it looks unnatural. On the right, the same shot with the camera's color balance adjusted to the color temperature of the existing light.

"Black shading works by measuring the pattern of fixed noise, storing it in memory, and then subtracting it out of all subsequent frames—leaving only random noise behind. The pattern stored in memory is called a *Calibration Map*, and is effectively a map of the black level for every pixel—hence the name black shading. With Red cameras, it's only necessary when exposure conditions differ substantially, such as with extreme changes in temperature and exposure time, or after a firmware update."

MAGENTA VS. GREEN

We tend to think of this process as purely about tungsten vs. daylight; this is probably because in the days of shooting on film emulsion, the manufacturers made only two types of film: tungsten or daylight. When shooting film in a lighting situation that included green (such as fluorescent in an office) you had only a few choices:

- Turn off the fluorescents and provide your own lighting.
- Put *Minus-Green* (magenta) gels on the fluorescents.
- Filter the lens with a *Minus-Green* (magenta) filter.
- Add *Plus-Green* to your lights on the set and shoot a gray card for reference and fix it in post.

As you can guess, this is not always necessary with a video camera, because white balance function on the camera is capable of removing any color cast that takes the image away from an overall neutral white appearance, which obviously does not apply to creative choices concerning color tone. This includes green/magenta imbalance as well as red/blue (daylight/tungsten) color shifts. Keep in mind, however, that altering the lighting is still often the best choice for maintaining control of the color. Lighting situations, especially those that involve a mixture of different types of sources, are seldom about just getting a mechanically “OK” neutral appearance. More importantly, fluorescent and other “green” sources are seldom *full-spectrum light*—their emissions are *discontinuous* and heavy in the green part of the spectrum and thus won’t reproduce color faithfully.

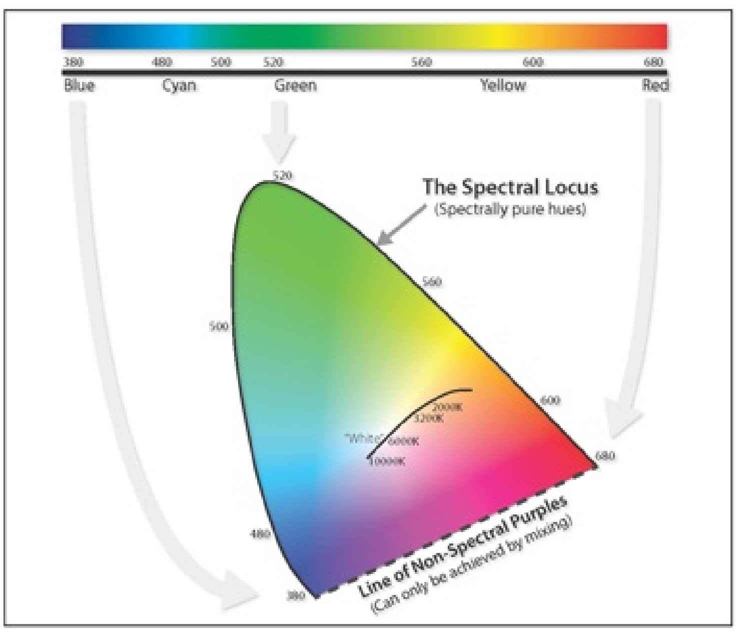


Figure 6.13. The anatomy of the *CIE Diagram*. Not unlike the color wheel, it starts with the spectrum. The *Spectral Locus* (horseshoe) represents the colors of the spectrum at maximum saturation, with saturation decreasing as you move toward the center, where all colors mix to create white. At the bottom is the *Line of Non-Spectral Purples* (Magentas) which are not spectrally pure in that they can only be achieved by mixing —they don’t appear in the original spectrum, just as there is no magenta in a rainbow. Near the middle is

the locus of the colors of a black body radiator at various temperatures. As you can see, no single one of them can be considered to be “pure white.”

THE CIE DIAGRAM

Over the centuries, there have been dozens of color systems—attempts to quantify color in diagrams or numbers. To some extent, all of them are pretty much theoretical. What was needed was a system based on actual human perception of color. This is why the *CIE* (*International Commission on Illumination* or in French *Commission Internationale de l'Eclairage*) was formed in 1913 to conduct research into color science to develop international standards for colorimetry.

THE SPECTRAL LOCUS

Today, you will see the *CIE chromaticity diagram* (Figure 6.13) just about everywhere that video color is being discussed. It is so significant that we need to examine it in detail. First is the "horseshoe" shape with the various hues. The curved outline of this diagram is really just the spectrum bent into the horseshoe shape. This outer boundary is called the *spectral locus*—it is the line of the pure hues of the spectrum at maximum saturation. Also note that not all hues reach maximum saturation at the same level.

Within the area enclosed by the spectral locus are all of the colors that the human eye can perceive. One tenet of color science is that if the human eye can't see it, it isn't really a color. Sometimes color science strays over that boundary into what are called *imaginary colors* or *non-realizable color*, but these are for purely mathematical and engineering reasons.

THE WHITE POINT

In the center is a *white point*, where all the colors mix together to form white. It is not a single point—the CIE includes several white points call *illuminants*, all of them along the *black body locus* we talked about earlier. In the example shown in Figure 6.13, the white point shown is D65, which is roughly the same thing (in theory) as a scene lit with daylight balance light. Other CIE Illuminants include A: Tungsten, F2: Cool White Fluorescents, and D55: 5500K. There is no one official standard but D65 (6500K) is the most widely used as the white point for monitors.

Figure 6.14. *Parade view* on the waveform monitor clearly shows the incorrect color balance of what should be a neutral gray chart. On the waveform, the Red channel is high, while Green is a bit lower and Blue is very low (top end of each channel is circled in this illustration). This is why so many colorists and DITs say that they “live and die by parade view.”

THE LINE OF PURPLES

Along the bottom straight edge is an especially interesting part of the diagram: the *line of non-spectral purples*, commonly called the *line of purples*. Think back to Newton’s color wheel, which bent around to join the short wave end of the spectrum (Blues) with the long wave end (Reds) which results in magenta and its variations—all of the purples. These are colors that can only be achieved by mixing.

GAMUT

The CIE diagram shows all colors that human vision can perceive, but currently no electronic (or photochemical) method yet devised can represent all of them. So within the horseshoe we can place representations of the various degrees of color that cameras, monitors, projectors, or software can achieve—this is called the *gamut*. The limits of gamut are important measures of a particular camera or a system of color. As with *dynamic range* (which we usually think of as grayscale range) cameras, monitors, and projectors are steadily improving in their gamut range. Gamut is most easily visualized on the CIE diagram; it is defined by its primaries, usually in the areas of Red, Green, and Blue and its white point. Figure 6.15 shows the gamuts of various *color spaces*. It also identifies one of the CIE-defined illuminants—D65, or 6500K. Once you have defined a gamut, it is easy to tell, either graphically or mathematically, when something is *out of gamut*, meaning it falls outside the triangle. As color is passed from one device to another or one *color space* to another, it is possible for some color points to be out of gamut. This can be dealt with in a variety of ways: the color can simply be *clipped*, or it can be brought back in through the mathematical operation of a *matrix transform* or by *gamut mapping*, such as with a *Look Up Table* (LUT), which we'll discuss later in *Image Control & Grading*.

VIDEO COLOR SPACES

Now that we have some basic concepts and terminology, let's look at some *color spaces* that are used in production, post, and distribution. Having a solid understanding of the various color spaces, their potential, and their limits is important for cinematographers, colorists, editors, VFX people, and those involved in mastering and distribution. Following are some of the most widely used color spaces in HD and UltraHD video work.

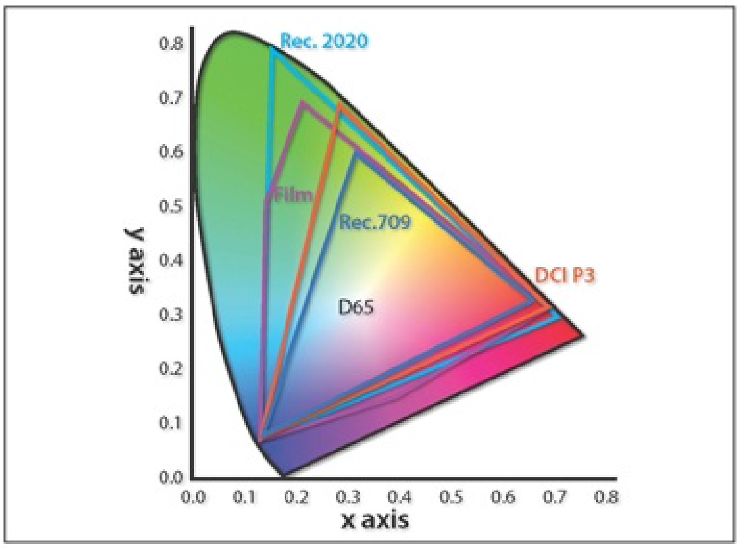


Figure 6.15. The relative *gamuts* of *film, Rec. 2020, DCI P3,* and *Rec.709*. This clearly shows the value of the CIE chart in comparing the relative gamuts (limits) of various imaging *color spaces*. Rec. 2020 is the gamut for UHD video. Remember that these are the theoretical limits of the gamuts of various color spaces —whether or not individual cameras, projectors, monitors, or color correction systems achieve these limits is a different issue.

REC.709 AND REC. 2020

HD production has used Rec.709 for many years; it is the official standard for HD video. It is important to remember that Rec.709 is for the world of HD, where cameras were more limited in dynamic range and gamut. Post-HD cameras not only have higher dynamic range, they also generally have wider color gamuts. Rec.709 is still the standard for the great majority of monitors so it is necessary to use it in many situations. Fortunately, most cameras provide the option of outputting Rec.709 video to the monitors; if they don't it can be accomplished in other ways, such as a *viewing LUT*, which might be applied through a separate *LUT Box*, by using a LUT applied to the monitor output of the camera or by other means.

Viewing material that is being shot as *RAW* or *log* in Rec.709 is not a perfect solution, but it generally serves as at least a guide and makes viewing more comfortable and understandable, particularly for the director and those outside the camera department. Despite the fact that Rec.709 is tied to the appearance of types of monitors that are no longer even manufactured, it has shown resilience in remaining a standard. ITU Rec. 2020 is the standard for 4K (3840x2160) and 8K (7680x4320) UHD. As shown in Figure 6.15, it has a substantially wider gamut than Rec.709.

DCI P3

The *Digital Cinema Initiatives* group was formed in 2002 by a consortium of major studios. Their primary aim was standardization of distribution and theatrical displays for the motion picture industry. The standards they have published include the *P3 color space* (Figure 6.15) and also the *Digital Cinema Package* (*DCP*) and *Digital Cinema Distribution Master* (*DCDM*) which standardized files and formats for distribution to theaters. The DCI work group decided on a wide gamut for their standardized color space, in recognition of the amazing advances that have been made in sensors, cameras, and projectors in recent years.

AMPAS ACES COLOR SPACE

If the folks at DCI thought big in terms of gamut, the *Science and Technology Council* of the *Academy of Motion Picture Arts and Sciences* (*AMPAS*) decided to go big, big! In formulating the *Academy Color Encoding System* (*ACES*) they actually went outside the gamut of colors encompassed by human vision; it is an ultra-wide gamut. The reasons for this are mathematical and technical, but the result is that the Green and Blue primaries are *imaginary*, *non-realizable* colors. There are actually two things called ACES—Figure 6.19 is the *color space* of ACES; we're going to talk about the ACES *workflow* later.

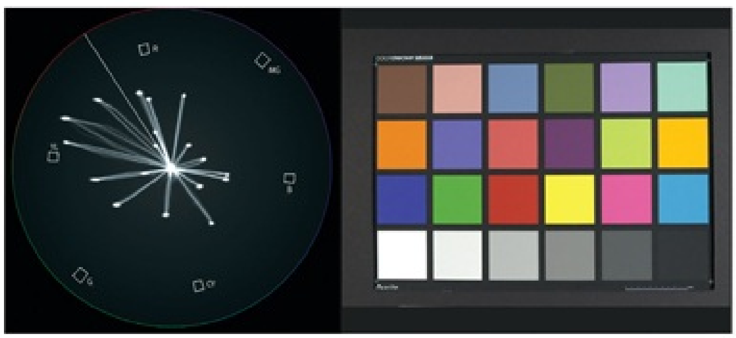


Figure 6.16. (top) All matrix controls set at zero on a Sony F3—camera default. The Macbeth Color Checker and its trace on the vectorscope.

Figure 6.17. (middle) Matrix control R-B set at +99.

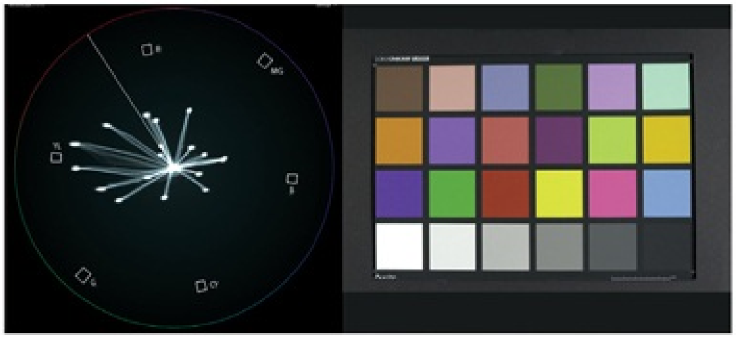


Figure 6.18. (bottom) Matrix control R-B set at -99. There are, of course, a vast array of different choices, these are just a couple of examples at extreme settings. They also illustrate the power of the vectorscope in evaluating color on the camera or in post as well as the importance of a properly calibrated test chart—without these, you're really just guessing. There are plenty of people they can hire who are just guessing—you don't want to be one of them!

THE MATR

The *matrix* refers to a mathematical/electronic function that controls how colors are converted from the sensor to camera output. In short, the matrix in the camera controls the way in which the red, green, and blue signals from the sensors are combined. It is a mathematical formula that can be altered to suit the needs of the shot and the look you're going for. It is not to be confused with *white balance*—which alters the overall color cast of the scene to adjust to differently colored lighting sources (and sometimes as a creative choice as well). White balance is an overall shift of all colors in one direction or another—usually toward blue (daylight balance) or toward red/orange (tungsten balance) but may also include adjustments for the green in fluorescents, for example. Matrix adjustments generally have little effect on the appearance of whites and neutral colors (such as the gray card); see Figures 6.16, 6.17, and 6.18.

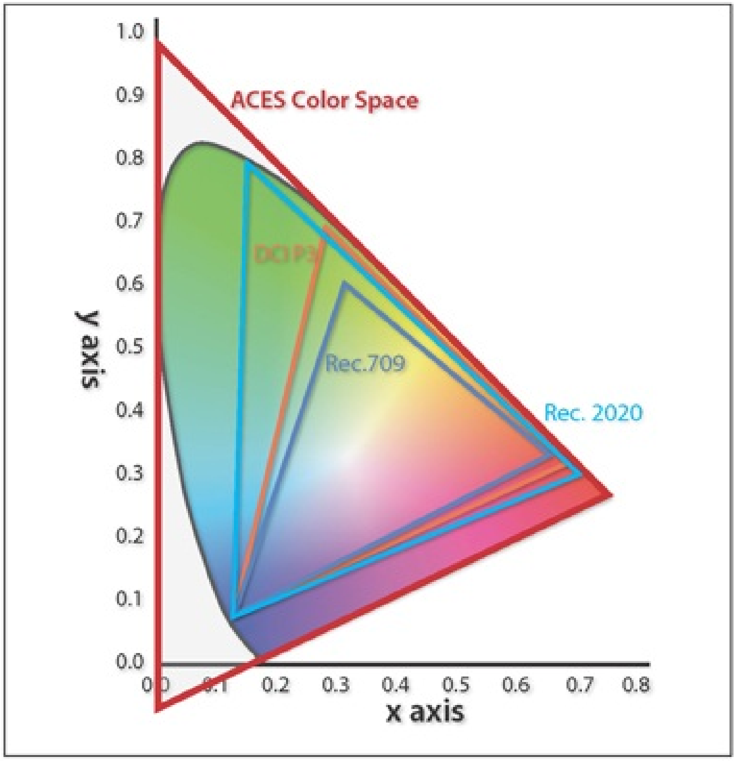


Figure 6.19. *AMPAS ACES* color space is actually larger than the gamut of the human eye. For mathematical reasons, the *ACES* color space includes not only every color the eye can perceive but also colors outside the spectral locus. These are called *non-realizable* or *imaginary* colors. They basically exist only to make the equations come out right.

Art Adams has this to say: “I describe the matrix as adding and subtracting color channels from each other. Not colors, but channels—that’s a big difference. Channels are just light and dark, like the black and white negatives from three-strip Technicolor. The dye filters on a sensor’s photosites require some overlap so they can reproduce intermediary colors. The way to get pure color is to subtract one color channel from another to remove its influence. Or, if a color is too saturated, you can add some of another channel’s color to desaturate it. Do the blue photosites respond a little too much to green, adding a bit of blue to anything that’s green? Subtract some of blue’s channel from green’s channel and you can clear that right up. It’s not as simple as this, but that’s the idea.”

As an example, the Sony F3 (which does not shoot RAW but has many other controls over the image) has several matrix presets in the *Picture Look* menu. This camera also offers several preset matrix combinations: in addition to a *Standard* matrix setting, there is a *HighSat* matrix which heightens the saturation of the colors, a *Cinema* setting which more closely simulates the color tone reproduction of film shooting and several other selections, and finally an *FL Light* setting for shooting with fluorescents.

Here it is important to remember that fluorescent lighting involves more than just a white balance setting, which is why there is no matrix preset for *Tungsten* or *Daylight*—those adjustments can be handled adequately with either using the white balance presets or by shooting a gray card or neutral white target under the scene lighting conditions. Many cameras have the ability to store user set matrix adjustments. Typically, for cameras that have matrix controls, the parameters that can be adjusted are:

- R-G: Red has only its saturation changed, while Green has both its saturation and hue *(phase*) altered.
- R-B: Red keeps the same hue but saturation changes, but Blue changes in both hue and saturation.
- G-R: Green changes only saturation but Red can vary in both hue and saturation.
- The same concept applies to G-B (green-blue), B-R (bluered), and B-G (blue-green).

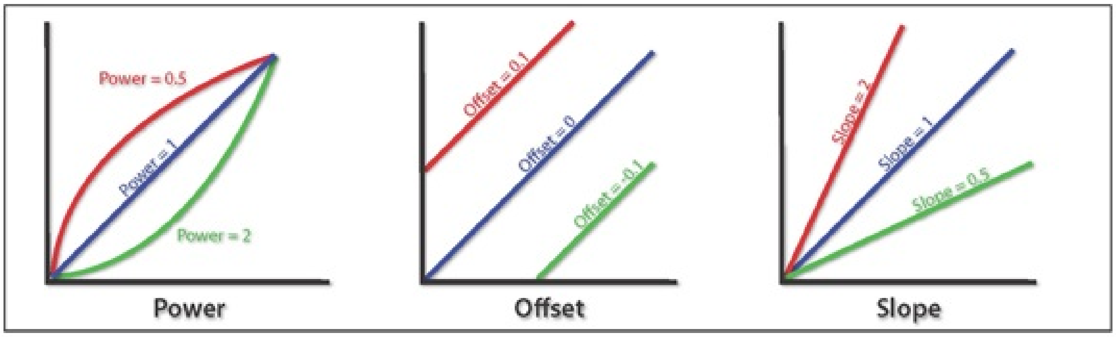


Figure 6.20. A conceptual diagram of the three controls in the *ASC-CDL* system—*Power*, *Offset*, and *Slope* and how they affect the image. The colors here are diagrammatic only; they do not represent color channels.

TEN NUMBERS: ASC-CDL

Cinematographers have a great deal at stake with how images are captured, processed, altered, and shown. The *American Society of Cinematographers* made an early move to ensure that the director of photography doesn't have to see their images put on a hard drive then just wave goodbye and hope for the best. During production when there is little or no chance of the DP having time available to supervise the production of dailies (either from film or from digital acquisition), they saw a need for an organized system for the cinematographer to convey their ideas to post people in some way other than vague statements such as "this scene was intended to have deep shadows and an overall sepia tone." For years, film cinematographers have communicated with the colorist doing their dailies by any means possible: written notes, stills taken on the set, photos torn from magazines—anything they could think of. How well it worked depended on the communications skills of the DP and also on the night shift colorist. Viewing on the set monitors often involves applying a Rec.709-based LUT, which has a far more restricted gamut than what is actually being recorded.

To facilitate control of the image after it leaves the set, the *ASC Technology Committee* devised the *ASC Color Decision List* (*CDL*). In operation, it allows the interchange of basic RGB color correction information between equipment and applications made by different manufacturers. Although the basic controls of most color correction systems are similar, they all differ somewhat in specific implementation and in the terminology used to label various controls or aspects of the image.

The terms *Lift* (for dark tones), *Gain* (highlights), and *Gamma* (mid-tones) are commonly used by most color correction systems, but those terms inevitably vary in detail from company to company (see *Image Control & Grading*). To avoid confusion with already existing systems, the committee decided on a set of three functions with unique names: *Offset, Slope* (*gain*) and *Power* (*gamma*).

Each function uses one number for each color channel so the transfer functions for the three color components can be described by nine parameters. A tenth number was added for *Saturation* and it applies to all channels. *ASC-CDL* is designed to facilitate that "transfer of the idea"—it's about giving the cinematographer the tools to send their decisions about the look down the line to the editor, colorist, and other links in the production chain. The system deals only with *primary* color correction, not *secondaries*. In practice, this is not the sort of thing that would be done on the set anyway; that kind of fine tuning correction is far more appropriate in a real color correction situation with proper viewing conditions.

ACES: WHAT IT IS, WHAT IT DOES

The *Academy of Motion Picture Arts and Sciences* was the organization that standardized such important features as the size and spacing of film sprocket holes in the early film industry. While sprocket holes may seem like a trivial issue, it is, in fact, an enormous part of the success and spread of filmmaking. We forget the fact that the size of film and the sprocket holes are what makes film universal. You can shoot a movie in Mumbai, process it in Paris, make release prints in Los Angeles, and have your premiere in New York—because the processing equipment, the editing machines, and the projectors have all been standardized for many decades.

With the introduction of digital production, post, and theatrical release, the Academy understood that there was again a need for some standardization. This is not to be thought of as creative interference—these standards in no way hamper the complete creative control of the director, DP, editor, or colorist. A primary goal, according to Jim Houston, chair of the ACES committee, was to "provide a consistent color pipeline." The process is also designed to ensure that results will be consistent from facility to facility.

This means that cinematographers have to give up "the knobs"—creative decisions that are baked into the footage at the time of shooting, but in return, they get a tremendous degree of creative freedom further down the line. For many DPs this will call for a real philosophical change and perhaps a sense of loss of control of the image—this is where tools such as ASC-CDL come into play. In the days of film production, the cinematographer had only one tool to control the image in postproduction, the *printer lights*. They could make the picture warmer or cooler, less or more green, or magenta and little else. In effect, the ACES process potentially gives the DP even greater control over the final image. We now have tools to enormously change the image digitally; this is wonderful, but it also means that other people have even more opportunities to mess with our images later on. This degree of control on the set and in post is also what makes the DIT such an important part of the process. The DP has specific ideas about what a scene should look like, but the cinematographer is doing several jobs at once—he or she rarely has time to dial in a CDL or work on a look in color correction software. The DIT can function as the implementer of the DP's vision for the scene by communicating with the cinematographer, perhaps even getting to know their preferences and artistic tendencies; offering them alternate looks to approve or disapprove and then translating that look into a CDL, a LUT, or a color grade to make sure that the look of the scene that the DP and director agreed on is then translated into a form that can pass down the line, either as a starting point or guidance or the final color correction process.

THE STAGES

As shown in Figure 6.21, the ACES workflow involves four basic stages in the process, which are defined by their transforms. They are *Input Device Transform, Look Modification Transform, Reference Rendering Transform*, and *Output Device Transform*. It looks a bit complex but, in reality, it is rather simple and elegant in its design. Here are some very brief definitions of the primary steps of the workflow. The overall concept of the ACES workflow is much easier to understand once you break it down and look at each individual stage:

- *IDT—Input Device Transform*. A calculation to convert a camera or other image sources to the *Academy Color Encoding Specification*, at which point the image will be scene referred and in an RGB floating point format. Each camera will need its own IDT, in most cases provided by the manufacturer.
- *LMT—Look Modification Transform*. This is where the colorist, DP, and director work their artistry, in other words, it is color correction. There is often a temporary transform to some kind of log or proxy space (depending on the color correction system). It can be guided by an ASC-CDL decision list, LUT, or dailies color grade.
- *RRT—Reference Rendering Transform*. A single transform that is designed to be the standard; it is also where *picture rendering* is done. Scene referred images do not look right to the eye, so the RRT converts the image to output referred. The RRT is an important part of making the final image.
- *ODT*—The *Output Device Transform*, also referred to as *Electro-Optical Conversion Function*, takes the output of the *RRT* and finishes the process to map data to the actual display devices where the project will be seen at home or in theaters.

ACES TERMINOLOGY

Let’s go over some of the new terminology used in the ACES workflow.

- *ACES*—The whole system, as based on the *Academy Color Encoding Specification* color space that includes the entire visible spectrum, is at the core of this method. ACES uses RGB values that are compatible with most existing image processing systems. The term ACES is also used to refer to the specific color space, see Figure 6.19.
- *Scene Referred*—ACES images are scene referred meaning that light is recorded as it existed at the camera sensor, regardless of how that might look when viewed in its raw state or independent of any output format or display device.
- *Display Referred*—A color space based on the actual gamut the display device (monitor or projector) is capable of reproducing. Although the front end of ACES is built around scene referred linear data, the back end has to be oriented toward how the images will actually be viewed, which is dependent on what projector or monitor will be used and also what the viewing conditions will be. Due to a phenom-enom called *picture rendering*, different viewing conditions (with different light levels) require different gamma levels to maintain the appearance of the original scene.
- *ACES* Color Space—This is the *scene referred*, ultra-wide gamut chosen by AMPAS to encompass not only all known current cameras and display devices but also is future proofed for new developments, since it encompasses all colors the human eye can see and then some. Since it includes every possible color, there is little chance that the color space will be outmoded by new technology.
- *ACES Proxy/Log ACES*—A color space based around “the knobs” in the *Look Modification Transform* (*LMT*) stage. ACES color space is so enormous that there isn’t really a way to manipulate it with current software/hardware. It is 16-bit integer (like many current grading systems) and it can be floating point as well. The *LMT* stage is where artistic, creative color decisions are made. There are several approaches to this phase of the process and software/hardware manufacturers are implementing this stage in various ways. Undoubtedly this technically difficult task will be evolving for several years.

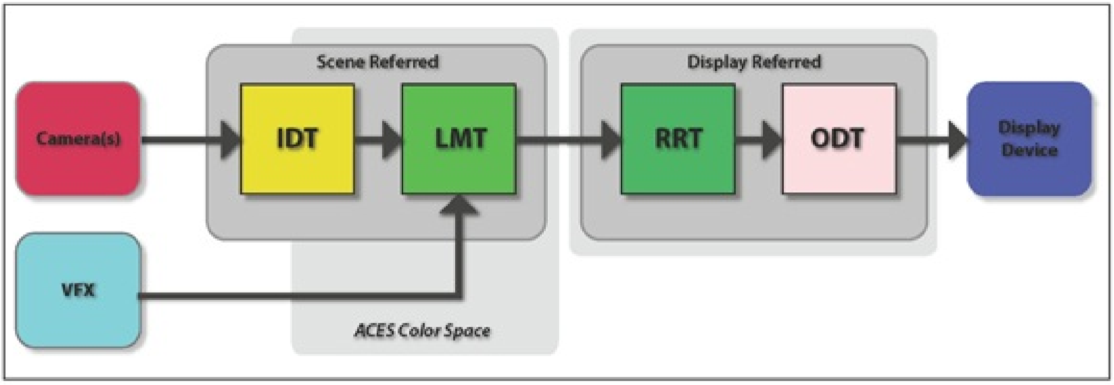


Figure 6.21. The AMPAS ACES workflow.

THE TRANSFORMS

These stages of the ACES workflow—IDT, LMT, RRT, and ODT are all *transforms*; but where do they come from? Since *IDTs* (*Input Device Transforms*) are particular to each camera, they will be provided by each camera manufacturer, especially if they don't want to reveal the inner workings of their own special *secret sauce*. It is possible, however, to create your own IDT. This can be done in several ways, from as simple as photographing a test chart and plotting the results all the way up to more high-tech methods which require specialized equipment. These methods are outlined in the ACES spec.

Look Modification Transforms (*LMT*) are largely the province of the developers of the software used in color correction and they are incorporating this into the applications. The *Reference Rendering Transform* (*RRT*), on the other hand, is strictly controlled by the ACES Committee. It is intended to be universal and the idea is that it will remain unchanged for long periods. The concept of the RRT is to encompass all of the transforms that are common to all *Output Device Transforms* (*ODT*) so that they don't have to be repeated. The *RRT* also includes *Picture Rendering* to adapt it to the viewing environment. *Output Device Transforms* will be developed by the manufacturers of monitors and of the projection systems used in cinemas.

For more information on *ASC-CDL* and the *ACES system* and workflow for cinematographers and DITs, see *The Filmmaker's Guide to Digital Imaging*, by the same author and published by Focal Press.

COLOR BALANCE WITH GELS AND FILTERS

The term *gel* refers to color material that is placed over lights, windows, or other sources in the scene. *Filter* is the term for anything placed in front of the lens to (among other things) control color. There are gel-type filters that can be used in front of the lens, but these are not commonly used in film production.

Figure 6.22. All companies that make lighting gels have gel books available for free. These include samples of their color gels and diffusions. This gel book from Rosco shows *CTB*, *CTO* and *Minus-Green*.

There are three basic reasons to change the color of lighting in a scene, which can be done by adding gels to the sources or by using daylight or tungsten units, or a combination of them:

- To correct (convert) the color of the lights to match the film type or color balance of a video camera.
- To match various lighting sources within the scene to achieve overall color harmony. The trend nowadays is to let the sources be different colors.
- For effect or mood.

Gelling the lighting sources gives you more control over the scene since not all lights have to be the same color. Using a filter on the camera makes everything uniformly the same color. The exception to this is filters called *grads*, which change color from top to bottom or left to right or diagonally depending on how they are positioned. Examples of grads in use are found in the chapter *Image Control & Grading*, where other aspects of using filters are also discussed. It is important to remember that gels and filters only work by removing certain wavelengths of light, not by adding color.

The three basic filter/gels families used in film and video production are *conversion*, *light balancing*, and *color compensating*. This applies to both lighting gels and camera filters. See Table 6.1 for just a few of the most commonly used types. There are also hundreds of gels that are random, non-calibrated colors called *party gels*.

CONVERSION GELS

Conversion gels convert daylight to tungsten or tungsten to daylight balance. They are by far the most commonly used color gels in film and video production. They are an essential part of any gel package you bring on a production. In general, daylight sources are in the range of 5400K to 6500K, although they can range much higher. Near sunrise and sunset, they are much warmer because the sun is traveling through a much thicker layer of atmosphere and more of the blue wavelengths are filtered out. The amount of dust and humidity in the air are also factors, which accounts for the different colorings of sun and sky at various times of the day, in different locales, or in different weather conditions. Daylight sources include:

- Daylight itself (daylight is a combination of direct sun and open sky).
- HMIs, Xenons, and some LED lights.
- Cool-white or daylight-type fluorescents.
- Color-correct fluorescent tube that can be daylight balance.
- *Dichroic* sources such as FAYs.
- *Arcs lights* with white-flame carbons (rarely used nowadays).

LIGHT BALANCING GELS

Light balancing gels are for *warming* or *cooling* the color temperature of the sources, which means they affect lights on the blue-orange axis (Table 6.1). Various grades are available so that a source can be fully corrected (such as from daylight to tungsten balance) or only partially corrected such as to just "warm up" a scene.

Light balancing gels also deal with warm versus cool color but in smaller ranges and more subtle corrections. Light balancing gels are used when only a slight correction is needed; they may also deviate from the strict blue to orange range. In the Wratten system, filters that begin with 82 are cooling filters, and those that begin with 81 are warming filters.

CTO

Correction to match tungsten balance is achieved with either *85* (camera filter) or *CTO* (a lighting gel), both of which are orange filters. They have essentially the same effect; the reason they have different names is due to the history of their development: 85 is a *Wratten* number, which is a system developed by Kodak for filters. Their designation system has been widely accepted in photography and filmmaking. *CTO* is the acronym for *Color Temperature Orange*. This means that it will convert 6500K (cool daylight) to 3200K (tungsten balance), which is excellent when correcting daylight sources such as HMIs.

An important variation of CTO is the combination of color correction and neutral density. In many cases when we are filming inside a room, the windows will be the wrong color (too blue) and much too bright. For these gels the 85 designation is used, so the flavors are *85ND3, 85ND6*, or *85ND9*, meaning that in addition to the warming effect, they also reduce the amount of light by one, two, or three stops.

CTO is used not only for color correction but also to warm up the lights. It's an old adage that everybody looks better under warm light; so warming a scene with *half CTO, quarter*, or *eighth CTO* is a common practice. There are other warming gels as well, and every DP has preferences as to how to approach making the light on a scene warmer. Some use dimmers on tungsten lights; dimming these lights down, makes them shift toward red/orange.

With film and video there are a wide variety of lens filters and lighting gels that can warm or cool a shot. Gel manufacturers provide a wide range of both warming and cooling gels that allow for great subtlety in lighting your shots. It is important to remember, however, that both of these methods change the color of the entire scene. Putting gels on lights or windows allows you to be selective with what lights and what parts of the scene you want to change.

CTB

Filters for converting warm tungsten sources to nominal daylight are called *full blue, Tough Blue*, or *CTB* (*Color Temperature Blue*). The problem with "blueing the lights" is that CTB has a transmission of 36%, while *CTO* (the equivalent of an 85 filter) has a transmission of 58%. This means that while you lose almost a stop and a half with CTB, you lose only about 2/3 of a stop with CTO. Also, because it is so dense, CTB tends to "burn out" faster than other types of gels, this results in a color shift which can be visible if it takes a long time to complete all the coverage on a scene.

CTB is inefficient; it can be used to balance tungsten lights inside a room with the daylight blue window light that is coming in. The window light is far more powerful than the tungsten lights to begin with. If we then lose a stop and a half by adding CTB, we are really in trouble. The alternatives are:

- Put 85 on the windows and shoot at tungsten balance. By doing this, we avoid killing the tungsten lights with a heavy blue gel, we don't have to use an 80B on the camera, and we lose 2/3 of a stop off the windows, which may help keep them more in balance.
- Put 1/2 85 on the windows and 1/2 blue on the lights.
- Put 1/2 CTB on the lights and let the windows go slightly blue. This is actually a more naturalistic color effect.
- Daylight balance lights inside: use HMIs, LEDs, or Kino Flos with daylight balance tubes.

Table 6.1. The basic filter families are conversion filters that convert tungsten to daylight or vice versa, and light balancing filters, used to warm or cool the light source.

The Basic Gel Families		
85	Conversion	Used to Convert Daylight to Tungsten
80	Conversion	Used to Convert Tungsten to Daylight
82	Light Balancing	Used to Slightly Cool the Light
81	Light Balancing	Used to Slightly Warm the Light

Figure 6.23. Dark, green tinted, and not full-spectrum is the color of the streets at night—the primary world in which *Nightcrawler* exists.

COLOR CORRECTION GELS

CC or *color correction* gels deal with the magenta versus green color range, the other axis that we measure and utilize in lighting film productions. CC gels primarily come into play when dealing with sources other than tungsten or HMI lamps, especially fluorescent lights and industrial sources such as mercury vapor and sodium vapor lights.

DEALING WITH FLUORESCENT LIGHT

One of the most common color problems we face today is shooting in locations where the dominant source is fluorescent light. The problem with fluorescents is that they are not a continuous spectrum source and in most cases their output is very heavy in the green part of the spectrum.

Another problem is that even if they may appear to be approximately correct in color, their discontinuous spectra may cause them to have a low *Color Rendering Index* (*CRI*). As a result, fluorescents cannot be corrected only by changing the color with a gel on the lighting unit or filter on the camera lens. All of this also applies to sources such as orange *sodium vapor* lights (often used for street lights) and blueish *mercury vapor* (frequently used in parking lots).

These are all classified as *discharge sources* because they produce light from a glowing gas excited by electrical discharge. Because of their discontinuous spectra, discharge sources can't be considered to have a true color temperature in degrees Kelvin. The black body color temperature that they approximate is called the *Correlated Color Temperature* (*CCT*). A good color meter is invaluable in these situations (Figure 6.24). If you don't have one, you can hold correction gels over the lens to test. Remember that correcting for undesired colors does not necessarily give these sources an adequate *CRI* (*Color Rendering Index*), and they may never be truly color correct no matte what you do. Additional tips on shooting with fluorescents, industrial lights, or any sources that are not normal daylight or tungsten balance on location include:

- Shoot a gray card or calibration chart at the head of a scene.
- Shooting with ordinary fluorescents alone and removing the green in post results in a very flat color rendition. Adding some lights (such as

tungsten with *Plus-Green*) gives a much fuller color feeling to the image.

- When shooting a large area, it is often more efficient to add green to your lights than to have the crew gelling existing lights, which may be numerous or inaccessible.
- When you add Plus-Green or Fluorofilter to lights, they give a very strongly colored light that looks wrong to the eye.
- Video cameras don't seem to need as much green correction and tend to be more tolerant of color imbalance than film.

Table 6.2. (left) Gels can be used to correct industrial sources such as the *sodium vapor* lights used in factories and *mercury vapor* lamps that are common in parking lots and street lights. These values are just a starting point, as industrial sources vary widely.

For best results check them with a color meter. An alternate is to hold various gels in front of the lens of a reasonable-quality digital still camera and check the results under good viewing conditions; including a gray card in the shot will assist in making the evaluation.

CC indicates *color compensating* filters, and the accompanying number and letter indicates the amount and color. For example, CC30M is thirty units of magenta, which is often the amount of compensation needed for fluorescent bulbs.

CAMERA FILTERS FOR INDUSTRIAL SOURCES		
Color Balance	**Existing Source**	**Camera Filters**
Tungsten	High-Pressure Sodium	80B + CC30M
	Metal Halide	85 + CC50M
	Mercury Vapor	85 + CC50B
Daylight	High-Pressure Sodium	80B + CC50B
	Metal Halide	81A + CC30M
	Mercury Vapor	81A + CC50M

Figure 6.24. (above) With the addition of the Luxi dome on an iPhone, Adam Wilt's *Cine Meter II* becomes an accurate color meter that tells you what correction gels will bring the light balance back to normal.

CORRECTING OFF-COLOR LIGHTS

HMI

HMIs sometimes run a little too blue and are voltage dependent. Unlike tungsten lights, their color temperature goes *up* as voltage *decreases*. For slight correction Y-1 or Rosco MT 54 can be used. For more correction, use 1/8 or 1/4 CTO. Many HMIs also run a little green or magenta. Have 1/8 and 1/4 correction gels available.

INDUSTRIAL LAMPS

Various types of high-efficiency lamps are found in industrial and public space situations. They fall into three general categories: *sodium vapor*, *metal halide*, and *mercury vapor*. All of these lights have discontinuous spectra and are dominant in one color. They all have very low CRIs. It is possible to shoot with them if some corrections are made. High-pressure sodium lamps are very orange and contain a great deal of green. Low-pressure sodium is a monochromatic light and so they are impossible to fully correct.

Camera Filtration for Industrial Sources

Table 6.2 shows recommended starting points for using camera filtration to correct off-balance industrial sources. They are approximations only—obviously, these units are not manufactured with much attention to precise color balance. These gel combinations should be confirmed with metering and testing. In video you may be able to correct partly with the camera's white balance function. In film, never fail to shoot a grayscale and some skin tone for a timer's guide. Only with these references will the color timer or video transfer colorist be able to quickly and accurately correct the color.

Figure 6.25. (right, top) A frame from *Skyfall*. These color analysis charts were created by Roxy Radulescu for her website *Movies In Color* and are used with her permission.

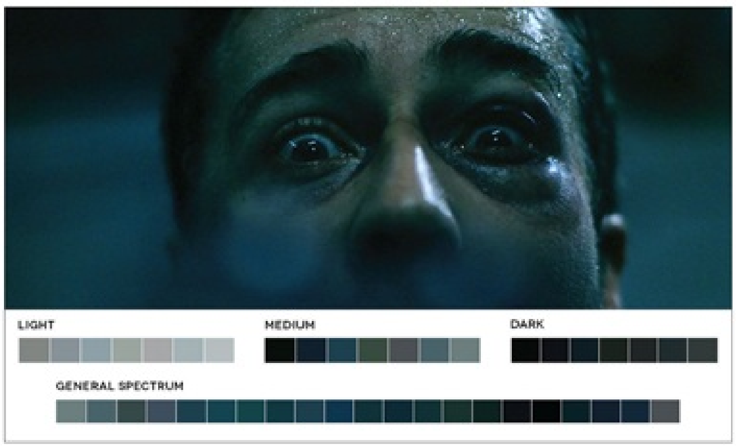


Figure 6.26. (right, middle) *Fight Club*.

Figure 6.27. (right, bottom) A shot from *O Brother, Where Art Thou?*

For more on shooting the color reference, see the chapter on *Image Control & Grading*. For more detailed information on controlling color on the set and on location, see *Motion Picture and Video Lighting* and *The Filmmaker's Guide to Digital Imaging*, also by Blain Brown and from Routledge.

COLOR AS A STORYTELLING TOOL

As with everything in film and video production, stylistic choices affect the technical choices and vice versa. This is especially true with color correction. Until a few years ago, considerable time and money were spent on correcting every single source on the set. Now there is more of a tendency to “let them go green” (or blue or yellow or whatever)—a much more naturalistic look and has become a style all its own, influenced by films such as *The Matrix*, *Fight Club*, *Seven*, and others. More extreme color schemes for particular scenes or the entire film are frequently used. These are accomplished through lighting on the set, filtration, adding a Look or LUT to the camera while shooting, or with color correction at the DIT cart or final color correction in post.

Figure 6.28. Apocalypse Now.

Figure 6.29. *Blade Runner*.

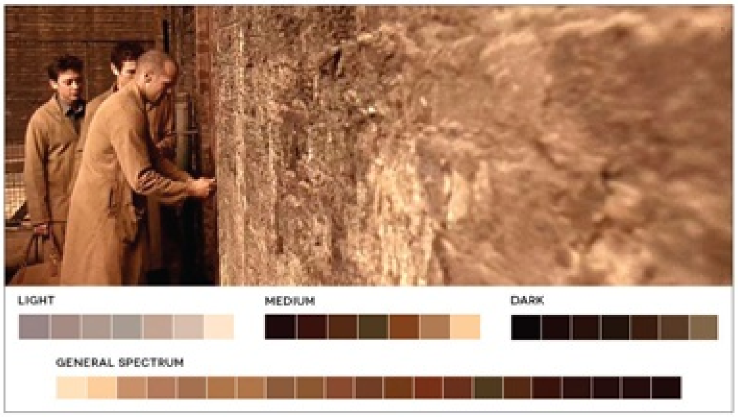


Figure 6.30. A scene from *Lock, Stock and Two Smoking Barrels*.

On the following pages are the color palettes of several films and a music video. One of the earliest (and still one of the best) examples of adding an overall color palette to a film was in *O Brother, Where Art Thou*? (Figure 6.27). Although it was shot on film, the Coen brothers and DP Roger Deakins knew that they wanted a very specific and evocative color scheme for the film. Deakins experimented with many combinations of camera filtration, lighting, and even different ways of processing the negative—none of them achieved exactly the effect he was going for. Finally, he settled on using a *Digital Intermediate*, its first use on a major production. A *DI*, as it is known, involved transferring the film negative to high-resolution video, doing color correction on the video, and then printing out that version to a master negative for making release prints.

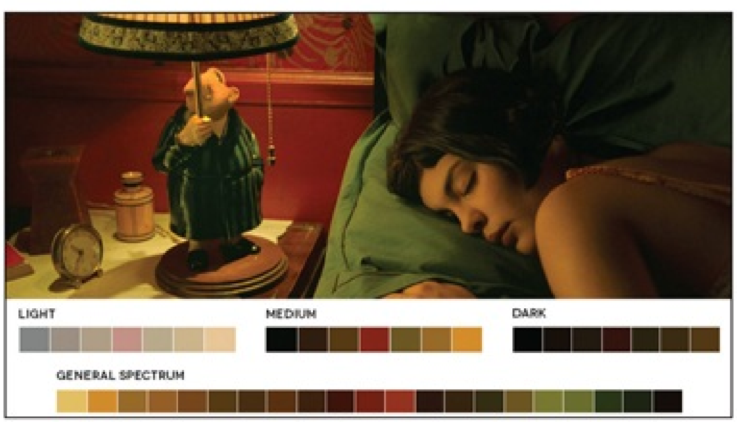


Figure 6.31. Color analysis of *Amelie* by Roxy Radulescu.

Figure 6.32. *Captain Phillips*.

It was an ideal combination at the time: shooting and distributing on film but with all the fine-tuning and control that video manipulation affords. Now that most theaters project digital video, it is not really a digital *intermediate* anymore, but you will still hear the term used on occasion.

On the following pages are some examples from the music video *Freedom*! (DP Mike Southon), *The Fall* (Colin Watkinson), *Snatch* (Tim Maurice-Jones), *Delicatessen* (Darius Khondji), *Fight Club* (Jeff Cronenweth) and *Ju-Dou* (Changwei Gu and Lun Yang), directed by Zhang Yimou, who was a cinematographer himself before he turned to directing.

Figure 6.33. The color pattern of the music video for *Freedom!* (1990), photographed by DP Mike

Southon.

Figure 6.34. Bold color in Tarsem Singh's *The Fall* (2006), photographed by Colin Watkinson.

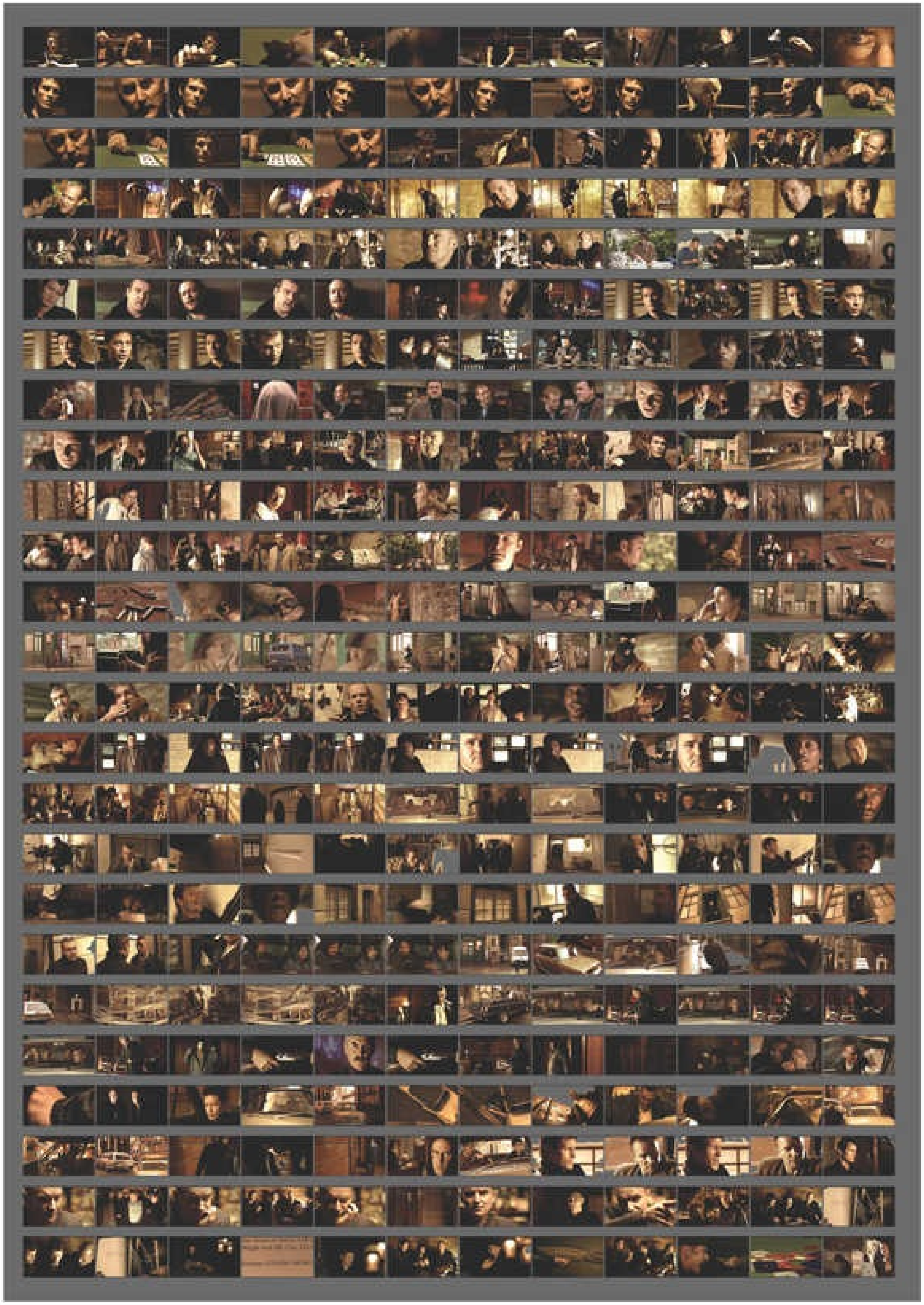


Figure 6.35. Color pattern of *Lock, Stock and Two Smoking Barrels* (1998); DP—Tim Maurice-Jones.

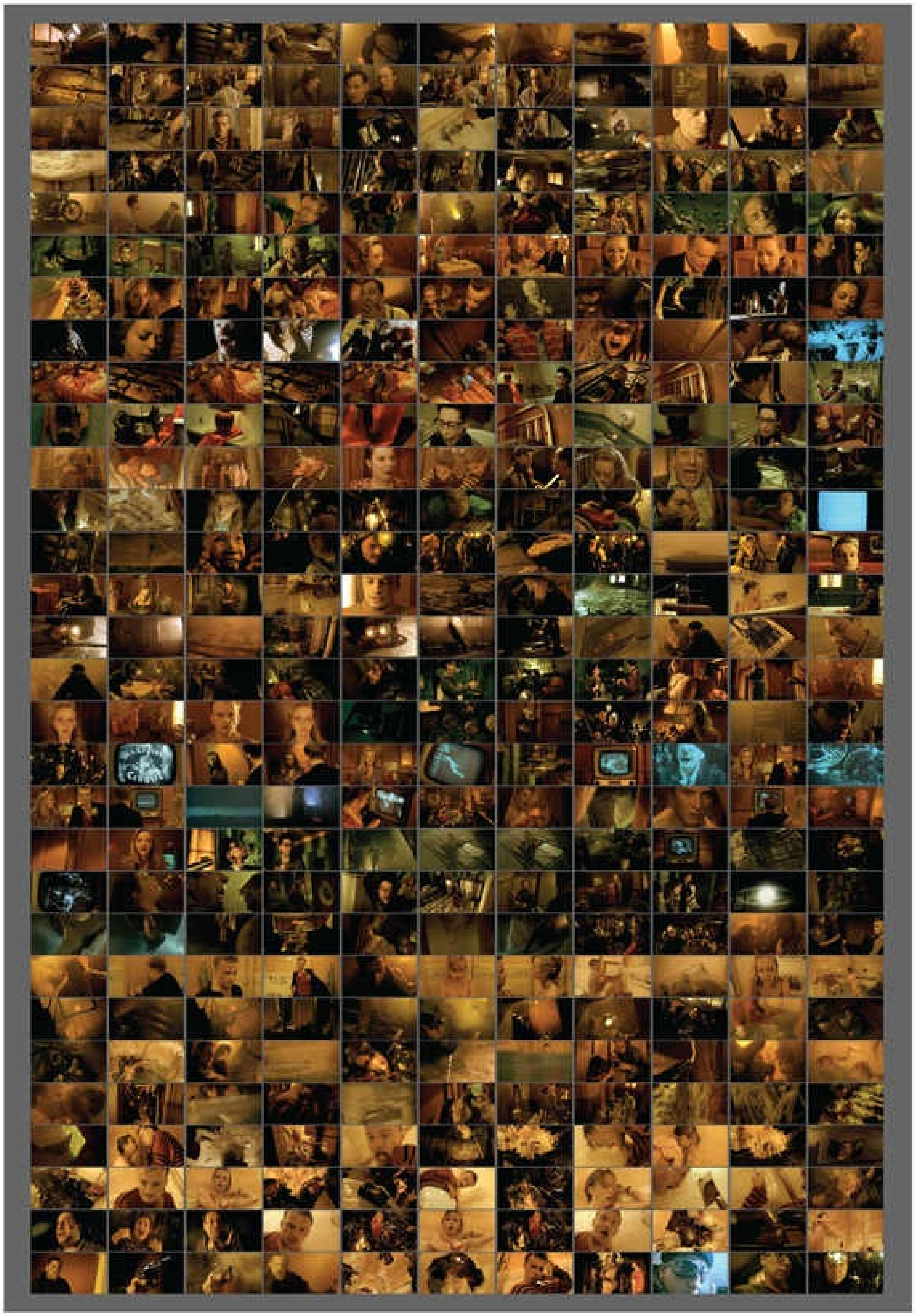


Figure 6.36. Color in Jean-Pierre Jeunet's film *Delicatessen*, shot by Darius Khondji (1991).

Figure 6.37. *Fight Club* (1999), photographed by Jeff Cronenweth.

Figure 6.38. Color in *Ju-Dou* (1990) by Zhang Yimou—cinematography by Changwei Gu and Lun Yang.

Figure 7.1. Camera assistants prepare two Arri Alexas for a day's shooting. Note that they are labeled cameras "A" and "B" and different colored tape is used—this helps keep accessories and cases sorted out. Camera "A" has a digital rangefinder mounted above the lens—it looks like a set of miniature binoculars. (Photo courtesy John Brawley).

Figure 7.2. The Sony F-65 on a camera *checkout* day. The recording module is mounted on the back, and a *TVLogic* monitor is set up for the camera assistant. (Courtesy of DIT Sean Sweeney).

THE DIGITAL SIGNAL PATH

Let's take a look at how the image is acquired and recorded in modern digital cameras; just a quick overview and then we'll get into the details later. The lens projects the scene image onto the sensor which reacts to light by producing voltage fluctuations proportional to the levels in the scene. Variations in voltage are *analog*, so the first process that must happen is to convert this signal to *digital*. This is done by the *Analog-to-Digital Converter* (*ADC* or the *A-to-D Converter*).

DIGITAL SIGNAL PROCESSOR

The data from the ADC then goes to the *Digital Signal Processor* (*DSP*) in the camera. Now that the video image is a stream of digital *code values* (*bits*) rather than an analog electronic signal (thanks to the ADC), the DSP applies various algorithms which both condition the signal for further use and also apply any modifications that we may want. These might include such things as color balance, gamma, color modification, gain and so on, which can be controlled by switches/buttons on the camera (commonly called the *knobs*) or, more commonly, menu selections in the camera controls, all of which are discussed in greater depth later.

The DSP does a couple of different jobs, some of these operations may include the *Color Correction Matrix transform*, *Gamma Correction*, *linear-to-log* conversion and *knee* adjustment—all of which we will explore in more detail. Most cameras that shoot RAW record the image without any of these adjustments such as color balance, changes in contrast, and so on; these adjustments are recorded separately as *metadata*; there are some exceptions which we'll get into later. By the way, RAW is not an acronym; it doesn't stand for anything. Also, writing it as all caps is an industry-wide convention. RAW is something we'll be talking about a great deal as it has become an important part of motion picture production.

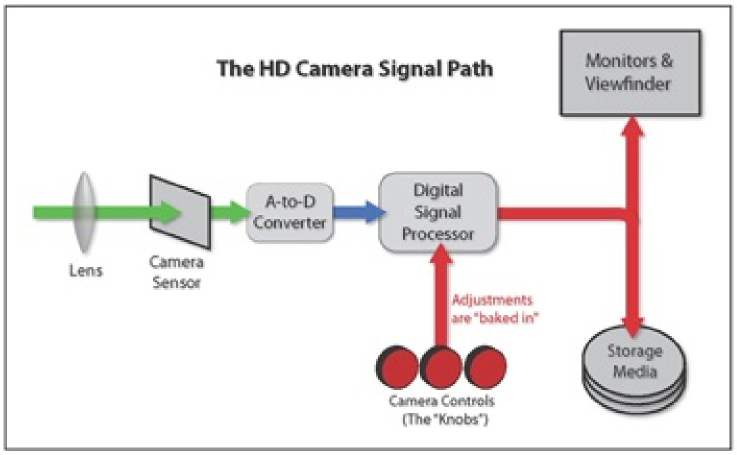


Figure 7.3. (left, above) The signal path of a traditional video camera includes the "knobs," or in-camera controls of the image which make adjustments which are then *baked in* to the image as it is recorded.

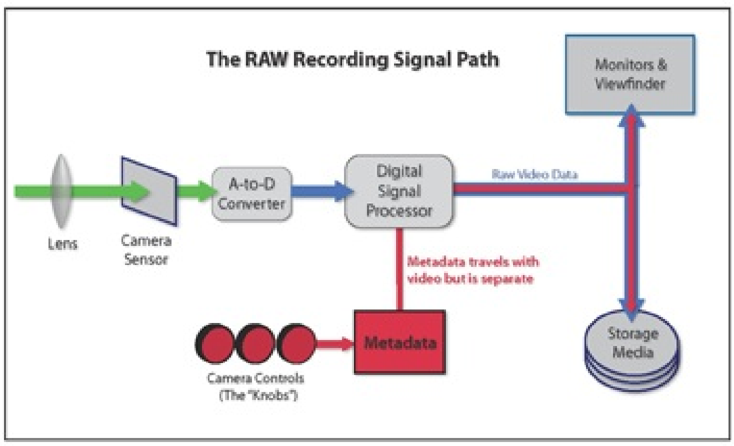


Figure 7.4. (left, below) The recording path of a camera that records RAW—adjustments to the image are not *baked in*, but are recorded as metadata alongside the image.

HD, HD+ AND UHD

We’re going to be talking about two types of cameras: *HD* (*Highdef*) and *post-HD cameras*. Highdef cameras were basically the first generation of cameras that surpassed the old *Standard Def* (*SD*) that was around pretty much since the beginning of television; it was 480 horizontal lines (US) and 576 horizontal lines (Europe and elsewhere). Highdef is considered to be anything that has more “def” than SD, but 720 lines is generally considered to be the minimum to be “High” def. HD has several formats, but the most commonly known are 1920×1080 pixels and 1280×720. *Post Highdef* (which we’ll refer to here as *HD+*) cameras are the current generation; they are capable of recording at much higher definition as we’ll see soon. UHD is Ultra High Def; however it is a standard for displays only: monitors and projects.

HD RECORDING

Traditional Highdef cameras employ a basic scheme as shown in Figure 7.3. The digital image flow starts at the image sensor as photons from the scene are focused by the lens onto the photo receptors (*photosites*). There are several types of sensors which we will look into later in this chapter, but all sensors work on the same principle: they convert a light image (photons) formed by the lens (optics) into an electronic signal (electrons). Video sensors are essentially analog devices which produce an electrical signal that is then converted to digital form in the ADC.

Figure 7.5. An *Arri Alexa* set up for camera tests. In this case, the color balance values are being adjusted in the menus. What is interesting about most modern cameras such as this is how few buttons, switches, and knobs there are. Even the menus are not particularly complicated when compared to HD cameras of the past.

The digital signal then travels to the camera's internal signal processor, the *Digital Signal Processor* (Figures 7.3 and 7.4). For most traditional HD cameras, the same signal that is recorded is also sent to the viewfinder and any external monitor outputs, although some viewfinders were reduced in resolution. Cameras of this type were first used around the year 2000. Traditional HD cameras have many adjustments that could be made to the image either with switches, selection wheels and dials, or in menus— "the knobs." Changes could be made to *gamma* (also known as the *midtones* or *mid-range*), color, the *highlights* (*knee*), *shadows* (*toe*), and other aspects of the image. Once these changes were selected the video was recorded that way; we call it *baked in* —once it is recorded in this manner, it is not easy to change it later.

POST HIGH-DEF

While there are still many Highdef cameras being made and used, especially at the consumer level, the high-end professional cameras have gone beyond 1920×1080. As we mentioned, some people refer to it as *Ultra Highdef* (*UHD*) but technically UHD is a standard for displays only so we refer to them here as HD+ or post-HD cameras. Some still just call these formats "high-def" although this is not technically accurate. In any case, it is much more common to refer to the video by its resolution, such as 4K video, 6K video, and so on (Figure 7.6).

There is another change in the naming of video formats: “1080” and “720” refer to the height of the format in *lines*. The problem is that the height of a frame is highly variable. It was a similar problem with 35mm film. While the width of 35mm film has remained unchanged from the time of Thomas Edison until today, the height of the frame has changed a great deal—the result of a constant hunger for “wider” formats (1.85:1, 2.35:1, etc.). None of these is actually wider film—they are all (with the exception of anamorphic, which is an optical trick, and 70mm, which didn’t last long as a theatrical format) the same width—what really changes is the height of the frame. This applies to video as well, when you change the aspect ratio of the frame, you mostly just cut off the top and bottom.

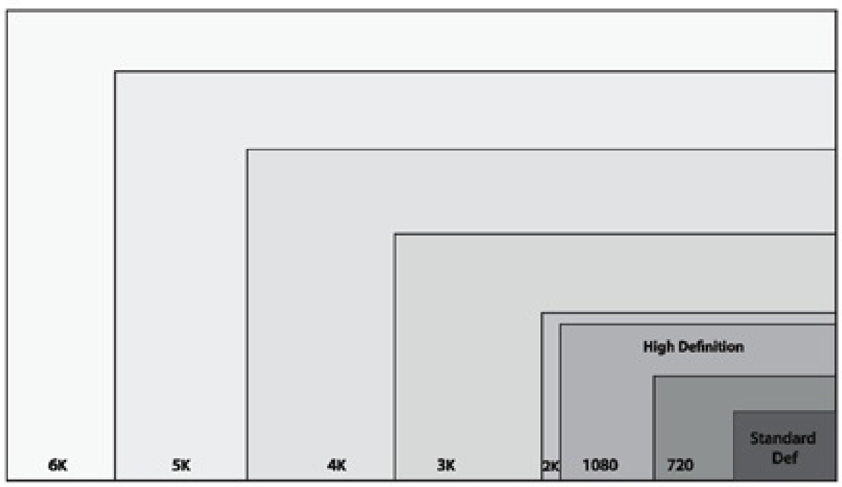


Figure 7.6. The relative sizes, and, therefore, resolutions from standard def (SD) up to 6K Ultra Highdef (UHD).

For this reason, it makes more sense to use the width of the frame as nomenclature, which is made easier since video no longer really consists of *scan lines* (a vertical measurement only) but of pixels, which can be quantified as either height or width. Thus, when we talk about *2K* video (a widely used format in theatrical projection), it means a frame that is approximately 2,000 pixels wide (actually 2,048) while *4K* video is 4,096 pixels wide. This means it doesn’t get complicated (in terms of names) when you change the aspect ratio to a taller or shorter frame. Fortunately, the high-def era has also brought about a wider standardization of aspect ratio: 16×9 is now universal in television sets, in broadcast, on Blu-Ray discs, and so on.

The presentation formats (theaters, televisions, disc players, etc.) need to be somewhat standardized—because millions of people who buy TVs and media players, or thousands of theater owners as well as postproduction facilities, invest in the equipment and it needs to remain more or less stable for some time. The origination formats (cameras and editing hardware) can be more flexible. Just as theatrical movies were nearly all projected in 35mm—they were originated on 35mm film, 65mm, 16mm, or video. Although there's some debate as to how much resolution is "enough"—there is an upper limit to how much fine detail the human eye can perceive, there can be no question that higher-resolution capture formats are better for postproduction and final viewing. How far cameras will go in terms of resolution remains to be seen; digital still cameras have made huge advances in sensor resolution—some still cameras go as high as 80 *megapixels* per frame. What is sufficient resolution for image capture always entails understanding the final size for which it will be used: an image created strictly for a cell phone clearly does not make the demands on resolution that are involved in something that is going to be shown on a large theatrical screen. Even when considering screen size, the viewing distance is a crucial factor. To really appreciate (and perceive) ultimate image resolution, it is necessary to sit no more than two to three screen heights away from the display/screen. This means that if the screen is 20' high, for example, then the ideal viewing distance would be less than 60' away. It is important to distinguish between the resolution of an image (how good it is at portraying fine detail) and other factors such as the brightness range it can represent: they are different factors and while they often improve side by side as manufacturers develop their technology, they are not necessarily connected. Along with dramatic increases in resolution with the introduction of 4K and higher video, the improvements in the brightness range video cameras can handle has been equally revolutionary.

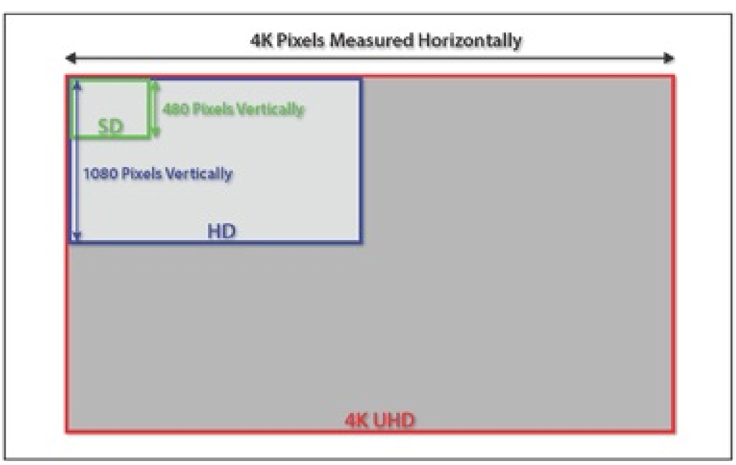


Figure 7.7. *Standard Def* and *Highdef* digital video were generally referred to by their vertical dimension. For example, 1920×1080 (HD) video is commonly called “1080.” The problem with this is that video can be acquired and displayed with different vertical dimensions to achieve different aspect ratios. For this reason, resolutions higher than HD are referred to by the horizontal dimension, such as 4K and 8K. As with many things digital, 4K is not exactly 4000, either in acquisition or display.

RAW VS. BAKED IN

The second revolution came a few years later with the introduction of the *Viper Filmstream* from Thompson, followed soon after by the *Dalsa* and *Arri* digital cameras and later on the *Red One*. These were the first systems to output RAW and also employed *tapeless recording* (digital files directly to a hard drive or flash memory, not to videotape). The last few years have brought a nearly complete changeover at the professional level to shooting and recording RAW or log video or both in a tapeless workflow.

Many cameras still allow you to make changes in the color matrix, the gamma, and other important image characteristics, but the big difference is that these manipulations are not actually recorded as part of the video signal—instead they are (in most cases) only saved as metadata, essentially this metadata is a sort of commentary on the video scenes, they can be freely changed later on.

RAW CAMERA SIGNAL PATH

In cameras that shoot RAW, the signal path is not the same as traditional HD cameras. What is recorded on the media storage (hard drive, flash card, or whatever) is just the RAW signal without any "creative" adjustments (Figure 7.4). In most cases the various manipulations of the image are not recorded "baked in." In fact, most UHD cameras have far fewer knobs and switches and their menus are substantially simpler. To be clear, these cameras offer almost all of the image options that HD cameras did; the big difference is that instead of being recorded as part of the signal, these image transformations are recorded separately from the video stream—as metadata, which means "data about data." It's a simple concept: instead of actually changing the video, you just add some "notes" to it which basically say to the editing or color software "when you show this clip, add these modifications to it." When video is recorded this way, it is called RAW. Fundamentally, RAW means that the original red, green, and blue photosite data is recorded with little modification. How much is changed, how much is or is not baked in depends entirely on the camera manufacturer and which model camera.

VIEWING STREAM

From the DSP, the signal splits: the signal is sent both to the recording section of the camera and to the monitoring outputs. In many cases, the viewing output is not the same as is being recorded and different outputs on the camera may be in various formats. For example, some camera viewfinders can't display HD/UHD video, so they are actually being sent a slightly lower resolution image.

Monitor output from the camera may be *SDI* (*Serial Digital Interface*), *HDMI*, or *component* video. High-end pro cameras generally have a variety of outputs for different purposes. In the case of the Red camera, for example, the monitoring path converts 16-bit RAW sensor data to white balanced 10-bit 1080 RGB 4:2:2 video. This image is modified by the ISO, white balance, or other color space adjustments and provides monitor and viewfinder feeds. Other types of cameras offer different monitoring signals but some *down conversion* of monitoring is typical. A few cameras have a traditional optical viewing system like a film camera.

DEFINITIONS

Before we go on, let's clarify the terminology. The terms *RAW*, *uncompressed* and *video* sometimes get used a bit loosely. RAW isn't really video yet, not until it is processed in some way, either in the DSP or in some other software or hardware later down the line. It isn't video because it is not really viewable. At any stage during processing, one or more types of compression may be applied to the data. Saying that the images are *uncompressed* is separate from whether it is RAW or not. For example, *log encoding* is a form of compression—it is frequently applied to RAW data, but not necessarily.

So what is the precise definition of RAW? Surprisingly, there can be some debate, particularly when it comes to specific cameras and how they work. DP Art Adams puts it this way, "The key thing to remember is that 'raw' means that the actual RGB values from the photosites are preserved: they aren't converted into pixels, or *deBayered* or *demosaiced*, which would happen if you stored the footage as ProRes, for example. Log and linear don't really factor into whether footage is classified as RAW or not. All that's happening is that the luminance information is being completely retained (*linear*) or compressed in a way that is visually lossless to a great extent (*log*). The information retained has not been demosaiced. The only thing that makes footage 'raw' is if the color information is still in an undemosaiced state. Beyond that... well, there's a lot going on under the hood in each raw format. The idea some people have, that all the sensor information is being stored in its entirety in some pristine state, simply never happens. And it certainly never happens in a way that's completely common to all formats." (More on all this later.)

Mitch Gross of *Convergent Design* takes a similar view, “To me the most important bit of info is that RAW just means ‘non-deBayered.’ It may have a gamma curve applied, it could be linear or log, it could have a white point set, it may have gains applied (analog or digital), and it may be compressed. But if it isn’t deBayered it can still be called RAW.”

DIGITAL NEGATIVE

Think of RAW as a *digital negative*. For folks who didn't come up in the world of film imaging, this might take a bit of explaining. The film negative is neutral: it is only capable of recording what came in through the lens. Of course, the film emulsion has some characteristics that alter the image in some ways; mostly ways that the eye finds entirely pleasant. This means that when you make a print from the film negative, you have a pretty wide range of creative choices. For those of you who have gone through the print phase of making a movie or commercial, you know the steps: you sit there with a print *timer* (a highly skilled individual who is an expert at film exposure and coloring—the equivalent of a video colorist) and make choices about each shot—the exposure and color balance. It is shot by shot, because as hard as we try to be consistent from shot to shot while shooting, there are always going to be some variations.

Then a print is made, and the DP and director sit through another timing session where they again ask for some variations for creative reasons. Usually by the third print, all three are agreed on a creative end point for the project. At that time, a print is made; or actually, an *internegative* is made for the print output for theatrical release. But the thing is, that is not necessarily the end of the road. You can always go back to that original negative and make a whole new print with different creative decisions. Undoubtedly, you have heard of films that have been restored from the original negative. We've all seen magnificent restorations of classic films such as *Gone with The Wind*, *Lawrence of Arabia*, and others. Now here's the tricky question: when a new generation of colorists go back to that original negative and make a new print, how do we know that they are printing the film in accord with the artistic intentions of the cinematographer who shot the film? After all, that DP was the one who was hired and entrusted with making the images (in collaboration with the director and art director, of course) and they are the ones whose artistic intentions must be respected, of course. Well, the short answer is we don't. Fortunately, the people who engage in these sorts of restorations are almost always the kind of people who go to great lengths to preserve the intentions of the original artists.

However, to a great extent, the DP on a film project can include their artistic intents into the negative. They can do this with exposure and with color; both color balance overall and with individual color within the scene. There are some "tricks" that DPs use to ensure that people later down the line can find it difficult to mess with their images; these include having some "reference white" and “reference black” in the frame. So what does this mean for those of us who now shoot RAW video? Can people further down the line alter our artistic intentions by changing the image in substantial ways? You bet they can.

What does this change? The basic idea of RAW is to simply record all of the data that comes off the sensors, mostly unchanged. Metadata is recorded at the same time and it can record artistic intentions about color, tonal range, and so on, but metadata can be changed or just ignored later down the line. Like a photographic negative, a RAW digital image may have a wider dynamic range or color gamut than the eventual final image format is capable of reproducing, as it preserves most of the information of the captured image.

The purpose of RAW image formats is to save, with minimum loss of information, data sent directly from the sensor, and the conditions of the image capture—the metadata, which can include a wide variety of information such as white balance, ISO, gamma, matrix, color saturation, and so on. The metadata can also include archive information such as what lens was used, what focal length, f/stop, time of day and (if a GPS unit is used at the time of shooting) the geographic coordinates of the shooting, and other slate data such as the name of the production, *etc.*

RAW image files can, in essence, fill the same role as film negatives in traditional film-based photography: that is, the negative is not directly usable as an image, but has all of the information needed to create a final, viewable image. The process of converting a RAW image file into a viewable format is sometimes called developing the image, in that it is analogous with the motion picture film process that converts exposed negative film into a projectable print.

With a motion picture negative, you can always go back to the original. If you shot the negative right to begin with, you can make substantial changes to the print, now or in the future. If five years from now, you decide you want to make the look of the print very different (within the limits of what is possible in making a film print, which is far more limited than what you can do with the digital image) you can do so. You can do the same with RAW; it is archival and non-destructive, and you can manipulate the image later. Such alterations at the time of processing, color correction, or anywhere along the line result in fewer artifacts and degradations of the image; this includes compensating for under or overexposure. A drawback is that RAW files are usually much larger than most other file types, which means that cameras often need to impose lossy or lossless compression to avoid ridiculously large sizes of captured files.

A widespread misconception is that RAW video is recorded completely uncompressed—most cameras record it with log encoding, a type of

Digital is changing the way

compression, but there are some exceptions. Log encoding is so important that we devote an entire section to it later in this book. Both with film negative and shooting RAW, it is important to remember that while you have a wide degree of control over the image, it is still not magic—avoid the myth of believing that we can “fix it in post.”

we make films and in some ways, it is changing the language of cinema itself.

Dante Spinotti (*LA Confidential, Public Enemies*)

There are many types of RAW files—different camera companies use variations on the idea. RAW files must be interpreted and processed before they can be edited or viewed. The software used to do this depends on which camera they were shot with. Also, RAW files shot with a Bayer-filter camera must be demosaiced/deBayered (the mosaic pattern imposed on the image by the Bayer filter must be interpreted), but this is a standard part of the processing that converts the RAW images to more universal JPEG, TIFF, DPX, DNxHD, ProRes, or other types of image files.

One problem with RAW is that every company has their own version of it and there is no standardization. Adobe has been trying to suggest that the industry should come together to agree on common standards—a common file format to store their proprietary RAW information in a way that wouldn’t require special apps or plugins. The Red company calls their version Redcode RAW (.r3d), Arri calls theirs ArriRAW, Adobe uses CinemaDNG (digital negative); ArriRAW is similar to CinemaDNG, which is also used by the Blackmagic cameras. DNG is based on the TIFF format, which is a very high-quality image with little or no compression. Standardization is also hampered by the fact that companies want to keep their proprietary information secret and don’t publish the inner workings of their RAW formats. Some Sony cameras also shoot 16-bit RAW which is part of what they call SRMaster recording. Although formats vary from company to company, there are some commonalities based on an *ISO* (*International Standards Organization*) standard which includes:

- A header file with a file identifier, an indicator of byte-order and other data.
- Image metadata which is required for operating in a database environment or content management system (CMS).
- An image thumbnail in JPEG form (optional).
- Timecode, Keycode, etc., as appropriate.

Keep in mind that not all professional video is shot RAW. For many types of jobs, log-encoded video is still preferred.

CHROMA SUBSAMPLING

Most camera sensors operate with red, green, and blue (RGB) information. An RGB signal has potentially the richest color depth and highest resolution, but requires enormous bandwidth and processing power and creates huge amounts of data. Engineers realized that there is also a great deal of redundant information: every channel contains both *luma* data (the black-and-white gray tone values of the pictures) and *chrominance* data: the color values of the image. Color scientists long ago discovered that most of the information we get from an image is actually in the black-and-white values of the picture, which is why in most situations we get almost as much from a black-and-white picture as we do from a color picture of the same scene—it's just inherent in how the eye/brain works. Each channel in an RGB video signal carries essentially the same gray tone values, so there are three redundant black-and-white images.

Another basic fact of human vision is that a great deal of our vision is centered largely in the green region of the spectrum. This means that the green channel in video is somewhat similar to the luminance information. You can try this yourself in any image processing software: take an average photo and turn off the red and blue channels. The green channel by itself is usually a fairly decent black-and-white photo. Now try the same with the other channels—they are often weak and grainy by themselves.

Chroma subsampling is the name for a form of data reduction that works with *color difference* signals. In this technology, the luma signal (black-and-white brightness or luminance) is sampled at a different rate than the chrominance signal (color). Chroma subsampling is denoted as Y'CbCr. Y' is the luma component while Cb and Cr are the color difference signals. Y represents *luminance*, which is actually a measure of lighting intensity, not video brightness levels, while Y' is *luma*, which is the weighted sum of the red, green, and blue components and is the proper term to use in this context. "Weighted" as it refers to luma means that it is non-linear.

You will notice that there is no Cg or green channel. It is reconstructed from the other channels. Green doesn't need to be sent as a separate signal since it can be inferred from the luma and chroma components. The editing, color correction software, or display device knows the distribution of the luminance gray tones in the image is from the Y' component. Crudely put—it knows how much of the image is blue and red, it figures the rest must be green. It's quite a bit more complicated than this, but that's the basic idea.

For luma (grayscale values), the engineers chose a signal that is 72% G, 21% R, and 7% B, so it's mostly comprised of green, but it's a weighted combination of all three colors that roughly corresponds to our own perception of brightness. To simplify a bit, the color information is encoded as B-Y and R-Y, meaning the blue channel minus luminance and the red channel minus luminance. This is called *color difference* encoded video—the Cb and Cr. This method of encoding is sometimes called *component video*; it reduces the requirements for transmission and processing by a factor of 3:2.

Because the human visual system perceives differences and detail in color much less than in gray scale values, lower-resolution color information can be overlaid with higher-resolution luma (brightness) information, to create an image that looks very similar to one in which both color and luma information are sampled at full resolution. This means that with chroma subsampling, there can be more samples of the luminance than for the chrominance. In one widely used variation of this, there are twice as many luma samples as there are chroma samples, and it is denoted 4:2:2, where the first digit is the luma channel (Y') and the next two digits are the chroma channels (Cb and Cr)—sampled at half the rate of the luminance.

Video that is 4:4:4 has the same chroma sampling for color channels as for luminance. There are other variations—for example, Sony's HDCam cameras sample at 3:1:1. You may occasionally see a fourth digit, such as 4:4:4:4; in this case the fourth number is the *alpha channel*, which contains transparency information. There are others as well, such as 4:2:0—see Figure 7.8 for a visual representation of these varieties. For our purposes, we can say that a 4:4:4 signal has more data. In any case, a 4:4:4 signal is going to be better in color depth and possibly in resolution as well—with the proviso that as always, it requires more processing power and storage. Some widely used chroma subsampling schemes are listed here. There are, of course, more variations than we can go into here.

4:4:4 — All three components are sampled at 13.5 MHz, meaning there is no compression of the chroma channels; however, the signal might still be compressed in other ways.

4:2:2 — Four samples of luminance associated with two samples of Cr, and two samples of Cb. The luminance sampling rate is 13.5 MHz; color component rates are 6.75 MHz.

4:1:1 — The luminance sample rate here is still 13.5 MHz, but the chrominance sample rate has dropped to 3.375 MHz.

4:2:0 — This is like 4:2:2, but doing what's called vertically subsampled chroma. The luminance sampling rate is 13.5 MHz, and each component is still sampled at 6.75 MHz, only every other line is sampled for chrominance information.

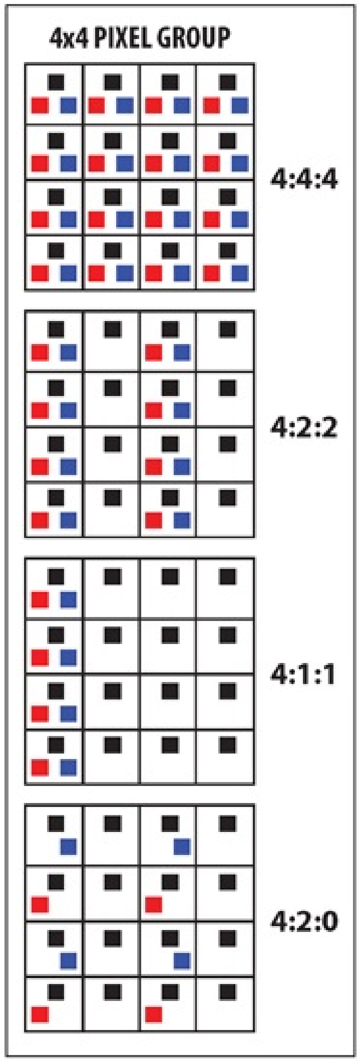


Figure 7.8. The operation of various forms of *subsampling*. The black blocks represent the luminance channel, which is why there is no green channel.

PIXELS

A pixel is not a fixed size; it is a point value that is mapped onto physical elements in a display. For example, the same images might have very small pixels when displayed on a computer monitor, but the same pixels will be quite large when projected on a theater screen. The reason we don't perceive these larger pixels as visible elements is viewing distance—in the theater, the viewer is much farther away.

RESOLUTION

The *resolution* of a device (such as a digital monitor or camera sensor) is sometimes defined as the number of distinct pixels in each dimension that can be displayed or captured. In some cases, this is expressed in *megapixels,* at least in the world of digital still cameras (DSLRs)—a megapixel being one million pixels. The term megapixels is almost never used in discussing video cameras.

Figure 7.9. The classic *Spectra Professional* light meter (with the dome removed for illustration) is basically a single photosite sensor—it produces voltage when light hits it.

However, pixel count is not the only factor in determining resolution; contrast is also an important element. Image processing software developer Graeme Nattress says this in his paper *Understanding Resolution*: "Our overall perception of detail depends not just on the finest image features, but also on how the full spectrum of feature sizes is rendered. With any optical system, each of these sizes is interrelated. Larger features, such as the trunk of a tree, retain more of their original contrast. Smaller features, such as the bark texture on a tree trunk, retain progressively less contrast."

Resolution just describes the smallest features, such as the wood grains, which still retain discernible detail before all contrast has been lost." He adds, "Resolution is not sharpness! Although a high resolution image can appear to be sharp, it is not necessarily so, and an image that appears sharp is not necessarily high resolution. Our perception of resolution is intrinsically linked to image contrast. A low contrast image will always appear softer than a high contrast version of the same image."

PHOTOSITES

Digital cameras, whether designed for video, still photos, or both, use sensor arrays of millions of tiny *photosites* in order to record the image (Figures 7.9 and 7.18). Photosites are *photon* counters—they react to the amount of light hitting them and output voltage proportionate to that. They sense only photons, which have no color (they produce color by affecting the cones of our eyes at different wavelengths) and by the same token photosites have no "color."

PIXELS AND PHOTOSITES ARE NOT THE SAME THING!

It is easy to think that photosites are the same thing as pixels but they are not; the process is a bit more complicated than that. The outputs from photosites are collected together, unprocessed, to form camera RAW images. In most sensors, outputs from adjoining photosites are combined in ways that vary between manufacturers. Pixels are the processed result of the data from photosites. In a display (such as a monitor) pixels are composed of *sub-pixels* — red, green, and blue, which can be varied in intensity to form a wide range of colors.

DIGITIZING

The key elements of digitizing are *pixels-per-frame, bitsper-pixel, bit rate*, and *video size* (the size of the file for a given time frame). Digitizing is the process of converting analog information (such as from the video sensor) into digital bits and bytes.

Digitizing involves measuring the analog wave at regular intervals: this is called *sampling* and the frequency of the interval is called the *sampling rate* (Figures 7.10 and 7.11). As you can see, if the number of samples per video line is low, the sampling is very crude and doesn't give a very accurate representation of the original signal. As the frequency of the sampling increases, the digital conversion becomes more accurate. Once the minimum sampling rate that will accurately represent the analog signal has been determined, the actual sampling rate that is used is generally at least twice that rate. The reason for this is the *Nyquist Theorem*.

NYQUIST LIMIT

The *Nyquist Limit* or *Nyquist Theorem* is a term you will hear mentioned frequently in discussions of digital sensors and video data. No need for us to go into the mathematics of the theorem here, but it states that the sampling rate of an analog-to-digital conversion must be double the highest analog frequency. In video, the highest frequencies represent the fine details of a sampled image. If this isn't the case, false frequencies may be introduced into the signal, which can result in *aliasing*—the dreaded stair-step, jagged effect along the edges of objects. Some people mistakenly think they need twice as many pixels as resolution. But because sampling theory refers to the frequency of the video image, which is made up of a *line pair*, you need as many samples as lines, not twice as many samples as lines.

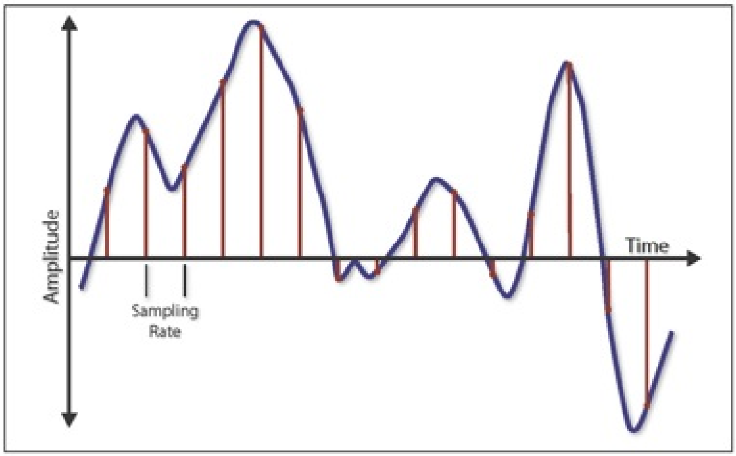


Figure 7.10. Digitizing at a low sample rate gives only a rough approximation of the original signal.

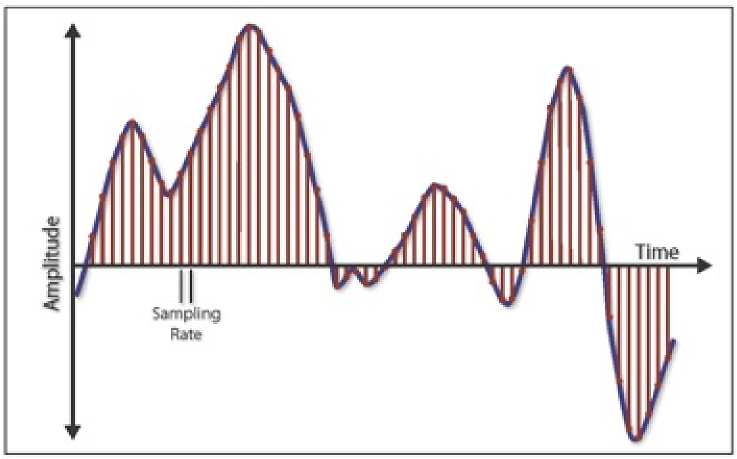


Figure 7.11. A higher sample rate results in digital values that are much closer to the original signal.

OLPF

Optical Low Pass Filters (*OLPF*) are used to eliminate *moiré* interference patterns, so they are sometimes called anti-aliasing filters. They are made from layers of optical quartz and usually incorporate an *IR* (*infrared*) filter as well, because silicon, the key component of sensors, is most sensitive to the longer wavelengths of light—infrared. The reason a sensor will create moiré is primarily due to the pattern of photosites in a *Color Filter Array* (Figure 7.14)—although all types of sensors (including black-and-white) are subject to aliasing. When a photograph is taken of a subject that has a pattern, each pixel is exposed to one color and the camera calculates (interpolates) the information that is remaining. The small pattern of photosite filters is what causes moiré—details smaller than the pixels are interpreted incorrectly and create false details—they spread the information out so details that might fall between photosites cover more than one photosite so fine detail doesn't fall between the cracks. The tradeoff of using an OLPF is a very slight softening of the image. For this reason, they are sometimes removed and in a few cameras, they can be internally changed by the user to select different "grades" of filtering. They work by cutting off the highest frequencies thus smoothing out any detail that is finer than the pixels.

Figure 7.12. An image recorded through a Bayer filter requires *DeBayering* and when this is done in post, there are generally options as shown here in *RedCineX Pro*.

DIGITAL SENSORS

At this time, the dominant technologies used in cameras are *CCD* and *CMOS*, although it is an arena in which we can expect many innovations in the future, as all camera companies constantly engage in research in this area. Both types of sensors have advantages and disadvantages in image quality, lowlight performance, and cost. Since their invention at Kodak in the early 1970s, digital sensors have steadily improved in all aspects of their performance and image reproduction as well as lower costs of manufacturing.

CCD

CCD stands for *Charge Coupled Device*. A CCD is essentially an analog device —a photon counter; it converts photons to an electrical charge and converts the resulting voltage into digital information: zeros and ones. In a CCD array, every pixel's charge is transferred through a limited number of output connections to be converted to voltage and sent to the DSP as an analog electrical signal (voltage). Nearly all of the sensor can be devoted to light capture, and the output's uniformity is fairly high. Each pixel is actually a *MOSFET—Metal Oxide Semiconductor Field Effect Transistor*.

So how do all those millions of pixels output their signal through a relatively few connector nodes? It's a clever process that was conceived at the very inception of the digital image sensor. Working at AT&T Bell Labs, George Smith and Willard Boyle came up with the idea of a *shift register*. The idea itself is simple; it's like a bucket brigade: each pixel registers its charge and then passes it to the next pixel, and so on down the line until it reaches the output connection.

FRAME TRANSFER CCD

A disadvantage of the shift register design is that after the exposure phase, during the *readout phase*, if the readout is not fast enough, erroneous data can result due to light still falling on the photosites; this can result in vertical smearing of a strong point light source in the frame. Also, the sensor is basically out of action as an image collection device during readout. A newer design that solves these problems is the *frame transfer* CCD. It employs a hidden area with as many sites as the sensor. When exposure finishes, all of the charges are transferred to this hidden area and then readout can occur without any additional light striking the photosites, and it also frees up the sensing area for another exposure phase.

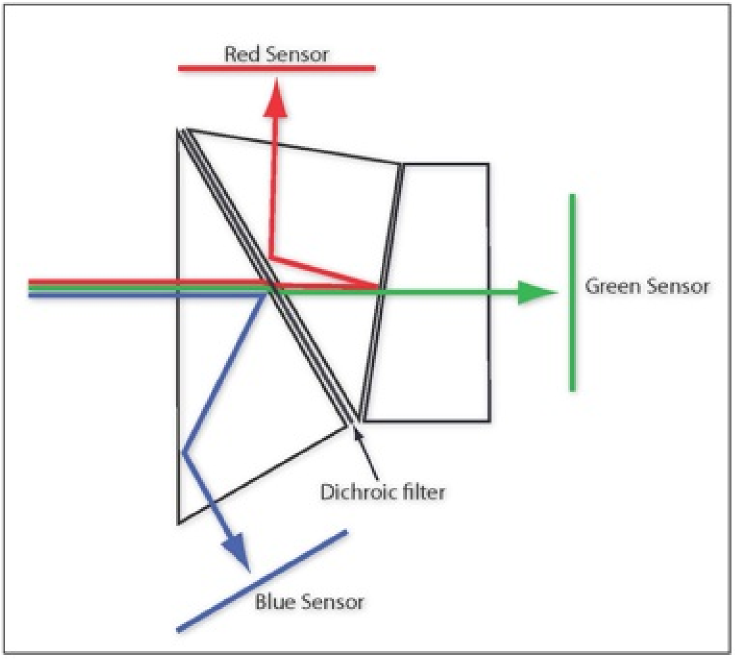


Figure 7.13. The sensor arrangement of a *three-chip camera. Dichroic filters* and prisms separate the red, green, and blue components of the image.

CMOS

CMOS stands for *Complementary Metal Oxide Semiconductor*. In general, CMOS sensors are lower in cost than CCDs because the manufacturing process is simpler and there are fewer components involved. They also tend to use less power in operation and have long been capable of higher rates of readout.

OTHER TYPES OF SENSORS

There are a few other types of sensors which are not used as much. Foveon sensors have three primary colors, on each individual pixel, arranged vertically on top of each other thus eliminating the need for a color filter array. *Junction Field Effect Transistors (JFET)* are similar to CMOS sensors but use a different type of transistor.

3-CHIP

Since the early days of television up to the introduction of UHD, most video cameras used three separate sensors (usually CCD) for the red, green, and blue components. This arrangement is capable of very high-quality images. Since there is only one lens, the image needs to be split into three parts, which is accomplished with prisms and dichroic filters as shown in Figure 7.13. It is critical that all three light paths be the same length so that they focus at the same plane. The sensors must be precisely aligned so that they line up properly when combined into a single color image.

MAKING COLOR FROM BLACK-AND-WHITE

Photosites are unable to distinguish how much of each color has come in, so they can really only record the number of photons coming in, not their wavelength (color). To capture color images, each photosite has a filter over it which only allows penetration of a particular color of light—although this differentiation can never be absolute, there is always some overlap. Virtually all current digital cameras can only capture one of the three primary colors in each photosite, and so they discard roughly 2/3 of the incoming light, this is because filters work by rejecting wavelengths that don’t match the color of the filter. As a result, the processing circuits have to approximate the other two primary colors in order to have information about all three colors at every pixel.

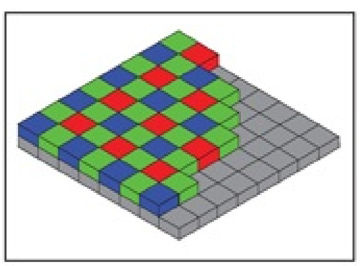


Figure 7.14. Arrangement of a Bayer filter on a sensor.

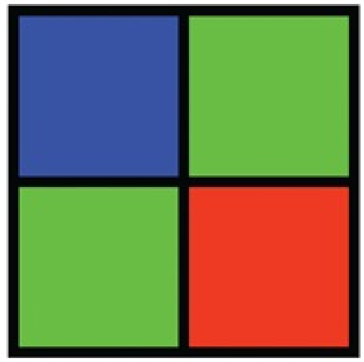


Figure 7.15. The most significant aspect of the Bayer filter is two green photosites for each red and blue. This is a typical arrangement only; some camera companies arrange them differently.

BAYER FILTER

The most common type of color filter array is called a *Bayer filter*, or *Bayer filter color array*. Invented by Dr. Bryce Bayer at Kodak, it is just one type of CFA (color filter array) (Figures 7.14 and 7.15), but it is by far the most widely used in cameras. The sensor has two layers:

- The sensor substrate which is the photosensitive silicon material, it measures the light intensity and translates it into an electrical charge. The sensor has microscopic cavities or *wells*, which trap the incoming light and allow it to be measured. Each of these wells or cavities is a photosite.
- The Bayer filter is a color filter array that is bonded to the sensor substrate. The sensor on its own can only measure the number of light photons it collects; since photosites can't "see" color, it is the filters that differentiate the wavelengths that result in color.

MICROLENS

It is still impossible to make the photosites sit precisely next to each other—inevitably there will be a tiny gap between them. Any light that falls into this gap is wasted light. The *microlens* array (as shown in Figure 7.18) sitting on top of the sensor aims to eliminate this light waste by directing the light that falls between two photosites into one of them or other. Each microlens collects some of the light that would have been lost and redirects into the photosite.

DEMOSAICING/DEBAYERING

There is one obvious issue with Bayer filters or anything like them: they are a mosaic of color pixels—not really an exact reproduction of the original image at all. *Demosaicing*, also known as *de Bayering*, is the process by which the image is put back together into a usable state. In this process, the color values from each pixel are interpolated using algorithms. Figure 7.17 shows a simulation of what an unde-Bayered image looks like. Some software applications allow limited control over this stage of the process. For example, in *RedCineX Pro*, you can choose from 1/16, 1/8, 1/4, 1/2 Good, 1/2 Premium, or full deBayer (Figure 7.12). This selection is made as you dial in your export settings. So, what quality of deBayer is sufficient to produce an image that is best for your purposes?

According to Graeme Nattress: "Full deBayer is necessary to extract 4k resolution for 4k footage. It also makes for the best 2k when scaled down. However, if you're going direct to 2k, the half deBayer is optimized to extract to the full 4k and scale down to 2k in one step, and hence is much quicker. If you're just going to 2k, then the half is fine, but you may get a percent or two more quality going the full debayer + scale route." (Graeme Nattress, *Film Effects and Standards Conversion for FCP*). In *RedCineX Pro*, there is also a deBayer selection named "Nearest Fit." This setting automatically selects the deBayer setting that is closest to the output resolution you select for that export. DP Art Adams puts it this way: "A good rule of thumb is that Bayer pattern sensors lose 20% of their resolution right off the top due to the deBayering algorithm blending colors from adjacent photosites into distinct pixels."

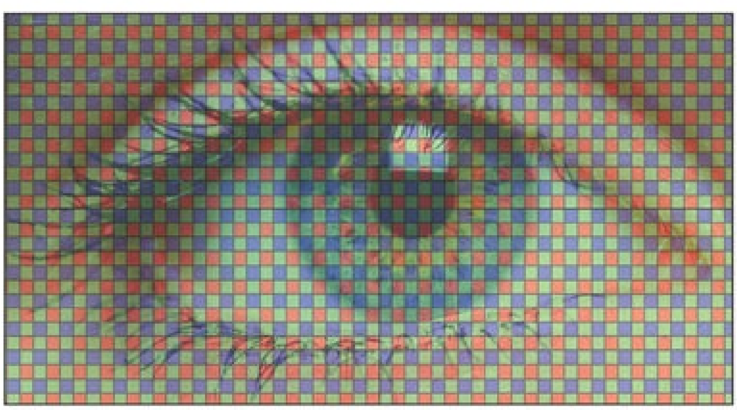


Figure 7.16. An image with a *Bayer filter* arrangement superimposed.

COLOR INTERPOLATION

The most striking aspect of the basic Bayer filter is that it has twice as many green sites as it does red or blue. This is because the human eye is much more sensitive to green light than either red or blue, and has a much greater resolving power in that range.

Clearly it is not an easy task to make a full-color image if each photosite can only record a single color of light. Each photosite is missing two-thirds of the color data needed to make a full-color image; also, the filters cannot do an absolutely precise job of separating the colors, so there is always going to be some “bleed” and overlap, but most cameras do a surprisingly good job of color interpretation.

The methods used for deBayering are quite complex. In very simplified terms, the camera treats each 2×2 set of photosites as a single unit. This provides one red, one blue, and two green photosites in each subset of the array, and the camera can then estimate the actual color based on the photon levels in each of these four photosites.

Figure 7.15 is an example of a 2×2 square of four photosites; each photosite contains a single color—either red, green or blue. Call them G1, B1, R1, G2. At the end of the exposure, when the shutter has closed and the photosites are full of photons, the processing circuits start their calculations. If we look at the demosaicing of each 2×2 square, here’s what goes on: for the pixel at G1, the green value is taken from G1 directly, while the red and blue values are inferred from the neighboring R1 and B1 photosites; in the simplest case, those photosites’ values are simply used directly. In more sophisticated algorithms, the values of multiple adjacent photosites of the same color may be averaged together, or combined using other mathematical formulae to maximize detail while keeping false color artifacts to a minimum.

Based on the Bayer pattern, if the photosite in the center is green, the surrounding photosites will be made up of two blue photosites, two red photosites, and four green photosites. If it is a red photosite in the center, it will have four blue photosites and four green photosites around it. If it is a blue photosite in the center, it will be surrounded by four green and four red photosites. In general, each photosite is used by at least eight other photosites so that each can create a full range of color data. This description is a typical example only, the method used for this color interpolation is proprietary to each manufacturer and is thus a closely held secret. Improvements in this process are a big part of how digital cameras keep getting better and better, along with improvements in sensors, compression, and other factors, including postproduction processing.

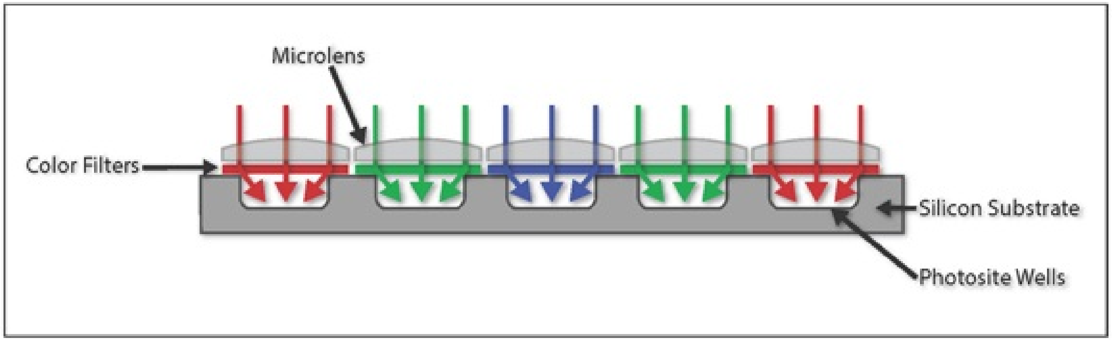


Figure 7.17. Red, green, and blue *photosites* of a typical single-chip, color filter array sensor.

WHAT COLOR IS YOUR SENSOR?

So what is the color balance of a digital sensor? The short answer is that, unlike film stock, which comes in either daylight or tungsten balance, camera sensors don't have a "color balance." Yes, all cameras allow you to choose a preferred color temperature or to automatically "white balance" to adjust to daylight, tungsten, overcast, fluorescent, etc., but these are electronic corrections to the signal—they don't actually affect the sensor itself.

On some cameras, this color correction is "baked in" and is a permanent part of the image. As we know, cameras that shoot RAW may display the image with corrected color balance, but in fact, this is just the metadata affecting the display—the RAW image remains unaffected and any desired color balance can be selected later in software and only needs to be baked in at a later time (there are some exceptions to this, as we'll see). However, that being said, some camera sensors do have a color balance that they are optimized for—this is called their "native" color balance, just as their "built in" sensitivity is referred to as their native ISO. Some are known to have slightly different responses at various color temperatures. What is the native ISO or white balance of a sensor is generally determined by what setting requires the least amount of gain (electronic amplification) to be applied. This results in the least noise.

For example, the native color balance for the Dragon sensor used in some RED cameras is 5,000 degrees Kelvin, but, of course, can be electronically compensated for any color temperature in the range 1,700 to 10,000 Kelvin—as we know, this is recorded in the metadata when shooting RAW images. White Balance presets are available for Tungsten (3200K) and Daylight (5600K) lighting; the camera can also calculate a color-neutral White Balance value using the standard technique. Canon takes the approach that color balance is baked in by applying gain at the time of shooting.

HOW MANY PIXELS IS ENOUGH?

Counting how many pixels a sensor has can get a bit complicated. You might think that a sensor listed as 2 MP would have 2 megapixels for each channel: red, green, and blue. In most cameras, this is not the case. Similarly, for cameras with Bayer filters, there are twice as many green photosites as there are red, or blue—how is this counted? Each camera company has made choices as to how to come up with a total count; there is no industry-wide standard. However, unlike digital still cameras, the megapixel count is rarely used when discussing the camera. Instead, the number of pixels measured across the horizontal axis is used—1920, 2K, 4K, 5K, *etc.*

Figure 7.18. All cameras react slightly differently under tungsten light and daylight. These examples from Arri show a color checker lit with tungsten (left) and with daylight (right). Tungsten is more difficult for digital sensors to deal with. (Courtesy Arri).

Figure 7.19. The *jello effect* caused by a rolling shutter distorts the fast-moving blades of this helicopter. (Photo by Jonen).

5K FOR 4K

Some cameras can now shoot at 5K, 6K, and beyond. There are currently no displays or projectors for this type of footage, so why? It can be thought of as “oversampling.” One popular use for this larger format is to shoot a frame larger than is intended for the final output, this leaves some room on the edges for repositioning, steadying shaky footage and other uses. In film, it is common practice to shoot larger formats such as *65mm* or *Vista Vision* for *VFX* (*visual effects*) shots. This ensured that there would be no degradation quality in the many steps of postproduction.

SHUTTERS

Shutters are always necessary in any type of photography, either still or motion. If the film or sensor was always exposed to the light of the image, it would record the movement in the scene all the time, meaning that the shot would be blurred. Also, there would be much less control over exposure—light would be constantly flooding onto the sensor.

SPINNING MIRROR

Still cameras had many different types of shutters: leaf, focal plane, guillotine, etc., but modern motion picture film cameras almost universally use a spinning mirror. In its most basic form, it is a half-circle (180°) so as it spins, when the mirror is out of the light path, light reaches the film and the image is projected onto the film emulsion. When the mirror rotates into the light path, it reflects the image up into the viewfinder. While the optical path is closed off by the shutter, the camera advances the film to the next frame. If the film was moving while light was coming in, the result would be a total blur.

ROLLING SHUTTER AND GLOBAL SHUTTER

Only a few digital cameras have this rotating mirror shutter; since the video sensor doesn't move between frames as film does, it isn't really necessary. This results in smaller and lighter cameras, but it does have a drawback—video sensors don't necessarily expose the entire frame all at once. Instead, they scan the image up to down. For an object that is moving, it will have moved in the time between when the top of the frame was recorded and shutter closes.

This can have several negative results, including the *jello effect*—a smearing of the moving object (Figure 7.19). There are some postproduction software fixes for this, but of course, it is always better to avoid the need for this sort of repair. One approach to preventing this problem is to add a rotating shutter to the camera like the ones used in film cameras. This has the added benefit of providing an optical viewfinder instead of a video one. In video, what is called the shutter is not generally a physical device; it is how the pixels are "read." In general, CCDs have a *global shutter* and CMOS sensors have *rolling shutters*. A global shutter controls incoming light to all the photosites simultaneously. While the shutter is open, the sensor is collecting light, and after the shutter closes, it reads the pixel charges and gets the sensor ready for the next frame. In other words, the CCD captures the entire image at the same time and then reads the information after the capture is completed, rather than reading top to bottom during the exposure. Because it captures everything at once, the shutter is considered *global*. The result is an image with no motion artifacts. A *rolling shutter*, on the other hand, is always active and “rolling.” It scans each line of pixels from top to bottom, one at a time, which can result in the *jello effect*.

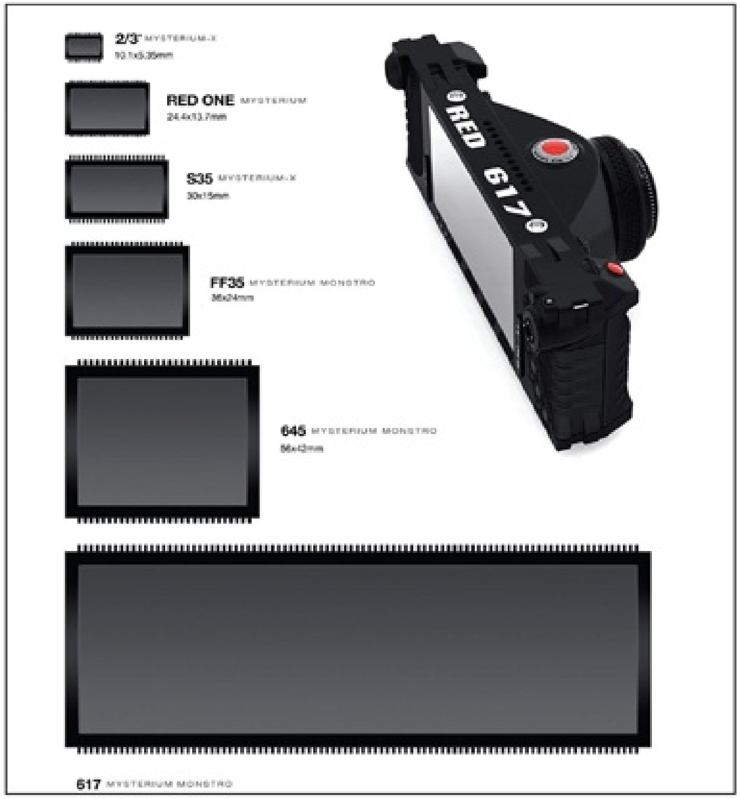


Figure 7.20. The relative sizes of various Red camera sensors. (Courtesy Red Camera).

SENSOR SIZE AND DEPTH-OF-FIELD

Sometimes people confuse the size of the sensor and resolution. For our purposes in this discussion, the physical dimensions of the sensor are the most relevant (see Figure 7.20 for some sensor sizes of Red cameras). This is because the size of the sensor has an important effect on the cinematic storytelling: it is a major factor in determining *depth-of-field*—the range of area in front of the camera that is in focus. In visual storytelling, it is a useful tool in directing the viewer's attention, among other things. It also contributes to the effect of making a scene look more "film-like." We talked about depth-of-field in the chapters *Language of the Lens* and *Visual Language*, and we'll go into depth-of-field in much more detail in the chapter *Optics & Focus* later in this book.

On the other hand, sensor size does not necessarily correlate to a number of pixels. Some very small sensors (such as in pocket cameras) have high pixel counts. This can be problematic in that the individual pixels must then be much smaller and closer together. This means that each pixel will "collect" less light (lower ISO) and be susceptible to cross-talk and contamination from adjacent pixels resulting in noise. Larger pixels (generally associated with larger sensors) also usually have greater dynamic range as well. Sensor size also results in a *crop factor*, meaning that it affects the apparent focal length of the lens. Since there is no one standard for the size of the sensor in professional HD/UHD cameras, lenses that have a certain field of view on one camera will have a different field of view on another camera. In discussing lenses, it is a common practice to refer to lenses in reference to what they would do on 35mm film (as we'll talk about in the chapter *Optics & Focus*) although this will likely fade as there are fewer and fewer people who have experience with shooting film.

ISO IN DIGITAL CAMERAS

ISO (*International Standards Organization*) refers to a number representing *sensitivity*—meaning how much light is needed to produce an acceptable image. Note the term "acceptable"—it is, of course, possible to shoot an image in very low light conditions and try to "fix it in post," but the result will usually be noisy, low resolution and with strange contrast ratios.

Cameras have a "native" ISO, which is just the design parameter of the sensor—what the camera would ideally expose at without any alterations such as *gain*—and is nothing more than electronic amplification of the image signal. It is the amount of exposure that just fills the photosites, not over or underfilling them. When we express gain as *dB* (*deci Bels*), every +6 dB increase represents a doubling of the level which means we can also express it in f/stops, as every increase in the f/stop equals a doubling of the exposure and a decrease of one stop cuts the exposure in half.

+6 dB = 1 f/stop of exposure
+12 dB = 2 f/stops of exposure
+18 dB = 3 f/stops of exposure

If +6 dB is like adding an f/stop, +3 dB is like adding a 1/2 stop of exposure and +2 dB is like adding 1/3 an f/stop. The catch is that when you amplify the image signal you are also amplifying the noise, so turning up the gain inevitably results in a picture that is degraded, although camera makers have made huge strides and in most cases, small increases in gain still result in usable images. However, gain is to be avoided if possible.

As the Red camera company puts it, "With Red, the native ISO speed describes the recommended starting point for balancing the competing tradeoffs of noise in the shadows and clipping in the highlights. This does not necessarily reflect anything intrinsic to a camera sensor itself or the performance of cameras by different companies. It is a reflection of the sensor design, signal processing, and quality standards all in combination." With cameras that shoot RAW, these changes to ISO are recorded as metadata and the real change in exposure takes place in postproduction. High-end Canon cameras are slightly different in this regard as we discussed earlier. DP Art Adams says this about native ISO for his own uses: "What I do is look at the noise floor on a waveform monitor. I have some idea of how much noise I like, and I can judge noise pretty well just by looking at the thickness of the trace on a Leader or Tektronix waveform monitor [see Figures 7.21 and 7.22]. I let the camera warm up, put the body cap in, do whatever black compensation operation is necessary to minimize noise, and look at the thickness of the waveform trace at different ISOs.

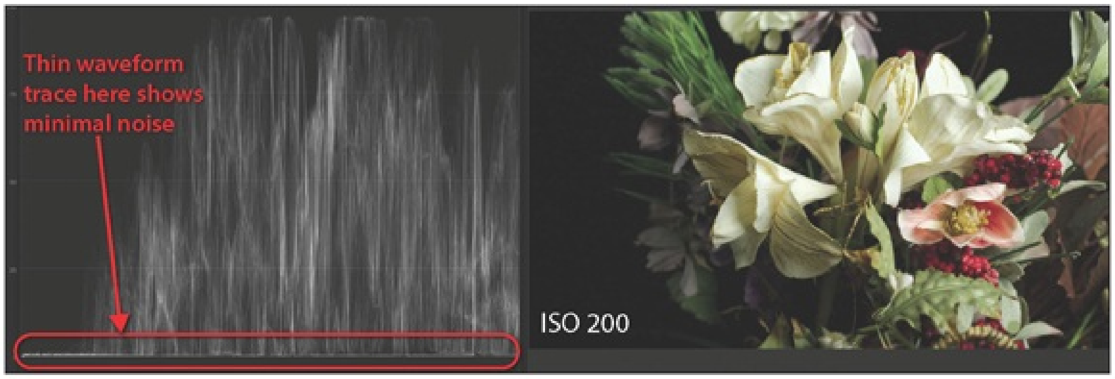


Figure 7.21. A frame from a Red camera at ISO 200. Minimal noise is shown at the bottom of the display, especially in the far left part of the waveform monitor—in the black and near black regions of the frame, the waveform trace is very thin. For more on understanding waveform monitors, see the chapter *Measurement*.

Figure 7.22. The same shot with the ISO cranked up to 2000 on the Red. The waveform trace in the black regions is now a very thick line, indicating lots of noise in the darkest areas. Some noise is also visible in the other parts of the frame; shown by a slight fuzziness throughout the waveform trace. There is noise throughout the frame, it just shows up more in the darkest parts of the shot.
This is an enlarged portion of the original frame and even so, the noise is barely visible. This illustrates the usefulness of the waveform monitor in checking for noise. On a large monitor and certainly on a cinema screen, the noise will be visible.

“When I find an ISO that gives me the width of trace that I want I verify the noise level by putting a lens on the camera, underexposing the image and looking at the shadow noise. If I’m happy with that level of noise, then that’s my new ISO. Where ISO is placed is based entirely on noise level and personal taste. The gain coming off the sensor may seem to indicate it is ‘natively’ 160, or

200, or 320, but if the signal is quiet enough you can put middle gray wherever you want by changing the ISO and seeing if you like the noise level."

DP David Mullen poses this question: "As sensors and signal processing gets quiet enough, the issue of 'native' sensitivity matters less than what is the highest ISO rating you can give it before the noise becomes objectionable. The [Red] Dragon sensor is quieter than the [Red] MX sensor so it can be rated faster than the MX sensor, but since there is more highlight information at low ISOs compared to the MX, it probably has a lower 'native' sensitivity. So should a sensor that can be rated faster with less noise be called less sensitive? Sort of makes you question what 'native sensitivity' actually means."

NOISE

Noise is not the same as film *grain* in appearance—some people make the mistake of trying to imitate the look of film by introducing video noise. There is always going to be some noise present in any electronic device—it's just an unavoidable consequence of the physics involved. It is especially a problem at the low end (darkest areas of the image). This is because as the actual signal (the image) gets lower in brightness, it becomes indistinguishable from the electronic noise. As we'll see in the chapter *Exposure*, some cameras are capable of giving warning signs when parts of the image are "in noise." Since noise is most visible in the darker areas of the image there are two consequences: first, an underexposed image will be noisy (just as happens with film negative) and second, at some point the level of noise overwhelms the detail in the image. Beyond this inherent background, the primary cause of noise becoming visible in the image is *gain*—electronic amplification.

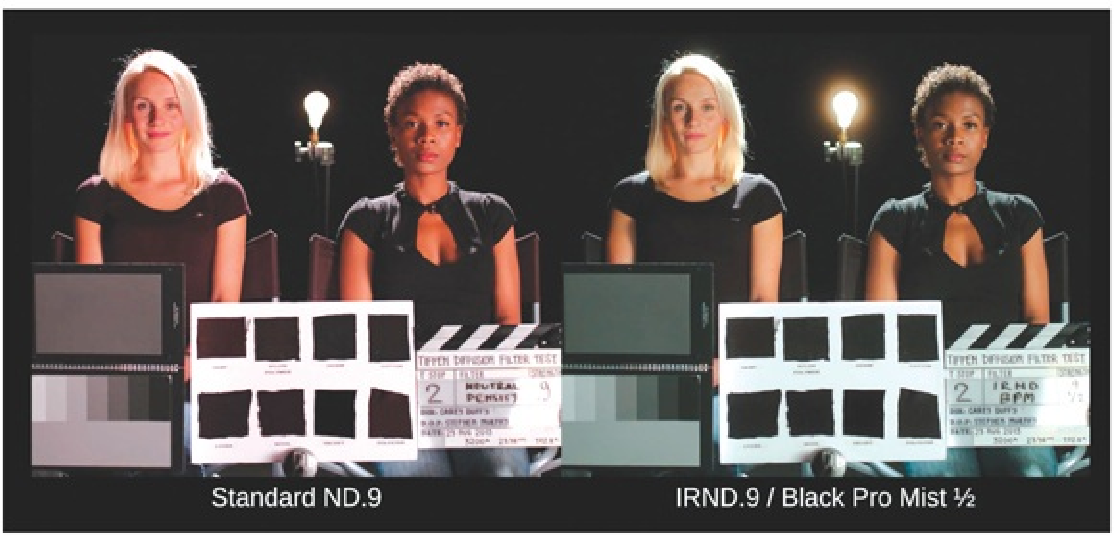


Figure 7.23. This filter test by Tiffen shows significant infrared pollution on the left using an ordinary .9 *Neutral Density* filter. Note especially the reddish IR contamination in the cloth samples in the center with the standard ND filter. The right-hand side shows the effect of their *IRND Neutral Density*, which is also combined with, in this example, a *Black Pro-Mist* 1/2. (Photo courtesy The Tiffen Company).

This can be a result of using a higher ISO, underexposing and compensating later, or even by color compensation in white balance, which may result in certain color channels being amplified more than others. Charles Poynton, color scientist, consultant, and writer says, "Sensitivity and noise are two sides of the same coin. Don’t believe any specification that states one without the other. In particular, don’t believe typical video camera specifications.” A standard measure of noise is the *Signal-to-Noise ratio* (abbreviated S/N or SNR), which is usually expressed in deciBels (dB). As DP Art Adams succinctly puts it —“When it comes to sensors, you don’t get anything for free.”

IR AND HOT MIRROR FILTERS

Some cameras (mostly early Reds) require an additional *IR* (*Infrared*) or *Hot Mirror* filter. Sensors can sometimes see things humans can't perceive, such as an excessive amount of infrared. In normal circumstances, IR is a small proportion of the light hitting a sensor. In lowlight situations, this amount of infrared at the sensor is overpowered by the rest of the spectrum and isn't a problem (Figure 7.23).

Unfortunately, when shooting outdoors, *Neutral Density* (*ND*) filters are usually necessary to reduce the amount of light to a manageable level. Although ND filters are designed (ideally) to introduce no coloration (that's why they are *neutral*) they usually do allow infrared light to pass. Unfortunately, despite the best efforts of filter makers and some highly advanced production techniques, few ND filters are truly 100% neutral. Testing before you shoot is advised.

Manufacturers of film stocks make very low sensitivity (as low as 50 ISO) which are useful for day exteriors. Digital cinema cameras rarely go this low. Traditional HD cameras often had an ND filter wheel and a color filter wheel to accommodate different lighting color situations and light levels. While ND filters work fine for reducing the amount of light to a workable level, they have a drawback—they don't affect infrared equally. The result is that the proportion of visible light compared to IR is changed; the ratio of IR is higher than normal. This can result in red contamination of some colors. IR filters and hot mirror filters are similar in their effect but not exactly the same thing. A hot mirror is a dichroic filter that works by reflecting infrared light back, allowing visible light to pass.

Figure 7.24. An example of the "knobs" on a traditional HD video camera, a Sony F900. In this case they are switches, of course. In cameras that shoot RAW, these have largely been replaced by menu selections that control only the metadata, not the baked-in image. Note also the switch for White Balance and Black Balance on the left side of the photograph.

The choice of an IR filter is camera-specific, as different cameras have different IR sensitivities. Cameras with built-in NDs typically have filters that are designed with that camera's IR response in mind. That doesn't mean that IR filtration is never necessary for cameras with internal NDs, or when shooting without NDs: some cameras show noticeable IR pollution (especially under IR-rich tungsten light) even with no Nd. As always, it's worth testing before an important shoot with an unfamiliar camera. A reddish color on black fabrics is often a telltale sign, but not always, some cameras show IR pollution more in the blue channel. Figure 7.23 shows on the left side, the effect of using a normal Neutral Density filter—skin tones are noticeably redder and the color contamination in the cloth samples is very apparent. On the right side of the frame, the problem is solved by using a Tiffen *IRND*. Internal ND filter wheels can be calibrated to be near perfectly neutral for that particular sensor.

BIT RATE

Bit rate is the measure of how many bits can be transferred per second. Higher bit rates generally mean better quality images but also much larger files. While media storage is measured in *bytes* (big "B") MegaBytes (MB), GigaBytes (GB), TeraBytes (TB), PetaBytes (PB), and perhaps ExaBytes (EB), data rates are measured in *bitsper-second* (small "b"). Several bit rates are used in serial digital video; for high-def applications requiring greater resolution, frame rate, or color depth than the HD-SDI interface can provide, the SMPTE 372M standard defines the *dual link* interface. This interface consists of two HD-SDI connections operating in parallel that supports 10-bit, 4:2:2, 1080P formats at frame rates of 60 Hz, 59.94 FPS, and 50 FPS, as well as 12-bit color depth, RGB encoding, and 4:4:4 color sampling. 3G-SDI transmits the same 2.97 Gb/s data as Dual Link but is able to do it with only one connection.

Figure 7.25. Controls on a Sony F55. There are still a few buttons but they mostly relate to menu selections. Notice also the selection called *MLUT*. This is Sony's *Monitor LUT* for on-set viewing. See the chapter *Image Control & Grading* for more on LUTs. At the upper left is the symbol of the focal plane—a vertical line through a circle. This mark is standard on all cameras as an indicator of where the focus puller should measure focus distance from.

BIT DEPTH

Bit depth is not the same thing as *bit rate*. Depth refers to how many bits of data are recorded per pixel. By way of example, most consumer video equipment is 8 bit, while high-end professional equipment may be 12 or 14 bits per pixel. This gives you more to work with and has huge implications for workflow, ability to achieve the image you want to, and issues such as dynamic range and color accuracy, but it also means that you have a lot more data to deal with (Figure 7.26). One thing to watch out for is that bit depth is counted in two different ways. One of them is bits total and the other is *bitsper-channel*, which includes the Red, Green, and Blue channels and, in some cases, also the Alpha channel, which is transparency data.

FRAME RATES

So film is 24 frames per second and video is 30, right? It would be great if the world was that simple, but, unfortunately, it's not. Yes, film has been shot at 24 frames per second since about 1929. Before that it was more commonly shot at from about 14 to 18 FPS, but since cameras were mostly hand cranked before then, it was really just an approximation. It was the introduction of sync sound that brought about standardization: in order for sound to be synchronized, cameras and projectors have to be running at a constant rate. Thomas Edison maintained that 46 FPS was the slowest frame rate that wouldn't cause eye strain. In the end 24 FPS was chosen as the standard. It was not, as is often said, for perceptual or audio reasons. Interestingly, some filmmakers now believe that 48 FPS is the ideal frame rate, while others advocate rates of 60 FPS and even 120 FPS.

When video was invented, 30 FPS was initially chosen as the standard rate, to a large extent because the power supply of the US runs at a very reliable 60 hertz (cycles per second or Hz) and electronic synchronization is a fundamental part of how video works both in cameras and on TV sets. In Europe, 25 FPS was chosen as the standard because the electrical systems run at 50 Hz.

Running video at 30 FPS soon ran into problems, it turned out with color that there was interference with the subcarrier signal. To solve the problem, engineers shifted the frame rate to 29.97. As a result of this, when 24 FPS film is converted to video, the actual frame rate turns out to be 23.976. Some people make the point that 23.98 (the rounded-off value) is not the same as 23.976 in that some software applications handle them in slightly different ways.

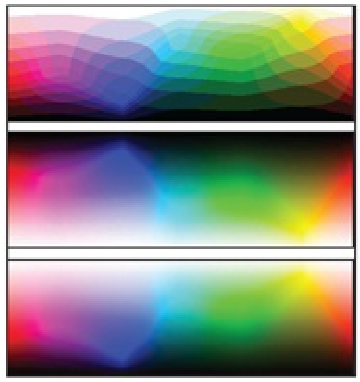


Figure 7.26. The top figure shows very low *bitsper-channel* and it exhibits visible *banding* because there are large jumps from one gradation of the color to the next (exaggerated for illustration here). Middle and lower figures show 16 and 24 bits per channel and the difference is obvious—there are much finer and more subtle changes in color.

THE FILM LOOK VS. THE VIDEO LOOK

Film at 24 FPS has a distinctive look that most people consider to be cinematic in appearance; on the other hand, 30 FPS has a “video” look. The primary reason for this is that we have become accustomed to 24 frames per second. In reality, when we see film projected, we are seeing 48 FPS. This is because projectors have a blade which interrupts each frame and makes it the equivalent of two frames—it appears that Edison was right after all. Film also has an impressionistic feel—it doesn’t actually show us every detail. For this reason, it has been the practice for some time in video to shoot dramatic material at 24 FPS and sports at 30 FPS (actually 23.98 or 29.97).

FILM CAMERAS

For more on film cameras including loading magazines and mounting them on cameras, see the website that accompanies this book.

Figure 8.1. The ARIB/SMPTE color bars are designed for use with HD/UHD video cameras.

THE WAVEFORM MONITOR

For HD/UHD work, on the set, at the DIT cart and in post, the *waveform monitor* (WFM)is a reliable reference. Used in conjunction with the vectorscope, it can give us a great deal of important information about our video signal.

Figure 8.2. A sync generator from Blackmagic. (Photo courtesy Blackmagic Design).

The waveform monitor can tell us "the truth" about our video even if our monitors (on the set or in the editing room) are not properly calibrated; or on location when viewing conditions are bad and it is difficult to get a good idea of the condition of the image even from a very good, well-calibrated monitor.

The waveform displays the *amplitude* (strength) of the video signal; this translates into the *brightness* or *luminance* (or more properly *luma*, as we'll talk about later) of the signal. Picture monitors on the set do not tell the whole story. In fact, relying solely on picture monitors for video quality checks can be an open invitation to disaster. First of all, not every problem with the digital image is obvious on a picture monitor, especially on a small one. Minor problems are easily overlooked. Some cannot be seen at all. For example, a marginal video signal can still produce a seemingly "good" picture on a forgiving monitor. The rule of thumb is that the smaller the monitor, the better things look—often a dangerous illusion. On a small monitor, focus problems, for example, are rarely visible unless they are very bad. Waveform examples are shown in Figures 8.3, 8.4, and 8.5.

EXTERNAL SYNC

All video requires time synchronization; it is critical to a usable video signal.

The waveform monitor can take an external sync source, such as a separate *sync generator*; however, they usually take sync from the video input they are displaying. The same applies to most video equipment: they can either generate their own sync signals or accept an externally generated one. In studios, there is sometimes a central sync pulse generator for all the equipment. This is often critical when shooting multiple cameras, especially when doing live switching from one camera to another—without sync, switching might produce a visible glitch. Multiple cameras can also be synced or *genlocked* by running a *BNC* cable from the *Genlock Out* port of the master camera to the *Genlock In* of the slave cameras and daisy-chaining additional cameras.

TYPES OF DISPLAY

Most waveform/vectorscope units and software displays are capable of showing the signal in several formats; all of which have their own uses at some point or other in the production and postproduction workflow. Some units can show several types of display at the same time, and this is user selectable to adapt to various situation and needs (see Figure 10.1 in *Linear, Gamma & Log*). Different technicians have their own favorites for each situation.

LUMINANCE/LUMA

The most basic of displays is a trace of the luminance/brightness/ exposure of the picture (Figure 8.3). For setting exposure levels this is often the quickest to use. Pure luminance shows only the Y (luminance) levels; some turn it off when exposure is the primary concern. Since it is capable of showing both luminance and chrominance (C), it is called Y/C display. Luminance-only display may not show when an individual color channel is clipping. For reasons more technical than we need to go into here, it is properly called *luma —Y'*.

OVERLAY

The Overlay display on a waveform monitor shows the red, green and, blue traces but overlaid on each other. To make this readable, the traces are color coded to represent each channel in its own hue (Figure 8.4).

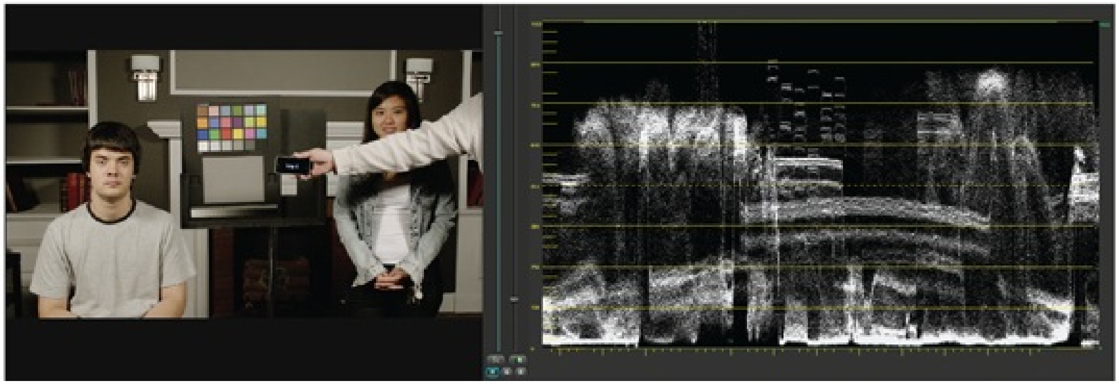


Figure 8.3. A frame shown with *luminance (luma*) waveform—only the grayscale values of the image.

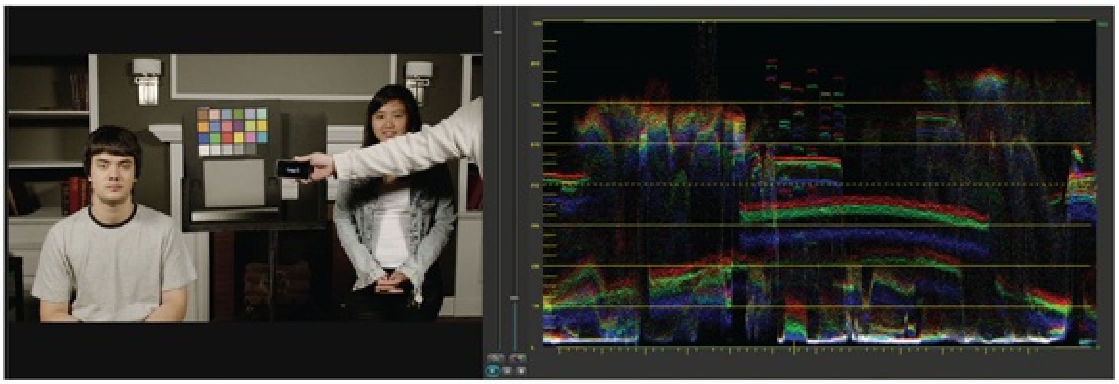


Figure 8.4. *RGB overlay* which shows all three signals at the same time.

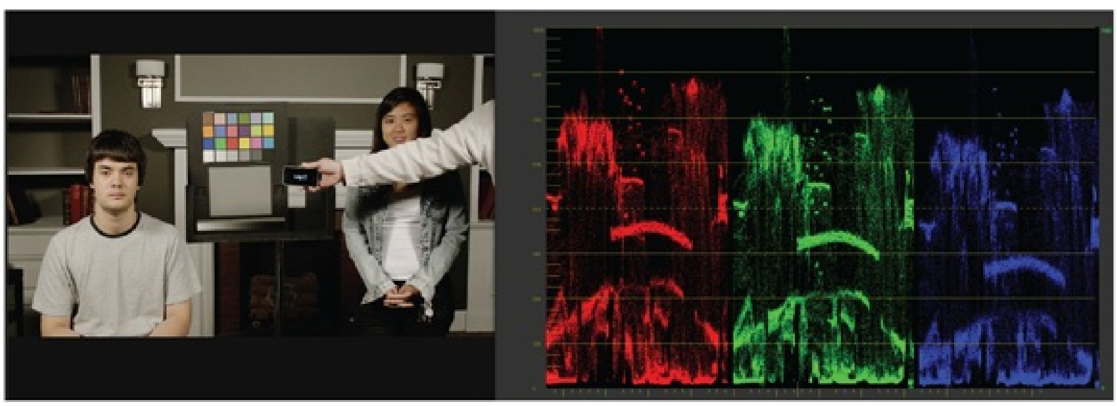


Figure 8.5. *RGB parade* is probably the most widely used display as it also shows the relative color balance of the scene and whether or not a particular channel is clipping.

RGB PARADE

Parade view shows the luminance of the red, green, and blue components shown side by side (hence *parade*). Many technicians say that they "make their living with parade display." Its value is obvious: rather than just showing the overall luminance levels of the frame, it shows the relative values of the different color channels; this means that judgments can be made about color balance as well as just luminance (Figure 8.5). It shows color balance and also when individual color channels are clipping.

Figure 8.6. The traditional SMPTE color bars. Lower right between the two pure black patches is the *PLUGE*. The I and +Q patches are from the now disused *NTSC* color system. Although Standard Def is deader than disco, you will still see these color bars and it's useful to understand them. The values are in *IRE (Institute of Radio Engineers*) where 0 is pure black and 100 is pure white. Although they technically do not apply to HD/UHD video, many people still refer to IRE values.

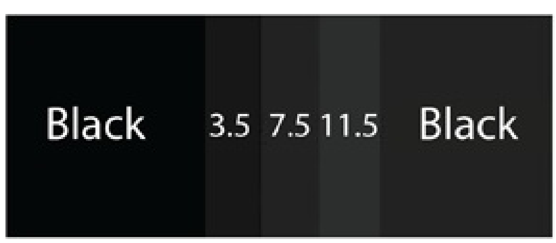


Figure 8.7. The *PLUGE* is valuable for monitor calibration. Between two pure black patches are sections that are at 3.5, 7.5, and 11.5 IRE.

YCBCR

This display is a bit trickier to interpret; it shows luminance first, followed by the color difference signals: Cb and Cr. Cb is blue minus luma and Cr is red minus luma. The two color signals will be markedly different from the left-hand luma reading—it contains the entire luminance range of the picture, where the Cb and Cr only reflect whatever color might be in the picture. Since the luminance is removed from these two signals, they are much smaller than the luma signal. In practice, it is seldom used on the set. When interpreting the YCbCr signals, remember that in 8-bit black is 16, and white is 235 (although it may be converted internally for display), and you want your signal to fall in between those limits. YCbCr is both a color space and a way of encoding RGB information. The output color depends on the actual RGB primaries used to display the signal.

Figure 8.8. UHD color bars are substantially different from HD bars. They include a Y-ramp (luminance from 0% to 100%) as well as 40% and 75% gray patches. The PLUGE is different as well in that it is measured in percentage instead of IRE. Technically IRE values don’t apply to HD signals. This set of color bars was developed by *ARIB*, the *Association of Radio Industries and Businesses*, a Japanese industry group. They have been standardized as *SMPTE RP 2192002*.

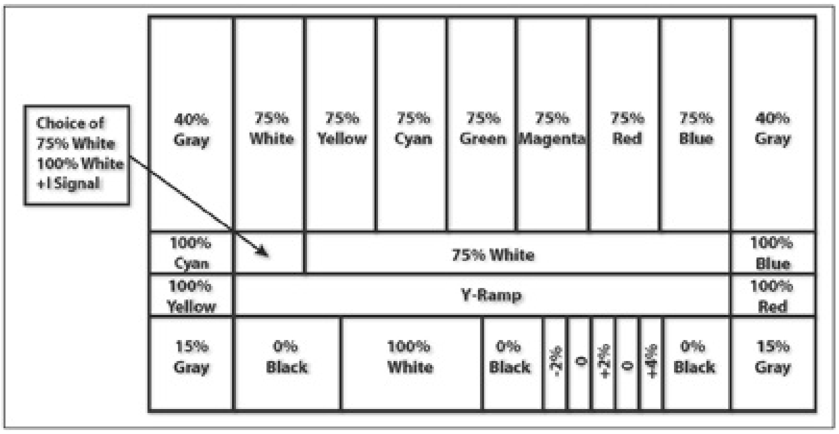


Figure 8.9. Anatomy of the ARIB/SMPTE HD color bars.

COLOR BARS IN DETAIL

On the old-style *SMPTE color bars* test chart (Figure 8.6), the top two-thirds of the frame are seven vertical color bars. These color bars have been officially replaced but you'll see them in many places, so we need to talk about them. They have been replaced by the ARIB/SMPTE color bars, which we'll explore in a moment (Figures 8.8 and 8.9). Starting at the left, the bars are 80% gray, yellow, cyan, green, magenta, red, and blue. The color patches are at 75% intensity—commonly called "75% bars."

In this sequence, blue is a component in every other bar—as we will see in calibrating monitors, this is a very useful aspect. Also, red is on or off with every other bar, while green is present in the four left bars and not present on the three on the right. Because green is the largest component of *luminance* (brightness), this contributes to the stair step pattern which descends evenly from left to right when viewing on the *waveform monitor*. Below the main block of bars is a strip of blue, magenta, cyan, and gray patches. When a monitor is set to "blue only," these patches, in combination with the main set of color bars, are used to calibrate the color controls; they appear as four solid blue bars, with no visible distinction between the bars and the patches, if the color controls are properly adjusted. We'll look at this calibration procedure in more detail in a moment—calibrating the monitors on the set is one of the most critical steps of preparing for the day's shooting.

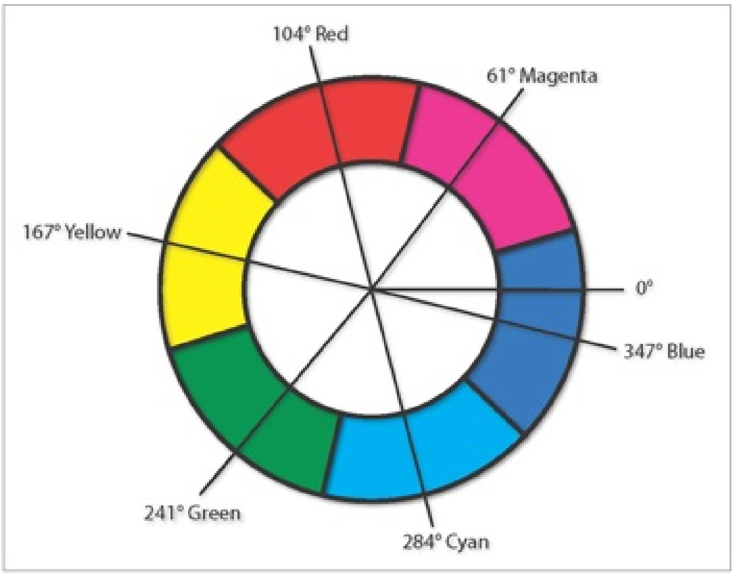


Figure 8.10. The vectorscope display is based on the color wheel. Every color is assigned a numeric value

based on its position around the circle, beginning with zero at the 3:00 o'clock position. In this diagram, the primary and secondary colors are shown as discrete segments for clarity, but, of course, in reality, the colors are a continuous spectrum.

The lower section of the SMPTE color bars contains a patch of white (100%) and a series of small patches of black and near black, called the *PLUGE*, which stands for *PictureLine-Up Generation Equipment*. It was developed at the *BBC* as a way to make sure all the cameras throughout the building were calibrated to the same standard. It was produced by a signal generator in the basement and sent to all the studios so that engineers could calibrate cameras and monitors.

USING THE PLUGE IN MONITOR CALIBRATION

In HD color bars, the PLUGE is underneath the red primary color bar (Figure 8.7); on the UHD color bars it on the bottom row at center right (Figure 8.9). In HD, it comprises three small vertical bars, a right most one with intensity just above the saturated black level, a middle one with intensity exactly equal to saturated black, and a left most one with intensity just below saturated black (or "blacker than black").

On the ARIB/SMPTE HD/UHD color bars, it has a similar design—pure black plus patches just above and below 0. In HD/ UHD, the numbers represent percentage. The PLUGE is critical to properly setting the black levels on a monitor. Think of it this way: if all there was to go by was a "black" patch, we could easily set the monitor controls to make it appear black, but how would we know if we had set it so it's just black or did we maybe go too far and make it darker than pure black? It would still appear the same on the monitor—black is black on a display screen. By having these patches that are just barely above black we can set the level so that it's black but not "too black"—which would affect the values of the rest of the picture as well: the middle tones and the highlights as well as the dark regions. When a monitor is properly adjusted, the right-hand PLUGE bar should be just barely visible, while the left two should appear completely black. It's an ingenious solution to the problem of setting the levels. The original PLUGE generator devised at the BBC used only −4% and +4% bars on a black background, but that left a fairly wide range of settings that could look correct. Absolute precision was not considered as important as having a system that could be used quickly and easily. Adding a −2% and +2% bar makes the pattern more precise, but is a bit more difficult to calibrate, because when the −2% bar disappears the +2% is often just barely visible. The ARIB/SMPTE bars have patches at minus 2%, plus 2% and plus 4%.

Figure 8.11. Accurate monitor calibration can be achieved with probes such as this *Spyder5Elite* by Datacolor. (Photo courtesy Datacolor).

Figure 8.12. The *SpyderCheckr 24* produces color correction presets for a number of applications, including *Lightroom*, *ACR*, and *DaVinciResolve 11*. This can be useful when it comes to adjusting video capture from different types of cameras, such as GoPros and DSLRs. (Photo courtesy Datacolor).

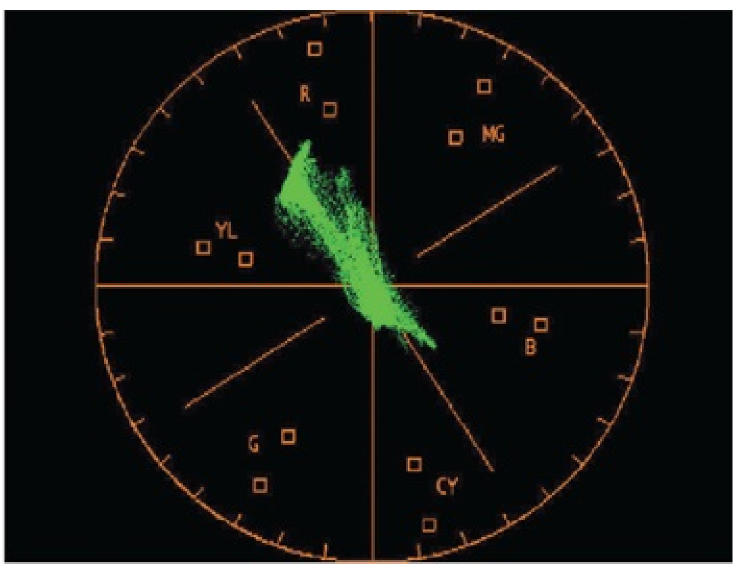


Figure 8.13. A typical image shown on the vectorscope. We can see that this frame has a good deal of red and some blue with not too much of the other colors.

In the bottom section are two patches that represent the “I” and “Q” signals. These relate to the no longer used *NTSC (National Television Standards Committee*) video, which has been replaced by *ATSC (Advanced Television*

Systems Committee) video so we won't go into them in detail. Although SD color bars were designed to calibrate analog video equipment in the standard def world, they remain widely used in digital video—although the form of the bars is different. SMPTE HD color bars are standardized as *ARIB* or *SMPTE RP 219–2002*. *ARIB* stands for the *Association of Radio Industries and Businesses*, a Japanese group that developed these color bars.

MONITOR PROBES

Other methods of monitor calibration include *probes*. The more advanced ones, such as the *Spyder5Elite* (Figure 8.11), have enough range to handle the wider color gamut of Rec. 2020 and P3, making them very useful on the set, at the DIT cart, or in post—precise monitor calibration is critical in all stages of production.

LEGAL AND VALID

There are both technical limits to a broadcast signal and statutory limits set by government or quasi-government agencies that help to ensure that a signal you send out basically won't mess up somebody's television reception. These standards specify that the signal must stay within a certain range. A signal that stays within these limits is called *legal video*. *Valid* means it remains legal even when displayed in a different color space.

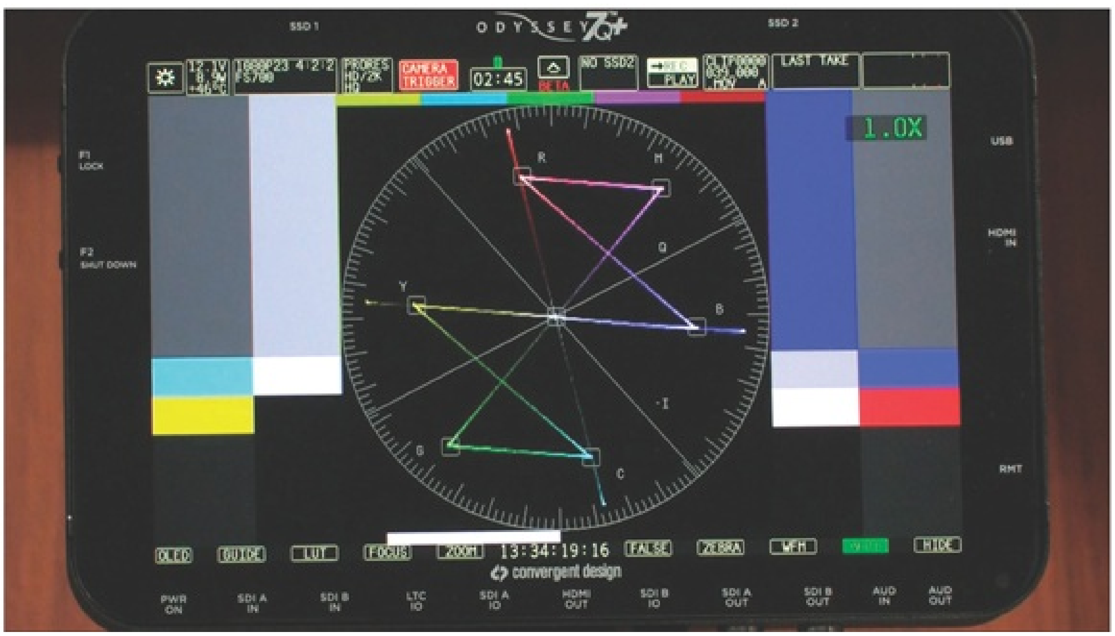


Figure 8.14. Color bars displayed on the *Odyssey 7q+* combination monitor/external recorder. Note the

boxes for the primaries red, green, and blue, and the secondaries magenta, cyan, and yellow. When everything is OK with the signal being generated by the camera, the corresponding patches on the color bars will fall into these boxes. Remember this is an internal camera signal, so it doesn't serve the same purposes as a test chart in front of the camera. (Photo courtesy Convergent Design).

HUE/PHASE

Phase is what we also call *hue*, or what many people mean when they use the word “color” casually. “Color” has too many meanings to be useful for engineering purposes. Hue is represented as a circle (just like the color wheel) and the “color” can be precisely described as degrees around this circle; video engineers use the term *phase* to refer to the relative position of hue on the vectorscope—Figure 8.10.

THE VECTORSCOPE

The *vectorscope* (Figure 8.14) is a bit more specialized than the waveform—it only measures the color signal, but when it comes to color, it is an invaluable instrument. Figure 8.13 shows a shot displayed on the vectorscope. We can see that this scene is heavy in red/yellow with some blue and cyan as well. On the set or in a postproduction suite the two are used together. The vectorscope display is basically the color wheel but, of course, this being video, it is called *phase*. It starts at the 3:00 position, which is zero degrees. As shown in Figure 8.10, the key positions are:

Magenta: 61°
Red: 104°
Yellow: 167°
Green: 241°
Cyan: 284°
Blue: 347°

These are in some respect "centers" of the color but only in a technical sense. In reality, we deal with all the subtle gradations of these colors, not just the pure hue; this is why a mathematical description is important—when it comes to digital signal handling, terms like "chartreuse" don't mean much. So, going around the circle is one dimension of measuring color. The other important dimension on the vectorscope display is how far the trace is from the center. Distance from the center is usually thought of as the measure of *saturation*, but in fact, this is not entirely accurate. Distance from the center can be saturation or value or a combination of the two (see the chapter *Color*). This means that a pure black-and-white frame will appear as a dot in the center of the screen. A monochromatic blue scene that had no other color in it at all would be a dot that is shifted to the right, for example. One display you will see and use frequently is *color bars* on the vectorscope. All color bars (and there are several, which we'll look at later) have the primary colors red, green, blue and the secondary colors magenta, cyan, yellow as well as other key color or grayscale chips.

Figure 8.15. An image displayed on the vectorscope that is part of *DaVinci Resolve*, a color correction program. The small dots represent the patches on the X-Rite color chart.

USING THE VECTORSCOPE ON THE SET

There are safe limits to what we can do with luminance in order to end up with a good image and there are also limits to what we can do with color. In order to monitor this, we use the vectorscope in various displays. As with the waveform monitor, it can be used to check the camera, set it up for a particular look, and to monitor the image during shooting.

Color limits vary according to what standard or color space you are using, simply because every color space and video format treats color differently. For example, a vectorscope display of a standard color chart will appear markedly different when Rec.709 (HD) is chosen than when ITU 601 (a different standard) is selected. For various technical reasons, 100% saturation is generally not used in test charts and patterns—they cannot be properly printed using standard inks and printing techniques. For this reason, the gain is adjustable on most vectorscopes to match the test pattern or chart you are using at the time.

COLOR BARS ON THE VECTORSCOPE

The vectorscope display has boxes for the primary and secondary colors (Figure 8.14). When color bars are generated from the camera or other source, the trace should fall into those boxes—if it doesn't, something is wrong. If the trace is rotated clockwise or counterclockwise, then phase (hue) is off. If they are too near the center or too far from the center, then saturation is too low or too high. Changing the hue in color correction software will also shift them in one direction or another. As we will see, most printed test charts are not set up for 100% saturations on colors, as they are impossible to print properly. Some test cards set saturation at 50% and the vectorscope is then set to 2X gain to give an accurate reading.

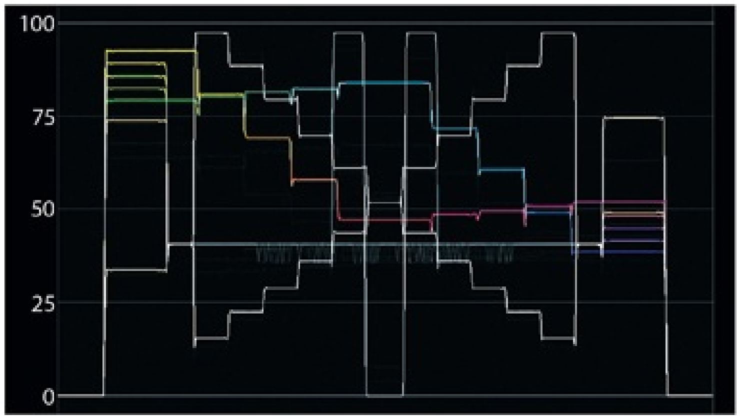


Figure 8.16. The DSC Labs *ChromaDuMonde* on the waveform monitor in *Final Cut Pro X*. Notice that the Cavi-Black gets all the way to zero—a reliable reference. The white patches do not go to 100% as expected, but to 90%. You can also see the luma (brightness) distributions of the various color patches and skin tone patches.

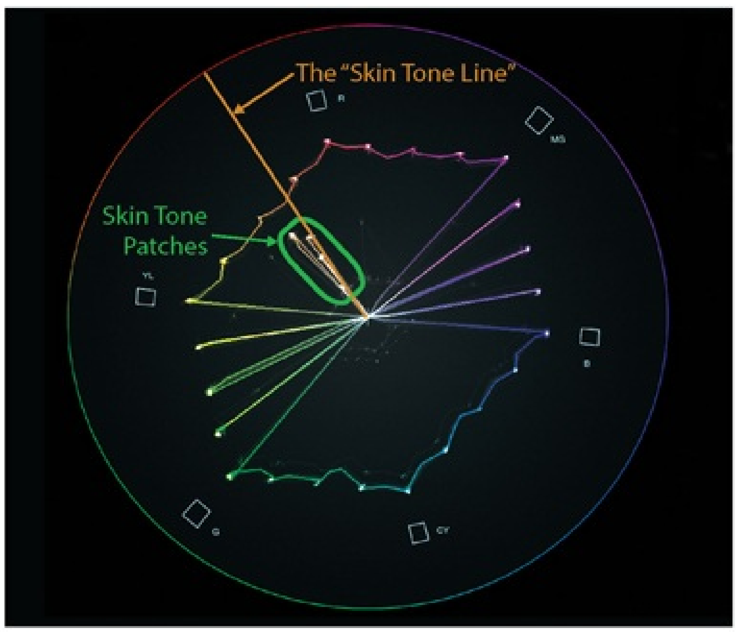


Figure 8.17. The *ChromaDuMonde* on the vectorscope. The color patches are distributed evenly as you would expect; however, notice that they do not reach "the boxes" on the graticule. This is because the DSC charts are designed to show full saturation when the vectorscope is set at 2x gain and *Final Cut Pro X* (unlike professional vectorscopes) does not have a setting for "times two."

Also, note how the skin tone patches fall very close to each other despite the fact that they are skin tones for widely varying coloration. In fact, human skin tone varies mostly by luminance and not by color.

The "Skin Tone Line" is a coincidence. In the outdated NTSC system, it was the "I" line and it just happens that most skin tone colors fall *approximately* along this line. It is a handy reference but it is no substitute for a good eye and a well-calibrated monitor. Also note that while the *ChromaDuMonde* chart is dead-on accurate, most cameras are not— there is almost always some small variation, often it's part of the "look" of that camera.

WHITE BALANCE/BLACK BALANCE

When the camera is aimed at a neutral gray card or neutral white target, white balance is readily judged on the vectorscope. Since a truly neutral *gray card* has no color bias in any direction, its trace should appear as a dot in the middle of the vectorscope—the image has luminance, but no chroma at all.

If the dot is not in the center, this means the white balance of the camera is off. If the dot is shifted toward blue, it probably means that the lighting on the test patch is daylight (blue) balance and the camera is set for tungsten. If the dot is shifted toward the red/yellow, it usually means the opposite: the lighting is tungsten and the camera is set for daylight balance. See Figures 6.8 through 6.10 in *Color*. Many technicians also use the parade waveform to judge color balance, as it shows the relative balance between the three color channels. We'll look at an example of this in a later chapter.

Black balance is also very important. Most cameras include an automatic black balance function. If you were to do it manually, you would cap the lens so that no light at all is reaching the sensor, then make sure the dot is in the center of the vectorscope. Some people also close down the aperture all the way as an added precaution.

An auto white balance execution by the camera (or a manual white balance) will both adjust the relative amplification values as well as the overall amplification of both R and B channels Keep in mind that a vectorscope represents points not on a R vs. B axis, but on a (R-Y) vs. (B-Y) axis. Typically in manually white balancing RAW images, I tend to leave the G channel alone (when possible) as that is the primary contributor to luminance (Y) and changes in G affect image brightness. Most in-camera WB adjustments manipulate only R and B gains.

Matt Whalen
Applied Color Science

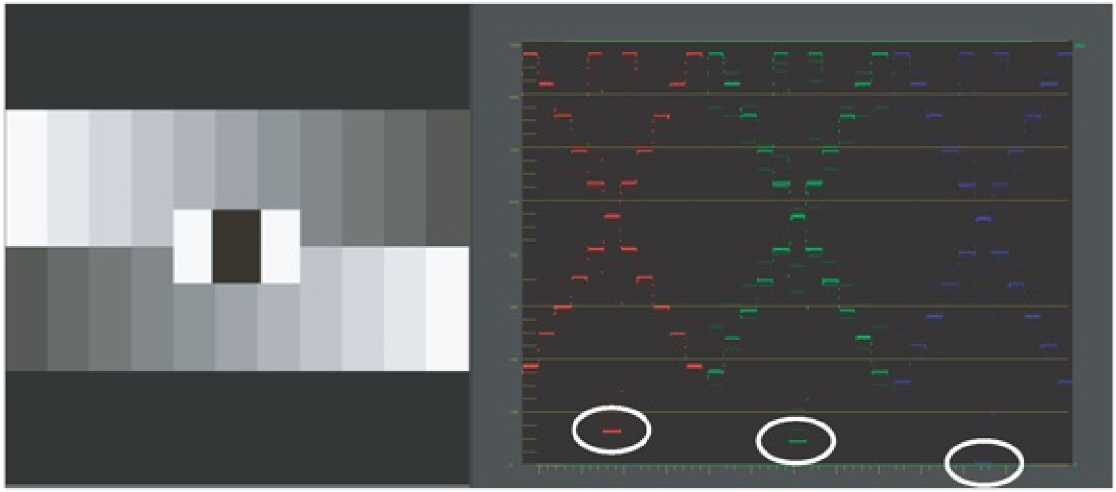


Figure 8.18. This gray scale in parade view on the vectorscope shows the effect of not having set the camera *black balance*.

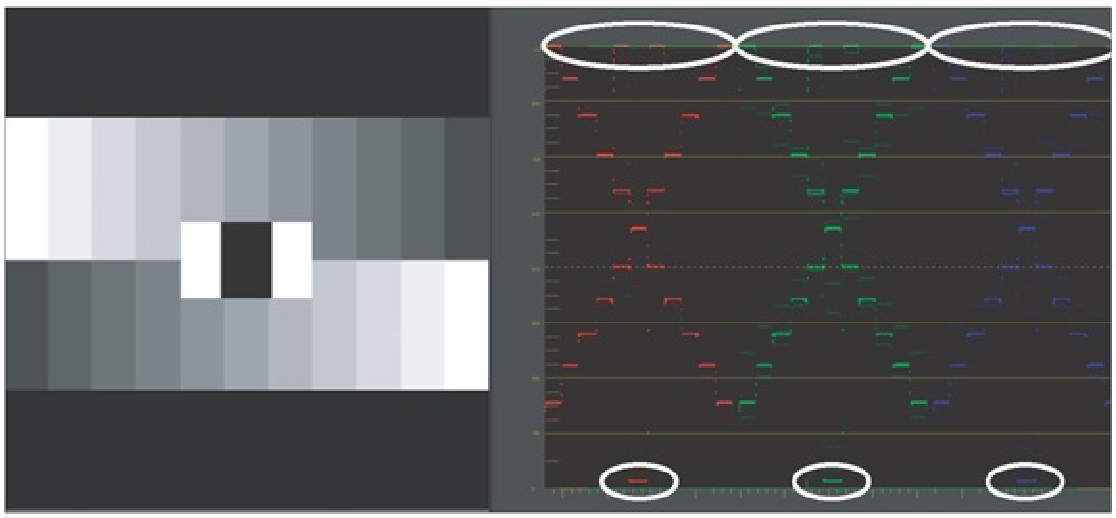


Figure 8.19. The same display with camera *black balance* and *white balance* properly set.

GAMUT

A primary concern with video is staying within the limits of *gamut* (which was discussed in greater detail in the chapter *Color*), particularly as defined by the rules and by the limits of the equipment. Some vectorscopes have displays and warnings that help with this, some of them patented by Tektronix and used in their units. Some software will give warnings when gamut limits are exceeded.

VIDEO TEST CARDS

Color bars are internally generated by the camera, which means that they tell us nothing about the scene we're shooting, the lighting, lens color and flare characteristics, or even camera setup modifications. To evaluate these, we need something external— *test charts*, also called *test cards* or *calibration targets*.

THE DECEPTIVELY SIMPLE NEUTRAL GRAY CARD

The 18% gray card has been an essential and necessary tool for still photographers and cinematographers for decades. In the Ansel Adams *Zone System*, the grayscale from black to white is divided into sections or zones, each one representing a piece of the continuous scale—see Figure 9.14 in *Exposure*. Traditionally, it is divided into eleven zones from 0 to 10, with 0 being pure black and 10 being pure white. Adams used Roman numerals to designate the Zones. There are several important landmarks we can reference: Zone 0 is theoretical pure black, but Adams considered Zone I to be the darkest "useful" Zone. At the other end, Zone X is theoretical maximum white, but Zone IX is the usable, practical top end. He termed Zones II through VIII to be the textural range: meaning they were areas of the grayscale in which you could still detect some texture and detail—these are also useful concepts in video exposure.

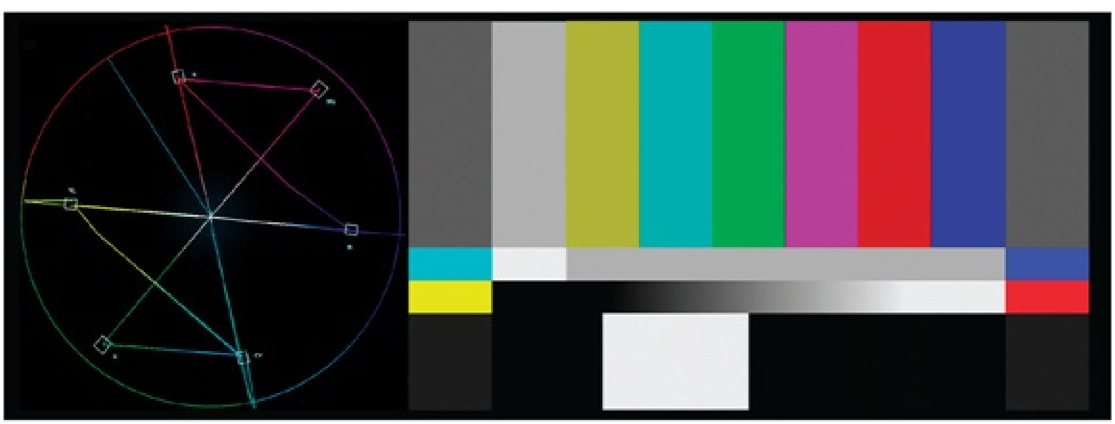


Figure 8.20. The ARIB/SMPTE color bars as shown on the vectorscope— all the primary and secondary colors of the bars are precisely centered in the appropriate boxes on the scope.

A useful reference point is *middle gray*—Zone V. This is *perceptually* halfway between black and white—it is not, however, 50% gray. This is because human vision is not *linear*, it is actually *logarithmic*. We perceive increases in brightness unevenly—at the dark end of the grayscale, we can discriminate small changes in brightness, at the high end of the scale it takes large changes in luminance for us to perceive a difference. This logarithmic change applies to most human perception; for example, it is why loudness is defined in terms of *deciBels* (dB) which are logarithmic units.

THE NEUTRAL PART

Notice that part of the name is “neutral”—as the name implies, it is designed and manufactured to be free of any color tint. This aspect of the card is extraordinarily useful when it comes to color balance and grading; in particular for white balancing the camera before shooting. Some DPs prefer to use the gray card for camera white balancing since it is likely to be more color neutral than a sheet of white paper or even the white side of the card. Some companies also make specialized white cards for white balancing cameras. Using a piece of white paper is a bad idea as there are so many variations of “white” paper, and many of them use bleach that can fluoresce.

THE 90% SIDE

The other side of the gray card is 90% diffuse white. The reason for this is that 90% reflectance is the whitest white that can be achieved on paper. Like the gray side, it is color neutral and is widely used as a target for white balancing cameras, although many people prefer the gray side for this purpose. It is dangerous to use just any old piece of white paper that’s lying around for white balancing a camera. The reason for this is simple—next time you go to a stationery store, take a look at how many dozens of “white” paper they have, none of them exactly matches the others. Worse, the “bright white” papers are made with bleach and other products that may cause them to fluoresce in the non-visible spectrum.

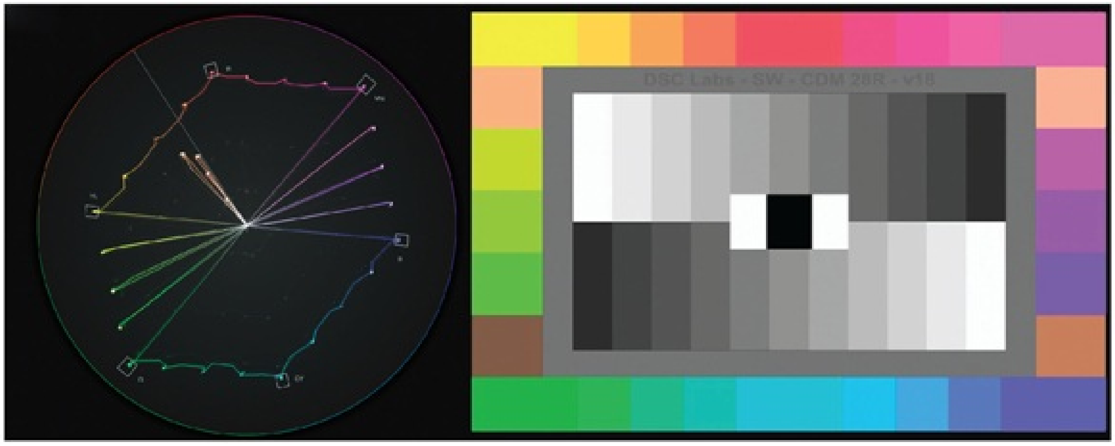


Figure 8.21. The DSC Labs *ChromaDuMonde* test target shown on the vectorscope. Because it is not possible to manufacture color patches at 100% saturation, the chart is designed so that the primary and secondary colors sit in their proper boxes on the scope when it is set at X2 (times two). Note also the skin tone patches clustered in the upper left quadrant, along what is know as the *skin tone line*.

THE GRAY CARD AND COLOR BALANCE IN FILM AND VIDEO

One problem cinematographers have dealt with since the earliest days is getting the telecine colorist to process the image in a way that matches what the DP intended when they shot it on the set. This is particularly true of *dailies*. In the long-form workflow (such as feature films) dailies are usually produced without the supervision of the cinematographer since they are done overnight, when the crew is (hopefully) getting some sleep before the next shooting day begins. When the DP couldn't be present for dailies, all sorts of devices were used to get the colorist to understand what was intended. Failure to do so can cause directors and producers to panic when they see dailies that do not reflect what the DP really intended, with all sorts of negative consequences, such as people getting fired.

In film, the colorist threads up the negative and then views it on a monitor—they really have no idea what the DP was trying to accomplish: is the scene supposed to be dark and shadowy? Bright and crisp? Blue and sinister or warm-toned orange? DPs send notes to the colorist, call them on the phone, send sample photos from magazines, photos from the set, all sorts of things.

These all work, sort of, but there is a simpler and more direct method that is purely technical and calls for no subjective, artistic vision on the part of the dailies colorist (who is often one of the lowest paid people in the facility). In film-based production "shooting the gray card" is a standard procedure on sets and has been for a long time; it is still important when shooting video.

When the camera is set up and the scene is lit, a camera assistant holds a neutral gray card in front of the lens and the operator shoots it at the f/stop calculated by the cinematographer to give an ideal exposure for the card. Once the colorist has this on their monitor, the rest is simple and quick. He or she places the exposure of the card at the prescribed level for middle gray on the waveform monitor (which is not going to be at 50% on the waveform monitor—more on that later) and then looks at the vectorscope and places the small dot the card produces at the exact center, which means it is neutral gray. With this, the image will be what the cinematographer intended. It is important to note that this works with film because the color science is built into the emulsion. With video cameras, the color science varies widely and can be changed by the user. It is possible to input wide variations in the color matrix that will not be affected by a gray card white balance. We'll talk about how to deal with this in a moment.

WHY ISN'T 18% GRAY ALSO 50%?

It's easy to assume that middle gray is going to fall at exactly 50% on the waveform monitor. It would be a nice, neat world if it did, but, it doesn't. When log encoding or gamma correction is applied, middle gray falls at anywhere from 38 to 46 IRE. First of all, that's a pretty big range, and it's also quite a way from 50%. In Rec. 709, middle gray is closer to 43% and can vary considerably from camera to camera. We'll go into this in the chapter *Linear, Gamma, Log*.

For now, it is enough to understand that the video signal is not linear—video data, especially from cameras that record log-encoded video, is manipulated in various ways in order to extend the dynamic range, and this results in the value for middle gray being pushed down the scale. It varies because different camera companies use different math in their digital signal processors and even present the user with several different choices. Understanding how this works is actually going to be a big part of learning how the video signal works in cameras, in all aspects of image acquisition and processing.

CALIBRATION TEST CHARTS

In the era of analog cameras from the early days of television until relatively recently, cameras need almost constant maintenance to keep them "on target." Cameras are pretty stable in these digital days but there are still lots of things that can happen to an image, for better or worse: lighting, exposure, compression, recording format, camera settings—the list goes on and on. All of these make in-front-of-the-camera calibration test charts absolutely essential.

DSC LABS TEST CHARTS

Without a doubt the top-of-the-line, the Lamborghinis of test charts are those from *DSC Labs* in Toronto, in particular, the *ChromaDuMonde*—you will see this chart in use on nearly every professional set using video cameras, in almost every rental house, and in use by cinematographers and camera assistants everywhere (Figure 8.22).

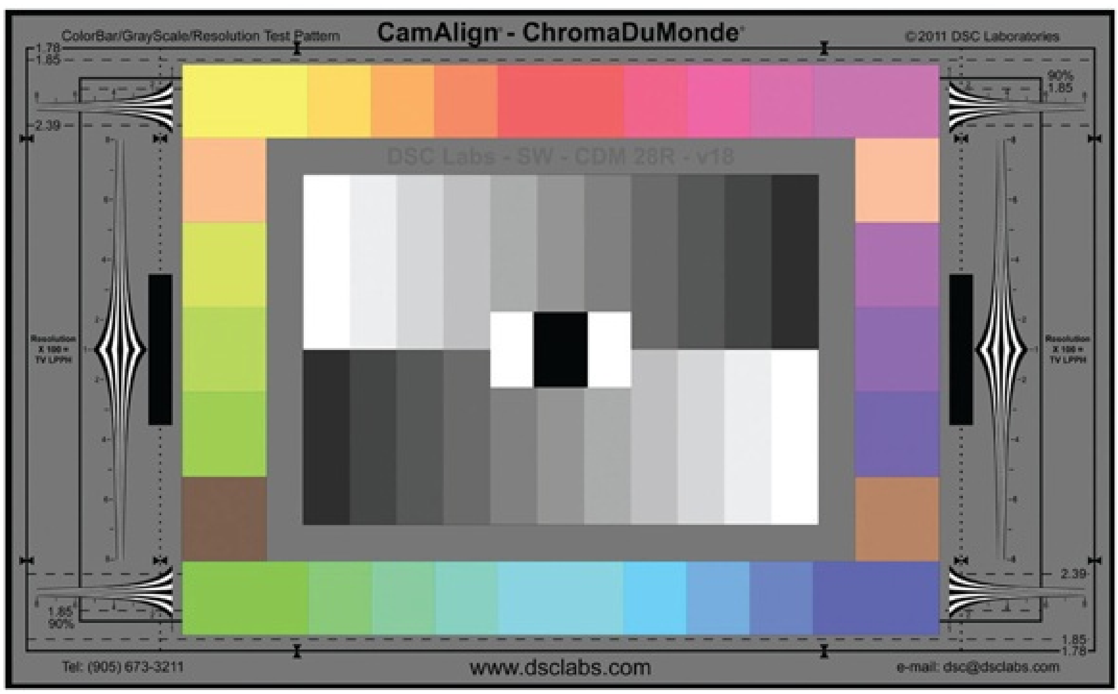


Figure 8.22. The *ChromaDuMonde* test target from *DSC Labs*—an extraordinarily useful tool. For technical reasons, the color patches are not at 100% saturation.

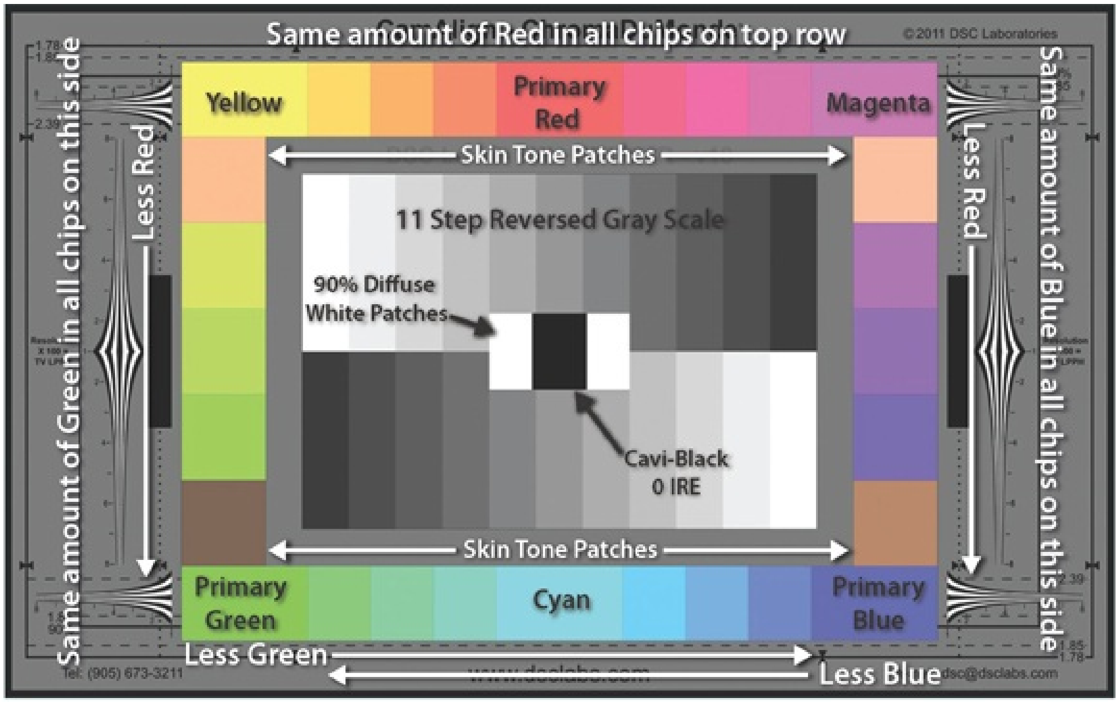


Figure 8.23. The *ChromaDuMonde* dissected.

The anatomy of this chart is shown in Figure 8.23. It consists of an 11 step crossed gray scale and 28 color patches which include primaries, secondaries, and four typical skin tone patches. One of the most useful and important features is in the center—called the *Cavi-Black*, it is a hole in the chart which is backed by a black velvet-lined box. This forms something that is truly black, zero percent video. When aligning a scene on the waveform monitor, having a reference that we absolutely know where it belongs on the display is a huge help. On either side of the Cavi-Black are 90% white patches, the most reflective that can be achieved with printed materials. Many people still refer to white patches such as this as 100% white—it isn't. The background of the entire chart is 18% neutral gray—another important reference point for exposure. Also included are resolution trumpets and framing marks for 1.78 (16x9), 1.85, and 2.39.

The chart is glossy, which gives deeper blacks and thus more contrast. Glossy also means that reflections and glares are readily visible and can be dealt with; this also means that careful positioning and lighting of the card is important as glares and reflections will most definitely interfere with proper use of the test target.

THE ONE SHOT

Cinematographer and author Art Adams, who consults for *DSC Labs*, designed a quick field reference test chart called the *OneShot*; it consists of black, white, and middle gray patches; the primary and secondary colors; and four typical skin tone patches (Figure 8.24).

Adams points out that if one is setting up a camera, grayscale references are vital for adjusting exposure, but tell you little about alterations made in the color matrix—these are much more easily tracked in the color patches and especially the skin tone areas. Blogging at ProVideoCoalition.com, Adams writes about this chart: "In the old days, we shot an 18% gray card to tell a film dailies timer where we wanted our exposure placed and what color we wanted dailies to be. Now that film is being replaced by HD a simple gray card is no longer enough, because while film colors are fixed by emulsion, video colors are not. A gray card in video doesn't communicate anything about accurate color. That's why I designed the *DSC Labs OneShot* dailies reference chart.

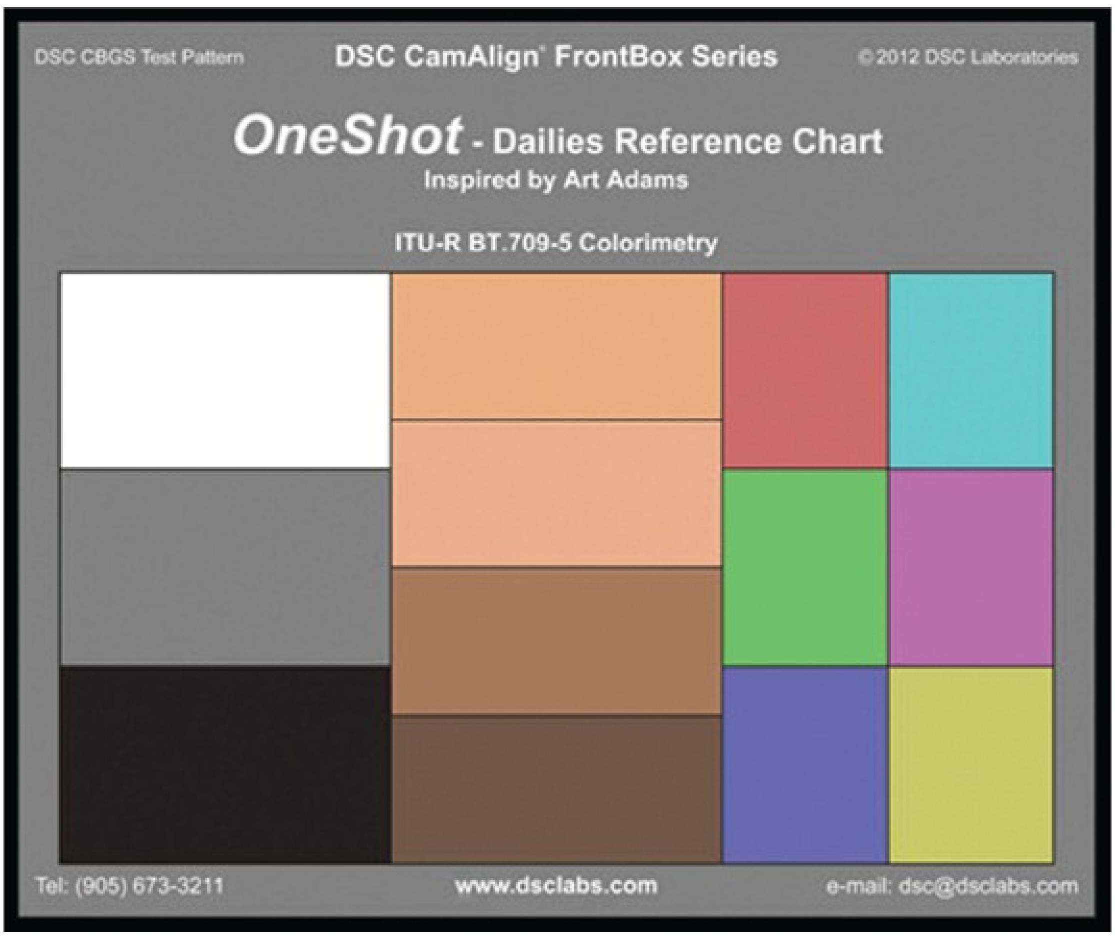


Figure 8.24. The *DSC Labs OneShot* includes gray, white, and black patches; the primary and secondary colors and skin tone samples. It is designed for quick field use when you might not have time to set up and light a full test chart.

“The *DSC Labs OneShot* is intended to give a colorist the most information possible without taking up a lot of time on set. The chart contains white and black chips for white and black balancing (yes, black has a color, and if it’s not right your entire image will suffer); an 18% gray chip for exposure; four common flesh tone references; and the Rec.709 primary and secondary colors, at 50% saturation. This chart is only truly usable for Rec.709 colorimetry, which is HD colorimetry. We’re working on a digital cinema version, but for now, this will do as dailies are frequently viewed in Rec.709.

“The Rec.709 primaries and secondaries are printed at 50% saturation because it is impossible to print them at full saturation: their colors, as seen properly on a monitor, are more saturated than modern printing technology can reproduce. The primaries and secondaries are perhaps the most important references on the chart. It is certainly possible to neutralize the image using only white and black references but this doesn’t necessarily mean that color will be accurate after doing so: the camera’s matrix generally doesn’t affect neutral tones (white, black and gray) but it always affects colors. White balance means that neutral tones will appear white, but says very little about how red, green, blue, cyan, yellow and magenta are rendered.” We’ll be discussing Rec.709 in detail later on. DSC Labs adds this about the *OneShot*—“Color charts are often technically more accurate than the cameras that photograph them. Different manufacturers have their own ‘secret sauce’ formulas for defining how their cameras reproduce colors, so while the chart is accurate, it’s important to know that some cameras may have difficulty reproducing certain colors. For example, most cameras can’t reproduce the color green saturation level that puts the green chip into the green target box on a vectorscope.

Figure 8.25. The *X-Rite ColorChecker Classic*. (Photo courtesy X-Rite Photo and Video).

Figure 8.26. The *X-Rite ColorChecker* Video card in use on the set. The vectorscope on the monitor provides a quick way to check color accuracy. (Photo courtesy X-Rite Photo and Video).

“The most important way to ensure color accuracy is not necessarily to make the chart colors fall into their vectorscope boxes, but rather to ensure that they fall on their ”vectors“, or the lines that run from the center of the scope through each color target. Color accuracy is determined by whether those colors land on their vectors; color saturation is determined by how far away from the center of the scope they land. Saturation depends on a lot of variables, including the camera used and the desired look. Placing the colors on their vectors almost always matters more. Most important is flesh tone accuracy, which is why the flesh tone chips are designed to fall immediately around the l-Q vector on any standard vectorscope [Figure 8.17].

“This chart’s primary use is to ensure that dailies remain as constant as possible once a look has been determined. As the chart contains unmistakable color references that line up with targets built into any standard vectorscope, it’s fairly simple to reproduce the DP’s intended look for dailies, or to use the chart as a starting point to neutralize the footage and then add an additional look from there.”

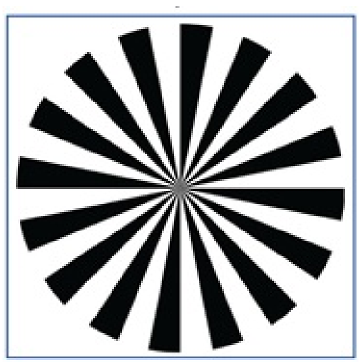


Figure 8.27. The *Siemens Star* is an excellent way to judge focus but there are several other focus targets from various companies.

THE X-RITE COLORCHECKER

Although some people still call it the *Macbeth* color checker chart (the original name), it is actually now made by the *XRite* company (Figure 8.26). You will see it frequently in camera tests, lighting tests, and other places where a familiar color reference is needed. Some color correction software can also use it (and other color test charts) for automated white balance. See Figures 11.3 and 11.4 in the chapter *Image Control & Grading*. For the precise color values of each patch, see *The Filmmaker's Guide to Digital Imaging*, by the same author, also from Focal Press.

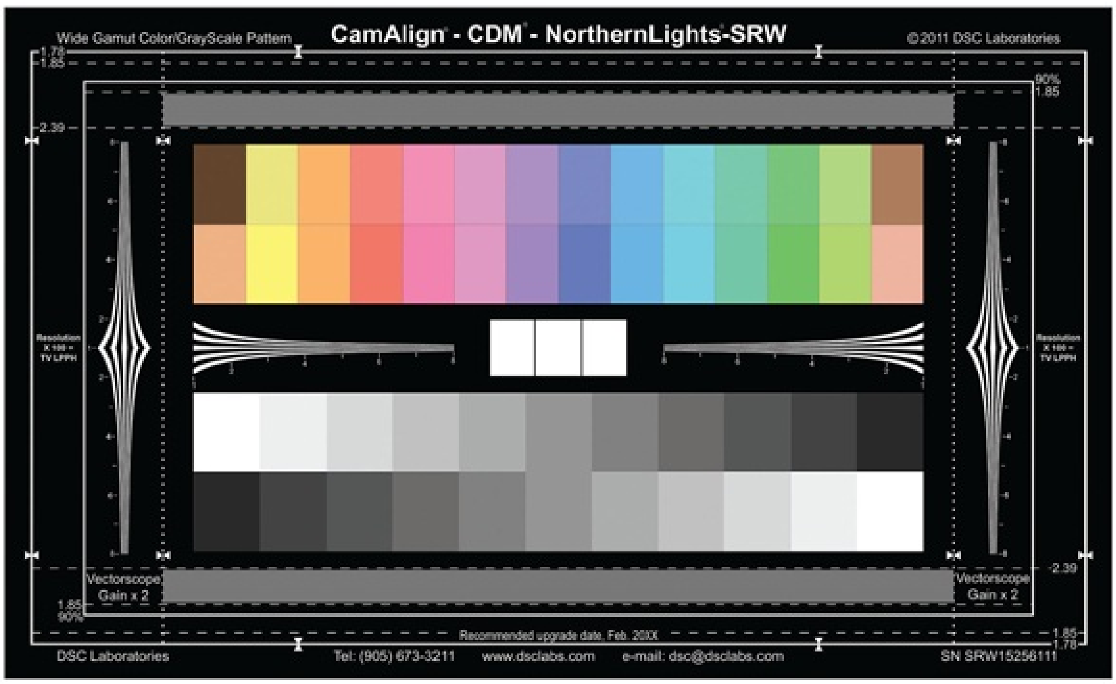


Figure 8.28. *NorthernLights* by DSC Labs is the first test chart with a wider gamut better suited to UHD cameras and formats such as DCI P3 and Rec. 2020.

CHROMAMATCH & SCREENALIGN

DSC Labs has introduced a new concept in color control on the set, at the DIT cart, or in post—the *ChromaMatch* (Figure 8.29). After shooting a few frames on the set, the image is displayed on the monitor and adjustments can be made by using the vectorscope (Figure 8.31) or by comparison with the *ScreenAlign*

(Figure 8.30). The *ScreenAlign* is placed in front of the monitor and visual comparison can be made between the monitor display and the device. The *ScreenAlign* has settings for different monitor color space and white point settings and various monitor brightness levels. With the use of a digital file of the *ChromaMatch* (available free from the DSC Labs website), the monitor can also be calibrated with great precision. This system also includes six patches in the larger gamuts used in such as Rec. 2020 and P3, making it especially useful for testing and calibrating Ultra High def cameras.

SKIN TONE

Because the reproduction of skin tones is such an important subject, nearly all camera tests will include a human subject. For even tighter calibration, images of people have long been used for this as well. In the early days of film, *China Girls* were a widely used standard. This has nothing to do with ethnicity; they are called that because they were hand painted on porcelain—china. They provided a stable and repeatable image of skin tone for calibrating film processing equipment.

A newer test reference is the *Cambelles* by *DSC Labs* (Figure 9.7 in the chapter *Exposure*). Carefully calibrated and printed, it has four models with typical and representative skin tones. When shooting camera tests, lighting tests or camera calibration, it is always important to include a live person in the frame along with charts—actual skin reacts to light in a way that no test chart can.

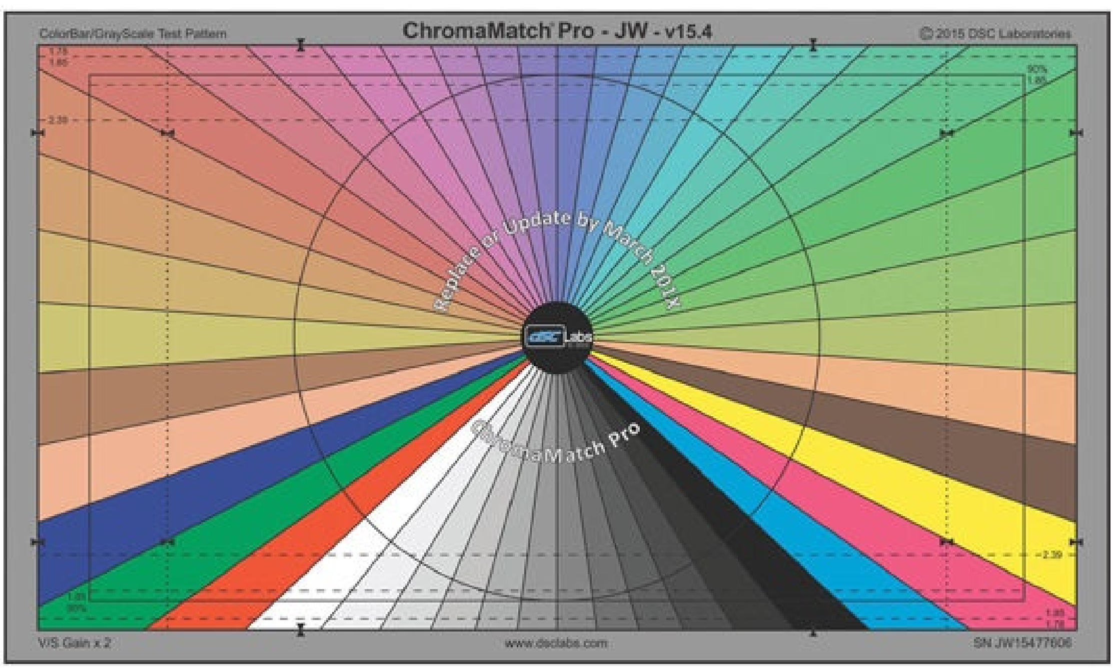


Figure 8.29. The DSC Labs *ChromaMatch* is a new concept in color management. It is photographed on set, then when displayed on the monitor precise adjustments can be made either visually or by using the vectorscope or waveform. As visual reference, it can be used with the *ScreenAUgn*—Figure 8.30.

Figure 8.30. With the image of either the *ChromaMatch* or a calibrated digital file available from DSC, the *ScreenAlign* is placed in front of the monitor and a visual comparison and corrections can be made. The digital file provides a known and precise reference standard. Digital files are also available to calibrate a smartphone or iPad—important as many directors now view the dailies on portable digital devices.

MEASURING IMAGE RESOLUTION

Testing resolution/sharpness is done with test targets that have progressively smaller detail—the point at which the viewer can no longer see the fine details is the limit of resolution. Resolution units can be tied to physical sizes (e.g. lines per mm, lines per inch), or to the overall size of a picture (lines per picture height).

A resolution of ten *lines per millimeter* means five dark lines alternating with five light lines, or five *line pairs* (*LP*) per millimeter (*5 LP/mm*). Lens and film resolution are most often quoted in line pairs per millimeter; some charts are measured in *lines per picture height* (*LPPH*). Some tests are expressed in *lines*, while some are in *line pairs*. Moreover, the results might also be in lines per picture height rather than lines per millimeter. Figure 8.32 shows the AbelCine test chart.

AbelCine has this advice about using their chart: “When the lens is optimally focused, you will see high contrast in low to medium spatial frequencies (i.e. where there are larger features in the image), maximum detail in higher frequencies (i.e. in finer features), as well as minimum chromatic artifacts (i.e. false color). All of these aspects can be observed individually on the chart. Start by looking at the patterns representing lower frequencies (exactly which patterns will depend on the resolution of the camera and lens, as well as the size of the pattern relative to the frame).

“As you rotate the focus barrel on the lens, the coarser patterns will increase in sharpness and contrast. You may see a slight shift in color when you pass the point of maximum focus. To achieve fine focus, you may need to engage the image zoom function of your camera and/or monitor. Slowly change the focus on the lens while looking at the finest pattern that shows any detail, and find the point that exhibits maximum sharpness in the finest visible pattern.” The circle with colors is used for testing *chromatic aberration*—if there is *color fringing* on the edges of these patches, then the lens suffers from chromatic aberration, meaning not all wavelengths are focused to precisely the same plane of focus.

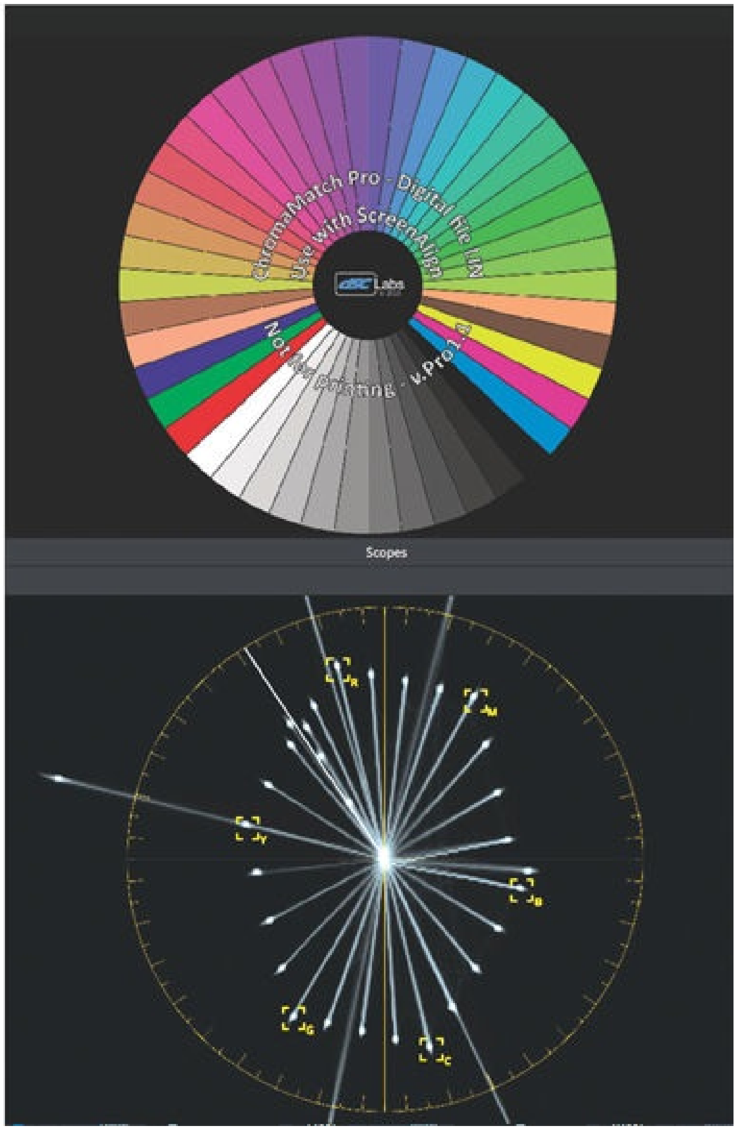


Figure 8.31. The *ChromaMatch* digital file on the vectorscope in Blackmagic Design's *DaVinci Resolve*. The primary and secondary colors fall precisely into their boxes on the vectorscope display when set to 2X (times two). Note that some colors fall outside the normal range, this is because they are the six high saturation colors used for Rec. 2020—the Ultra High-def color standard.

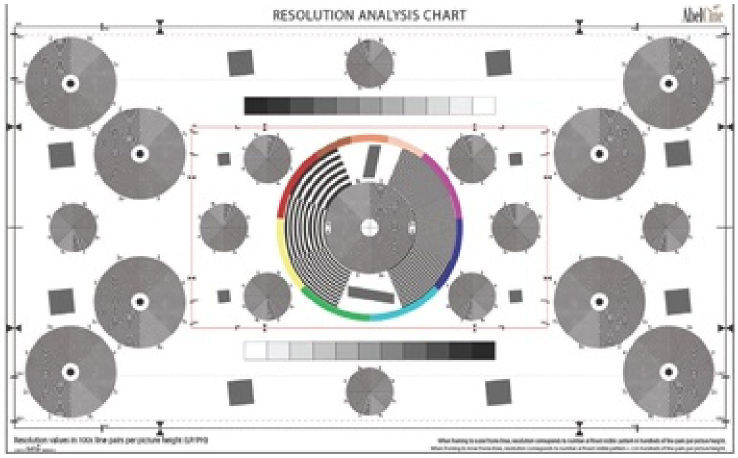


Figure 8.32. A resolution test chart “by AbelCine. (Courtesy AbelCine).

Figure 9.1. The basic elements of exposure—a light, a light meter, and a person to interpret what the light meter says.

exposure

EXPOSURE THEORY

Frankly, exposure can get pretty technical, so it's important to grasp the basic concepts first before we plunge into the world of exposure control for technical and artistic purposes. Let's take a look at exposure the simple way just to ease into it. As a camera person or DIT, you may think you completely understand exposure (and you may well do), but it is also very possible that there's a lot more to it than you may have thought.

This introduction is a bit simplified, but it will provide a working understanding of exposure that is useful without being too technical. First of all, there is one notion that has to be put away right now: some people think of exposure as nothing more than "it's too dark" or "it's too light"—that's only part of the story. There are many other important aspects of exposure that are vitally important to understand.

WHAT DO WE WANT EXPOSURE TO DO FOR US?

What is it we want from exposure? More precisely, what is "good" exposure and what is "bad" exposure? Let's take a typical scene, an average one. It will have something in the frame that is very dark, almost completely black. It will also have something that is almost completely white, maybe a white lace tablecloth with sun falling on it. In between, it will have the whole range of dark to light values— the middle tones, some very dark tones, some very light tones.

From a technical viewpoint, we want it to be reproduced exactly as it appeared in real life—with the black areas being reproduced as black in the finished product, the white areas reproduced as white, and the middle tones reproduced as middle tones. This is the dream.

Now, of course, there will be times when you want to deliberately under or overexpose for artistic purposes, and that is fine. In this discussion, we are only talking about theoretically ideal exposure, but that is what we are trying to do in the vast majority of cases anyway. So how do we do that? How do we exactly reproduce the scene in front of us? Let's look at the factors involved. Figure 9.2 shows film negative underexposed, overexposed, and at normal exposure.

THE BUCKET

Let's talk about the recording medium itself. In film shooting it is the raw film stock; in video, it is the sensor chip, which takes the light that falls on it and converts it to electronic signals. For our purposes here, they are both the same: exposure principles apply equally to both film and video, with some exceptions. They both do the same job: recording and storing an image that is formed by patterns of light and shadow that are focused on them by the lens. In this context, we'll only mention film exposure when it serves the purpose of illustrating a point or highlighting an aspect of general exposure theory.

Think of the sensor/recording medium as a bucket that needs to be filled with water. It can hold exactly a certain amount of water, no more, no less. If you don't put in enough water, it's not filled up (underexposure). Too much and water slops over the sides and creates a mess (overexposure). What we want to do is give that bucket the exact right amount of water, not too much, not too little—that is ideal exposure. So how do we control how much light reaches the sensor? Again, in this regard, video camera sensors are no different from film emulsion.

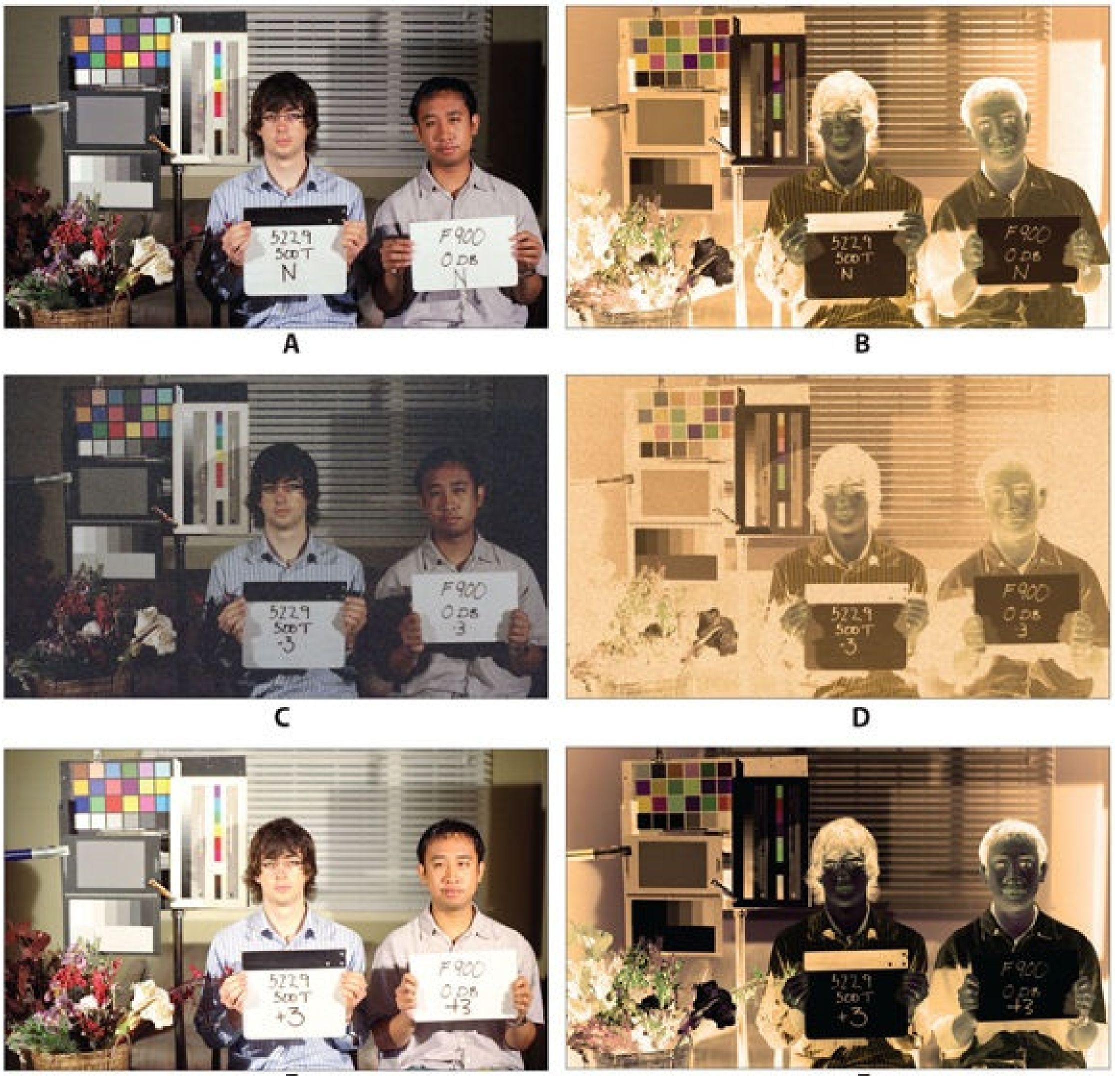


Figure 9.2. Exposure on film. (A) is normal exposure—good contrast, a full range of tones, and minimal grain. (B) is the negative of the normal exposure. Notice that it also has a full range of tones from near total black (which will print as white) to almost clear negative (which will print as black). (C) is a severely underexposed frame—three stops under. It's dark but also very grainy and doesn't nave a full range of tones, hardly anything above middle grays. (D) is the negative of the badly underexposed shot; it's what we calfa "thin" negative. (E) is three stops overexposed and (F) is the negative of this shot, it's what is called a "thick" negative, difficult to get a good print from.

CONTROLLING EXPOSURE

We have several ways of regulating how much light reaches the film/sensor. The first is the iris or aperture, which is nothing more than a light control valve inside the lens. Obviously, when the iris is closed down to a smaller opening, it lets less light through than when it is opened up to a larger opening. How open or closed the iris is set for is measured in f/stops (we'll talk about that in more detail later).

Remember, the film or sensor wants only so much light, no more no less (they're kind of dumb that way). If our scene, in reality, is in the bright sun, we can close down the iris to a small opening to let less of that light through. If our scene is dark, we can open up the iris to a wider opening to let in all the light we can get —but sometimes this will not be enough. There are other things that control how much light reaches the image plane, which we'll talk about.

Table 9.1. Typical light levels in various situations. Clearly, there is an enormous range.

LUX	LIGHTING
100,000 +	Direct sunlight
10,000+	Indirect sun
1,0000	Overcast sky
500	Clear sunrise
200–500	Office lighting
80	Hallway
10	Twilight
5	Streetlights
1	Candle at 1 m
1	Deep twilight

CHANGE THE BUCKET

There is another, more basic way to change the exposure: use a different bucket. Every video sensor has a certain sensitivity to light; it's part of their design. This means that some are more sensitive to light, and some are less sensitive. It is rated in *ISO* which stands for *International Standards Organization*. It was previously called *ASA* for *American Standards Organization*. Although the acronym ISO has many other uses (because the organization publishes standards for all sorts of things), in the world of cinematography it signifies a "rating" of the sensitivity of the camera/sensor; the two must be thought of as a unit because some aspects of ISO are actually handled in the *Digital Signal Processor* and elsewhere in the camera circuitry, not just exclusively in the sensor. In some cases, the term EI (Exposure Index) is used to indicate the sensitivity of the recording medium. The difference is that while ISO is derived from a specific formula, EI is a suggested rating based on what the manufacturer believes will give the best results.

A sensor with a low sensitivity needs lots of light to fill it up and make a “good” image. A high-speed film is like using a smaller bucket—you don’t need as much to fill it up. A low-speed sensor is like a larger bucket—it takes more to fill it up, but on the other hand we have more water. In the case of film and video images “having more water” in this analogy means that we have more picture information, which in the end results in a better image. As we’ll see later on, this is one important difference between how film and HD cameras work and how most cameras that shoot RAW work.

Art Adams puts it this way: “Speed in a sensor is similar to speed in film: it’s about how far down the noise floor/base fog level you push things. Natively all [digital] sensors seem to be roughly the same ISO (this used to be 160, but now it appears to be 320), but what separates the adults from the kids is how well they handle noise. The farther down the noise floor, the more dynamic range a sensor will have. It all comes down to what has been done on the sensor, and in internal processing, to eliminate noise from the signal.

“One aspect of speed relates to how big the photo sites are on the sensor. Bigger ones take less time to fill and are more sensitive; smaller ones take longer to fill and are less sensitive. In this way your water analogy works well.”

THE ELEMENTS OF EXPOSURE

So we have several elements to contend with in exposure:

- The amount of light falling on the scene. Also, the reflectance of things within the scene.
- Aperture (iris): a light valve that lets in more or less light.
- Shutter speed: the longer the shutter is open, the more light reaches the film or sensor. Frame rate also affects shutter speed.
- Shutter angle: the narrower the angle, the less light reaches the sensor.
- ISO (sensitivity). Using a higher ISO film is an easy fix for insufficient exposure, but it involves the penalty of more video noise and an image that is not as good.
- Neutral Density (ND) filters can reduce the light when it is too much for the aperture and other methods to deal with.

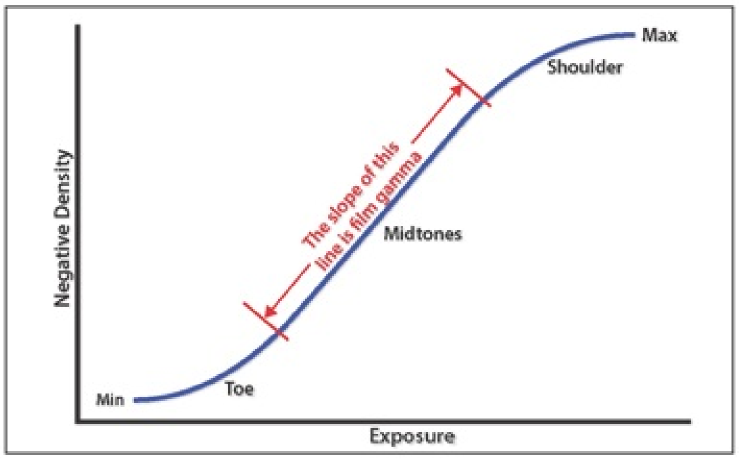


Figure 9.3. The *Hurter and Driffield (H&D*) characteristic curve shows the exposure response of a generic type of film—the classic S-curve. The *toe* is the *shadow* areas; the *shoulder* is the *highlights* of the scene. The *straightline (linear*) portion of the curve represents the *midtones*. The slope of the linear portion describes the *gamma* (contrastiness) of the film—it is different in video. As we'll see later, although the output of video sensors tends to be linear (not an S-curve like this) it is quite common to add an S-curve to video at some point.

LIGHT

Intensity of light is measured in *foot-candles* (in the United States) or in *lux* in metric (SI) countries. A foot-candle *(fc*) equals 10.76 lux. A foot-candle is the light from a standard candle at a distance of one foot (it's like the standard horse in horsepower). One lux is the illumination produced by one standard candle at 1 meter. A sensor exposed to a standard candle 1 meter away, receives 1 lux of exposure. Table 9.1 shows some typical lighting levels for common situations. These are just general averages, of course, individual situations may vary greatly, especially when it comes to interiors. Some typical points of reference include:

- Sunlight on an average day ranges from 3,175 to 10,000 fc (32,000 to 100,000+ lux).
- A bright office has about 40 fc or 400 lux of illumination.
- Moonlight (full moon) is about 1 lux (roughly a tenth of a foot-candle).

As you can see from Table 9.1, the brightness range between the darkest situations humans encounter and the brightest situations is over 100,000 to 1—a fairly amazing range for the eye.

F/STOPS

Most lenses have a means of controlling the amount of light they pass through to the film or video sensor; this is called the aperture or iris and its setting is measured in f/stops. The f/stop is the mathematical relationship of overall size of the lens to the size of the aperture.

Stop is a short term for f/stop. On a lens the f/stop is the ratio of the focal length of the lens to the diameter of the entrance pupil. This works out to each f/stop being greater than the previous by the square root of 2. Opening up one stop means twice as much light is passing through the iris. Closing down one stop means that 1/2 as much light is going through.

To be exact, the entrance pupil is not the same thing as the size of the front element of the lens but they are related. An f/stop is derived from the simple formula:

f = F/D which translates to:
f/stop = Focal length/Diameter of entrance pupil

F/stops are frequently used in lighting as well; they don't only apply to lenses. In lighting, the fundamental concept is that one stop more equals *double* the amount of light and one stop less, means *half* the amount of light. If the brightest point in the scene has 128 times more luminance than the darkest point (seven stops), then we say it has a seven stop scene brightness ratio. We'll see that this plays an important role in understanding the dynamic range of a camera or recording method.

You will sometimes hear the related term *T/stop* (Transmission stop). It's the same idea but derived in a different manner. F/stop is determined by the simple calculation shown above. The drawback is that some lenses transmit less light than the formula indicates. A T/stop is determined by actually measuring the transmission of the lens on an optical bench. T/stops are especially useful for lenses that transmit less light due to their design, such as zoom lenses which may have a dozen or more glass elements. Most lenses these days are marked only in T/stops; some older lenses had both markings.

SHUTTER SPEED/FRAME RATE/SHUTTER ANGLE

These three work together in determining exposure. Film cameras (and a few video cameras) have rotating shutters that either allow light to reach the recording medium or close off the light. Frame rate or frames per second (FPS) applies to both film and video. Obviously, if the camera is running at a very low frame rate (such as 4 FPS), each frame will get more exposure time. At a higher frame rate, such as 100 FPS, each frame will be exposed to light for a much shorter time. When a camera has a physical shutter, as all film cameras and only a few video cameras do, the shutter angle may be 180° (open half the time, closed half the time) or may have a variable shutter angle. In conjunction with frame rate, this also affects *shutter speed*.

THE RESPONSE CURVE

In the 1890s, Ferdinand Hurter and Vero Driffield invented a way to measure how exposure affected a film negative. The H&D diagram is still used today. Figure 9.3 shows a typical H&D response curve for film negative. The X-axis indicates increasing exposure. The Y-axis is increasing negative density, which we can think of as brightness of the image—more exposure means a brighter image. To the left on the X-axis is the darker parts of the scene, commonly called the shadows. On the diagram, it is called the toe. To the right on the X-axis are the brighter parts of the scene—the highlights, called the shoulder on the diagram. In video, this area is called the knee. The middle part, which is linear, represents *midtones*.

UNDEREXPOSURE

Figure 9.4 shows underexposure. All of the original scene brightness values are pushed to the left. This means that highlights in the scene are recorded as just light or medium tones. The shadows are pushed down to where there is no detail or separation recorded because the response curve at that point is essentially flat—decreases in exposure at this point result in little or no change in the image brightness—the detail and separation are completely lost.

OVEREXPOSURE

Figure 9.5 shows overexposure—the scene brightness values are pushed to the right. Dark areas of the scene are recorded as grays instead of variations of black. On the right, the scene highlights have no separation or detail—they are on the flat part of the curve; increases in exposure in the flat part of the curve don’t result in any change in the image: again all detail and separation are lost.

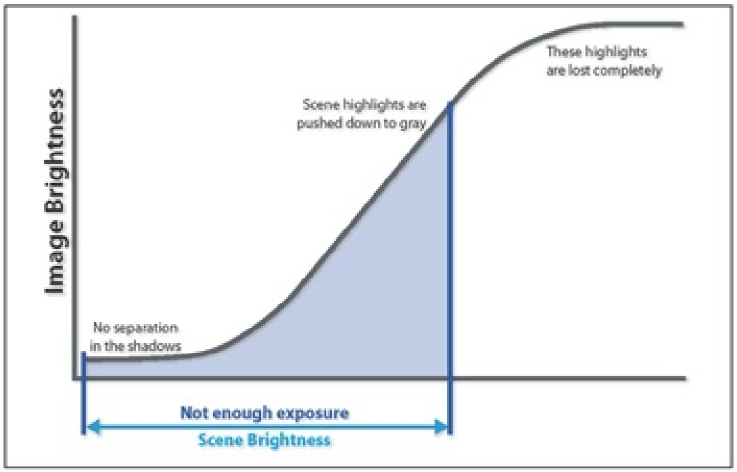


Figure 9.4 Although the shape of the curve might be different for video, the basic principles remain the same as film, shown here. Underexposure pushes everything to the left of the curve, so the highlights of the scene only get as high as the middle gray part of the curve, while the dark areas of the scene are pushed left into the part of the curve that is flat. This means that they will be lost in darkness without separation and detail.

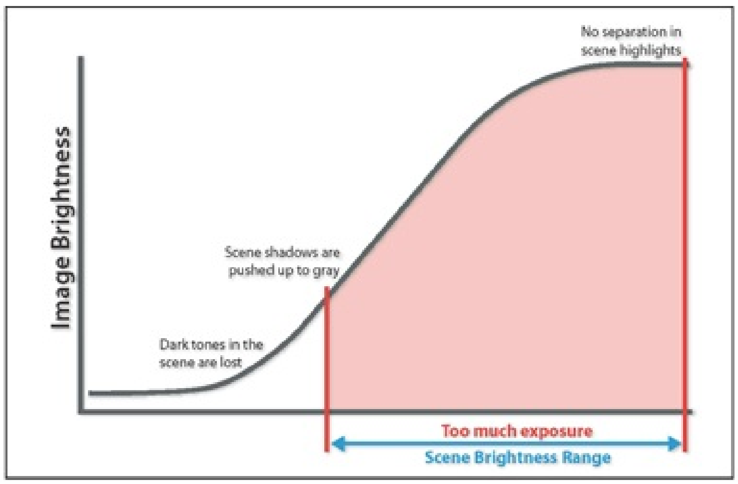


Figure 9.5. With overexposure, the scene values are pushed to the right, which means that the darkest parts of the scene are rendered as washed out grays.

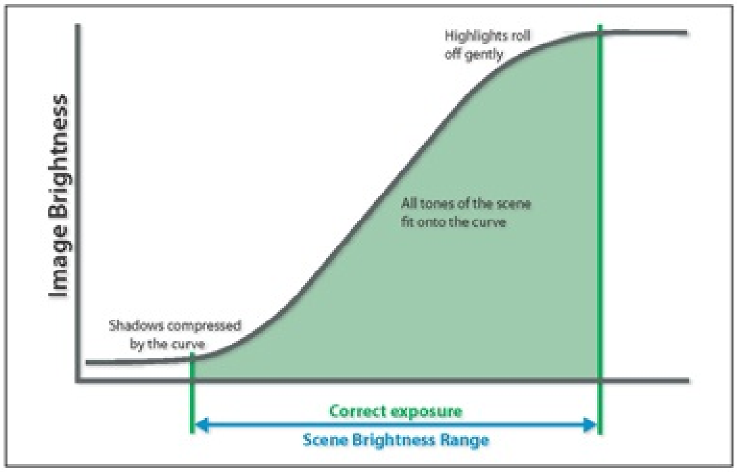


Figure 9.6. Correct exposure fits all of the scene brightness values nicely onto the curve. As we'll see later in this chapter, the visual representation here is very similar to what we see in a histogram.

CORRECT EXPOSURE

Looking at Figure 9.6 we see how theoretically correct exposure places all of the scene values so that they fit nicely on the curve: highlights go up to just where the curve flattens and scene shadows only go down to where they are still recorded as slight variations in image brightness.

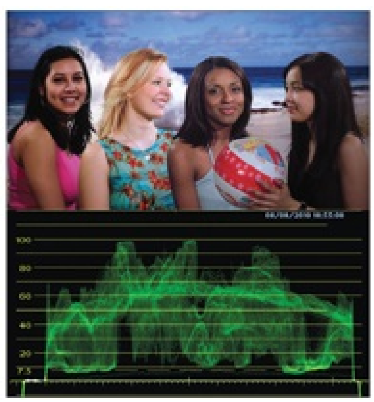


Figure 9.7. A properly exposed frame of the DSC Labs *Cambelles* and its representation on the waveform monitor. Notice how there is a full range of tones from very dark to almost pure white. The two patches of surf beside the blonde model's head are very close to 100% (pure white) on the waveform.

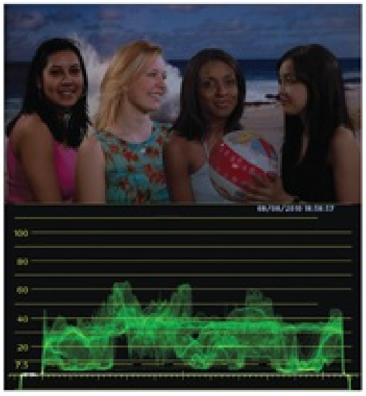


Figure 9.8. The shot is badly underexposed: very little of the frame even reaches middle gray, and the tones of the scene are crushed together at the bottom.

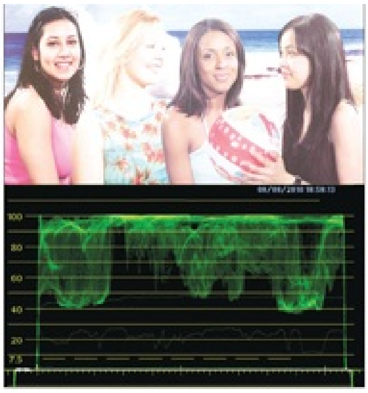


Figure 9.9. This frame is badly overexposed: there are no real blacks or dark areas at all (the darkest tone in the scene only gets down to 40% on the waveform), but worse, all the light tones are clipped at the top. They reach 100% and then flatline—there is no information at all, just blank white, blown out. Clipping cannot be fixed in post!

HIGHER BRIGHTNESS RANGE IN THE SCENE

The problem is more difficult if we consider a scene that has more stops of brightness than the sensor or film can accommodate. Here there is no aperture setting that will place all of the values on the useful part of the curve. If we expose for the shadows (open up the aperture), we get good rendition of the dark gray and black areas, but the brighter scene values are hopelessly off the scale. If we "expose for highlights" (by closing down to a smaller f/stop), we record all the variations of the light tones, but the dark values are pushed completely off the bottom edge and don't record at all; there is no information on the negative, no detail to be pulled out.

TWO TYPES OF EXPOSURE

There are two ways to think about exposure: overall exposure and balance within the frame. So far we've been talking about overall exposure of the entire frame; this is what you can control with the iris, shutter speed, and some other tools, such as neutral density filters, which reduce the total amount of light.

You also have to think about balance of exposure within the frame. If you have a scene that has something very bright in the frame and also something that is very dark in the frame, you may be able to expose the whole frame properly for one or the other of them, but not both. This is not something you can fix with the iris, aperture, changing ISO, or anything else with the camera or lens. This is a problem that can only be fixed with lighting and grip equipment; in other words, you have to change the scene. Another way to deal with it in exterior shooting is to shoot at a different time of day, change the angle or move the scene to another place, such as into the shadow of a building. For more on lighting, see *Motion Picture and Video Lighting* by the same author as this book.

HOW FILM AND VIDEO ARE DIFFERENT

There is one crucial way in which film and video are different. With older HD cameras (which had the look "baked in"), it was absolutely critical that you not overexpose the image. This is not as critical with negative film. Film stock is fairly tolerant of overexposure and doesn't do as well with underexposure; HD, on the other hand, is very good with underexposure, but remember, you will always get a better picture with exposure that is right on the money: this is the crucial thing to remember about exposure.

We should note, however, that what we said about film applies only to *negative film* (which is what we almost always shoot on commercials, music videos, features, and shorts when shooting on film).

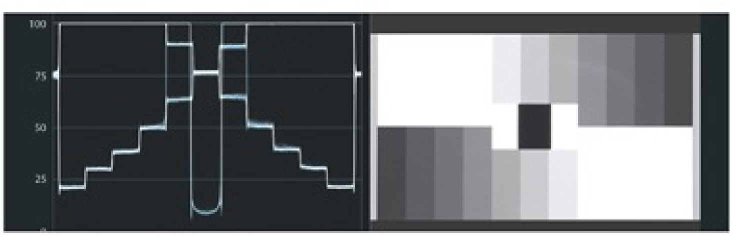


Figure 9.10. This very overexposed 11 step grayscale shows *clipping* in the lighter steps and the darkest

steps are more light gray than they should be. These grayscales and the waveform traces that represent them would apply equally to footage shot on digital and footage shot on film that has been transferred to digital.

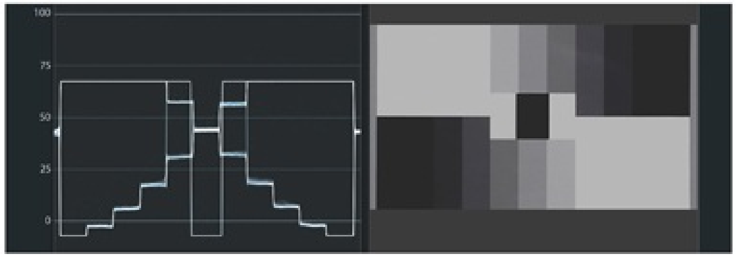


Figure 9.11. Here an attempt has been made to “save” this shot by reducing brightness in postproduction. It does nothing to bring back any separation to the clipped steps and reduces the dark steps till they just mush together. Only middle gray is where it should be and that is only because we placed it there in post.

Figure 9.12. A severely underexposed frame of the grayscale. Not only are the highlights just mushy gray but the darker tones are crushed—there is much less separation in the steps. The lowest steps are also deeply into video noise.

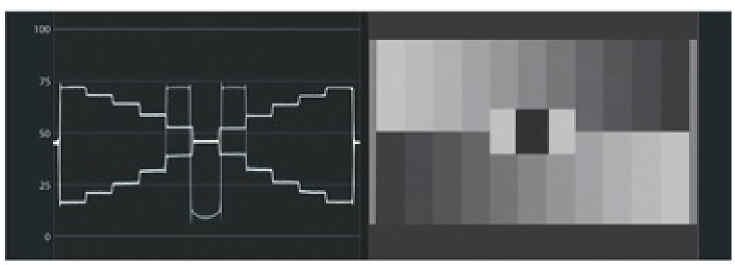


Figure 9.13. Trying to “save” this shot by bringing middle gray back up does nothing to bring the separation between the steps; it only serves to make the darkest steps muddy gray, and, of course, the video noise will still be there.

There is another type of film called *reversal film* (also known as transparency or positive film). This is just like slides or transparencies in still film: the same film that ran through the camera comes back from the lab with correct colors, not reversed like negative film. Traditional HD cameras were often compared to reversal film in that they are both extremely intolerant of overexposure.

WE'LL FIX IT IN POST

One thing you will hear sometimes on a set is "don't worry, we'll fix it in post." There is nothing wrong with making an image *better* in postproduction: there are many incredible tools you can use to improve the look of your footage. What you don't want to do is take the attitude that you can be sloppy and careless on the set because "everything can be fixed in post." It's simply not true. When it comes to exposure, fixing it in post generally means scrambling to come up with an image that is merely acceptable (Figures 9.10 through 9.13). Improving and fine-tuning an image, ensuring consistency of exposure and color, and going for a specific "look" in post has always been an important part of the process. It always has been. However, this is not to be confused with "fixing" a mistake, which almost never results in a better image.

THE BOTTOM LINE

Here's the key point: exposure is about much more than just it's "too dark" or "too light." Exposure affects many things: it's also about whether or not an image will be noisy, it's about the overall contrast of the image, and it's about whether or not we will see detail and subtleties in the shadows and in the highlights. It's also about color saturation and contrast. Overexposure and underexposure will desaturate the color of the scene; this is particularly important in greenscreen and bluescreen shooting. In these situations, we want the background to be as green (or blue) as possible, in order to get a good matte. We'll talk about chroma key in *Technical Issues*.

The bottom line is this: you will get the best image possible only when your exposure is correct. This is true of still photos on film, motion picture film, digital photography, and, of course, video.

EXPOSURE IN SHOOTING RAW VIDEO

Some people make the mistake of thinking that just because you're shooting RAW video that exposure isn't critical—"It's all captured in RAW so anything can be fixed later." This is a myth of course; you can still screw up the image with bad exposure just as you can with any other type of image acquisition. Underexposure can result in a noisy image and overexposure can cause clipping. Clipped highlights cannot be fixed. There is no magic software, no cute little button you click in post, that will bring detail back into the highlights—clipping means that there is just no information there at all, nothing to recover.

There is a difference between "appearing" to be clipped and actual clipping. Sometimes when RAW footage is subjected to a quick down-and-dirty conversion to Rec.709, for example, some of the highlights may appear to be burned out and clipped. However, when you look at them on the waveform monitor they are very close to the maximum but there is still something there—these are highlights that can probably be recovered with proper treatment in color correction software. This is why the waveform monitor is so important: viewing footage on a less than stellar monitor or even seeing them under unfavorable viewing conditions can be misleading.

VIDEO EXPOSURE

The same principles of exposure apply to video; the same ideas of the curve, toe, and shoulder, also apply, although in video the highlights are called the knee and the darkest parts of the scene (called toe in film) are simply referred to as shadow areas.

Figures 9.10 through 9.13 illustrate test shots of an 11 step grayscale. In the overexposed frame (Figure 9.10) the highlights are clipped—no information there; just burned out white. Notice that in the underexposed frame (Figure 9.12) all the tones are crushed together. Simply making it brighter in post will not restore a full range of tones. The result will be dull and flat with video noise. Figures 9.11 and 9.13 show the fallacy of the attitude that "We'll fix it in post." Some things can't be fixed in post, they can only be made less bad. Figures 9.7, 9.8, and 9.9 show the *Cambelles*, standardized test subjects made by DSC Labs. They illustrate the same principle: proper exposure gives you a full range of tones from black to white, and the tones are rendered as they appeared in the scene. This is the constant balancing act of exposure: to get the middle tones right without losing the dark tones to underexposure or the light tones to clipping.

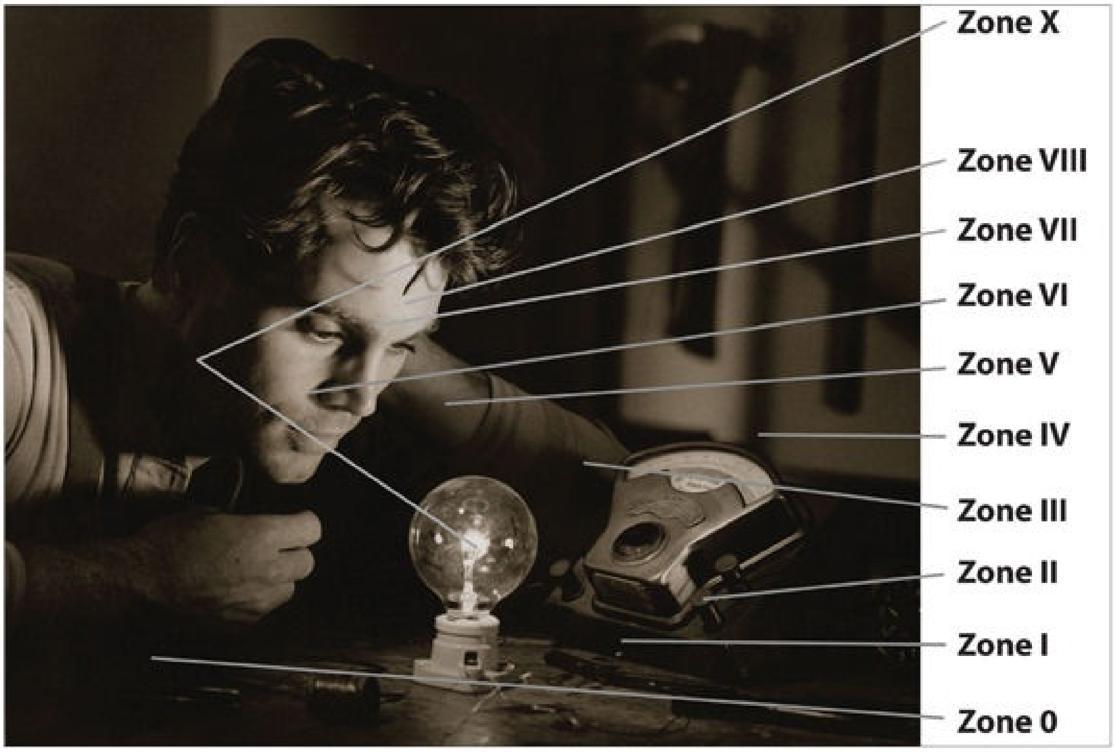


Figure 9.14. Ansel Adams' *Zone System* makes discussions of various tones in the scene and in exposure much easier and far more accurate.

THE TOOLS OF EXPOSURE

When shooting film (as different from video), the two most basic tools of the cinematographer's trade are the incident meter and the spot meter. There is a third type of meter, the wide-angle reflectance meter, but it has extremely limited use in film; it is a holdover from the days of still photography. This type of meter gave you a general reading of the average reflectance of the entire scene but little else. It only read the light as it was being reflected off the scene and one had to be very careful in how you pointed it.

THE INCIDENT METER

The incident meter does not always work as it should with traditional HD cameras. If you haven't made any changes to the image with camera controls, then an incident reading will be pretty much accurate, but if you have changed any of those settings it will not be. This is not as much of a problem with cameras that shoot RAW and record log-encoded video, as discussed in the next chapter. The incident meter measures scene illumination only—in other words: the amount of light falling on scene. To accomplish this purpose, most incident meters use a hemispherical white plastic dome that covers the actual sensing cell (Figures 9.15 and 9.33).

The diffusing dome accomplishes several purposes. It diffuses and hence "averages" the light that is falling on it. Unshielded, the dome will read all of the front lights and even some of the side-back and back light that might be falling on the subject. Many people use their hand to shield the back light off the reading and use a combination of hand shielding and turning the meter to read the backlight and usually the key, fill, side lights, and back lights separately. The classical practice, however, is to point the hemisphere directly at the lens and eliminate only the backlights, then take a reading exactly at the subject position. Reading key, fill, and backlight separately is in fact only a way of determining the ratios and looking for out-of-balance sources. In most instances, reading the key light is what determines the exposure—how the lens aperture will be set. The key light, crudely put, is the main light on the subject, whether it's an actor or a can of dog food. Later we will look at applications that go beyond the simple classical approach and are useful in dealing with unusual situations. Most meters that are used with the diffusing dome also come with a flat diffusing plate that has a much smaller acceptance angle (about 45° to 55°). This means that the angle of the light falling on the plate has an effect on the reading, just as it does in illuminating a subject.

Figure 9.15. A *Sekonic DualMaster* light meter. It is a combination of both an *incident meter* and a *spot meter*. It can read both continuous light and strobes.

Figure 9.16. A close-up of the readout for the Sekonic meter. In the upper right is the ISO (320 in this case). On the left is the frame rate—24 frames per second (24 f/s). Middle right is the reading: f/4. The smaller numbers are 1/10 of a stop, in this case, 2/10th, which you would probably round off to 1/3 of stop, for a lens setting of f/4 and 1/3rd. At the bottom is a graphic indicator of the f/stop. This meter can take several readings and average them if you wish.

The flat plate makes taking readings for individual lights simpler and is also useful for measuring illumination on flat surfaces, such as in art copy work. Incident meters are sometimes also supplied with a lenticular glass plate that converts them to wide acceptance reflectance meters, which can read the reflected light of an entire scene. Lenticular is like glass beads. These see little use on most sets as they have very wide acceptance angles and it is difficult to exclude extraneous sources. For the most part, incident meters are set for the film speed and shutter speed being used and then display the reading directly in f/numbers.

THE REFLECTANCE METER

Reflectance meters (most frequently called spot meters) read the luminance of the subject, which is itself an integration of two factors: the light level falling on the scene and the reflectivity of the subject. It is why they are called reflectance meters (Figure 9.32).

On the face of it, this would seem to be the most logical method of reading the scene, but there is a catch. Simply put, a spot meter will tell us how much light a subject is reflecting, but this leaves one very big unanswered question: how much light do you want it to reflect? In other words, incident meters provide absolute readouts (f/stops), while spot meters give relative readouts that require interpretation.

Think of it this way: you are using such a meter and photographing a very fair-skinned woman holding a box of detergent in front of a sunset. You read the woman's face: f/5.6, the box reads f/4, the sky is f/22. So where are you? Not only do we not know where to set the aperture, we don't even know if the situation is good or bad. Using a spot meter to set exposure requires a high-level understanding of exposure theory. In most cases, spot meters are actually used to check potential problem areas of a scene such as a lampshade or a window which might "blow out" and clip if they're too hot.

A DIFFERENT WORLD OF EXPOSURE

With cameras that shoot RAW, the procedure used by many DPs has changed over time, as we'll talk about in the section *Strategies of Exposure* later in this chapter. Adjusting the aperture is the most commonly used way of adjusting exposure, but not the only way. *Neutral density* filters, frame rate, shutter angle (if it's adjustable), and changing the ISO or gain can all be used to make adjustments, but of course, the key element is often adjusting the lighting of the scene.

You can adjust the scene brightness values by adding or subtracting lights, dimmers, nets, flags, scrims, overheads, or other grip equipment. There are many options available even when shooting day exterior. You might also deal with exposure problems by changing the frame to exclude the offending objects. Don't underestimate the power of persuasion in convincing the director to change the camera angle or the background to achieve better lighting results. Of course, choice of location and time of day to shoot are powerful factors in the lighting of a scene. See the chapter *Lighting Basics* here and the book *Motion Picture and Video Lighting* by the same author for more information on specific lighting techniques.

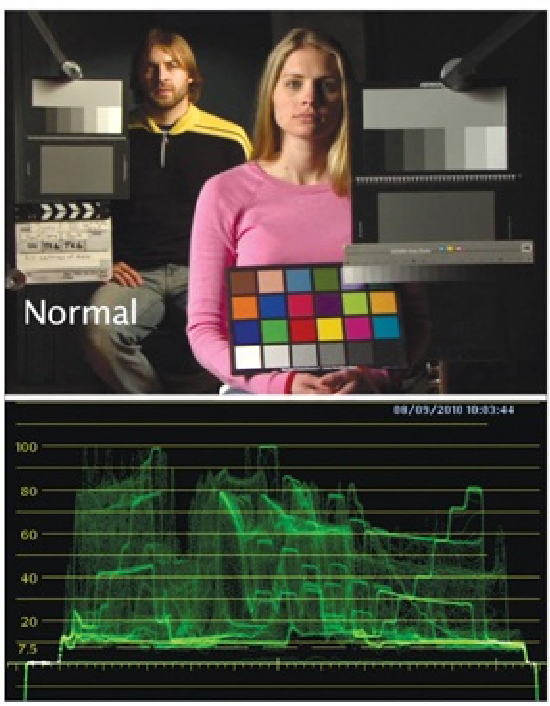


Figure 9.17. Normal exposure on an HD camera. Notice the proper skin tones, the correct color saturation

in the chart, and how all segments are shown on the gray scale. These images are from a latitude test on an HD camera.

Figure 9.18. At just two stops overexposed, the skin tone is blown out, the color saturation is severely reduced and there is no *separation* visible in the lighter tones on the gray scale. *Clipping of the highlights* appears on the waveform monitor as a flatline at the top of the signal. This is at only plus two stops of exposure and already it has exceeded the *latitude (dynamic range*) of the HD camera. This is an older camera; more current cameras have substantially more dynamic range.

SETTING EXPOSURE WITH THE WAVEFORM MONITOR

As we saw in the chapter *Measurement*, the waveform monitor is a very precise tool for judging exposure values. It may be built into the camera or monitor or may be a freestanding unit. With HD cameras, the DP would look at the waveform and set whatever values they felt were important. *Measurement* contains most of what you need to know about the waveform monitor, in this chapter we'll deal more with their specific use in judging the scene, setting exposure, and the general theory of exposure control. With the waveform monitor, the real trick is having some references you can use. You need to pick something in the scene that you know where you want them to fall on the waveform monitor. First, let's get some background information.

F/STOPS ON THE WAVEFORM

It would be nice if a one stop change in exposure resulted in a uniform, predictable change on the waveform monitor. Unfortunately, it doesn't quite work that way. If you are shooting straight Rec.709 with no gamma or other adjustments, a one stop change in exposure will be approximately a 15% change on the waveform. This really only applies in the middle part of the curve but it's a general rule of thumb to use as a starting point. In the highlights and shadows, there will be less of a change on the waveform. Digital consultant Adam Wilt puts it this way—"If you are shooting with a wider dynamic range, and monitoring that signal without a viewing LUT or other output conversion, then the stop variation will depend on the camera, and possibly where on the brightness scale the signal is. For example, on Alexa, or a Sony's Hypergamma, the brighter your signal is, the less of a change you'll see on the WFM with a 1-stop change. With the Blackmagic Cine Camera in "film mode," on the other hand, you will see something like 10% change at low levels, and about a 13% change at brighter levels."

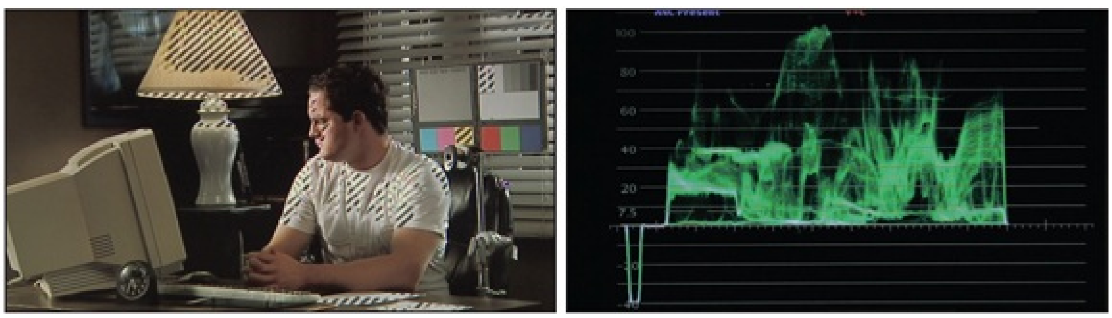


Figure 9.19. Normal exposure with the zebras in the viewfinder (70% and 100% in this example) and shown on the waveform monitor.

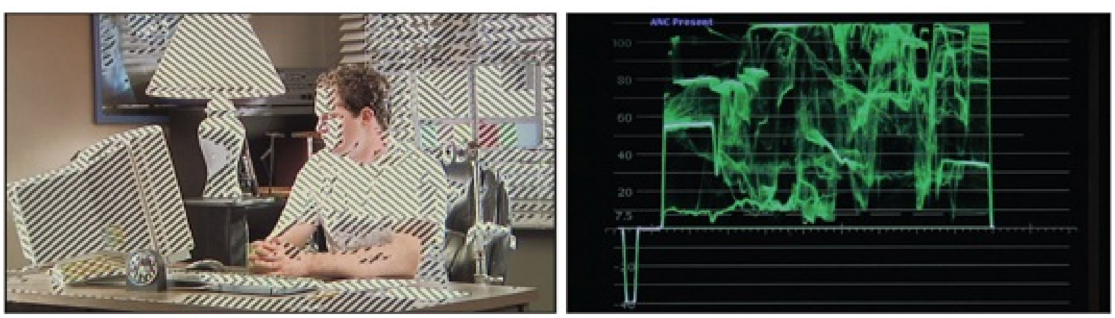


Figure 9.20. The same scene very overexposed with zebras and the waveform. On this Sony camera, the two types of zebras are shown as opposite diagonal angles.

THE 18% SOLUTION

A widely used reference value is middle gray (18% reflectance). If you're using a gray card or a DSC chart, you will have something that you know for certain is 18% middle gray. That's the simplest case, so let's deal with that situation for now. Your first instinct might be to place 18% gray at 50 IRE—half way between black and white. After all, it is middle gray.

Unfortunately, it's a bit more complicated than that. There are a couple of factors involved. The main one is that in many cases, you will be feeding a log-encoded image to the waveform monitor, which we'll talk about in detail in the next chapter. Log encoding changes the signal by lowering the highlights, at least temporarily during recording; they are brought back up in grading. Inevitably this has some effect on the midtones as well, meaning that middle gray is not going to be the same on the set as it will after it is altered by log encoding, Hypergamma, a LUT, or other manipulation. Of course, you may be using viewing LUTs on the set, as well for the DP and director viewing monitors. Whether this LUT is being applied to the signal going to the waveform is another matter—obviously it is critical that you know if it is or not. You will always need to be aware if the signal is log, Rec.709, has a modifying LUT or gamma curve applied to it, and so on, as these affect how it appears on the waveform monitor. Fortunately, camera companies publish the data for where 18% gray should fall on the waveform, see Figure 10.25 in *Linear, Gamma, Log*. Interestingly, none of these ever come out to be 50 IRE, the logical, expected place for it to fall on the waveform monitor and we'll talk about why that is later.

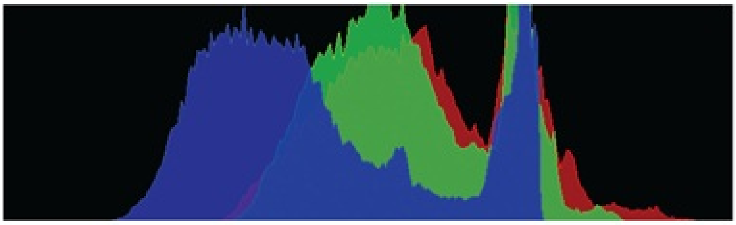


Figure 9.21. Histograms can be a very useful tool for judging exposure. The top figure shows a fairly normal distribution of highlights, midtones, and shadows.

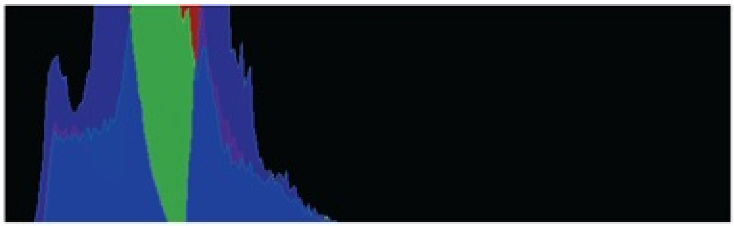


Figure 9.22. An underexposed shot—all tones are pushed to the far left.

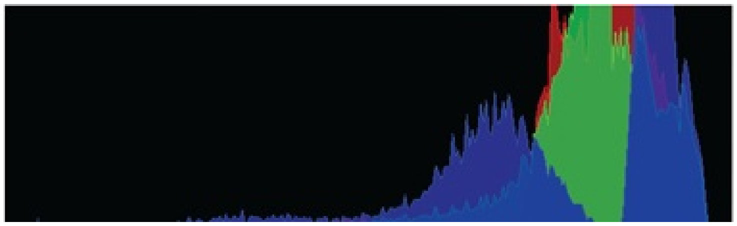


Figure 9.23. An overexposed shot, with all tones pushed far to the right.

EXPOSURE INDICATORS IN THE CAMERA

Digital camera manufacturers have provided a number of useful exposure guides that are built into the camera and visible in the viewfinder.

ZEBRAS

In the viewfinder or appearing on the camera operator's monitor, zebras have long been a useful tool for judging exposure. Unlike histograms or goal posts, they show you specifically within the frame where there is overexposure or exposure at the specific level you are looking for, such as skin tone.

Zebras indicate a particular IRE level in the scene; however, they are useless unless you know what IRE level the zebras are set to indicate. Aside from being useful in judging specific tones for exposure, zebras excel at indicating overexposed areas. Professional cameras offer the choice of selecting what IRE level you want to set the zebras for and generally have two sets of zebras which can be used in a variety of ways. A fairly common use is to target one set of zebras for midtones (such as typical skin tone) and the other set for dangerous overexposure, such as 90, 100, or even 108 IRE. Cameras use different methods for differentiating the two sets of zebra stripes (and usually offer the option of turning one or both of them off). In some cases, one set of stripes is diagonal, and the other set is the opposite diagonal; some are horizontal, some are "crawling ants", and so on. Figures 9.19 and 9.20 show a method used by Sony —the zebras are diagonal lines in opposite directions.

HISTOGRAM

The histogram is probably the simplest tool around for analyzing an image. It is somewhat primitive but can be very effective, especially for a very quick look at the overall exposure of a shot. It is also nearly ubiquitous: even the simplest consumer still cameras have histogram displays. It is basically a distribution diagram of the tones in our scene: on the left hand are the dark tones and on the right side of the diagram our light tones (Figures 9.21 through 9.23). A normal scene properly exposed will have a more or less even distribution of tones from dark to light and won't be too much pushed up against the left or right sides. The distribution of tones in the middle will change based on the scene; it's the light or dark tones pushing up against the extreme limits that you really want to watch.

Sony uses two types of zebras: (1) Anything above a certain value triggers zebras. (2) Anything that falls within a specific range triggers zebras (such as 60%,+/−5%). If the zebras ask you to set an aperture (+/−), then they are this type.

(1) Style zebras can be deceptive. Log curves are mathematical formulas that don’t flex much, and they often fall short of the actual limits of the storage medium. For example, Sony log curves often don’t get to 108–109%—they stop short, maybe around 104%, because that’s just how the formula work.

When I rate their cameras a stop slower, my highlights will often go no higher than 96%. If I set zebras to come on at 100%, they’ll never come on… but the image will still clip, but above 96%. That’s why I’ll set zebras at 95%, or at other values depending on the camera and settings. I’ll often aim the camera at a highlight and blow it out, and then—with zebras set at a low value—dial them up until the zebras disappear, and then back off one click. That’s the top edge of the LUT’s active range.

Art Adams

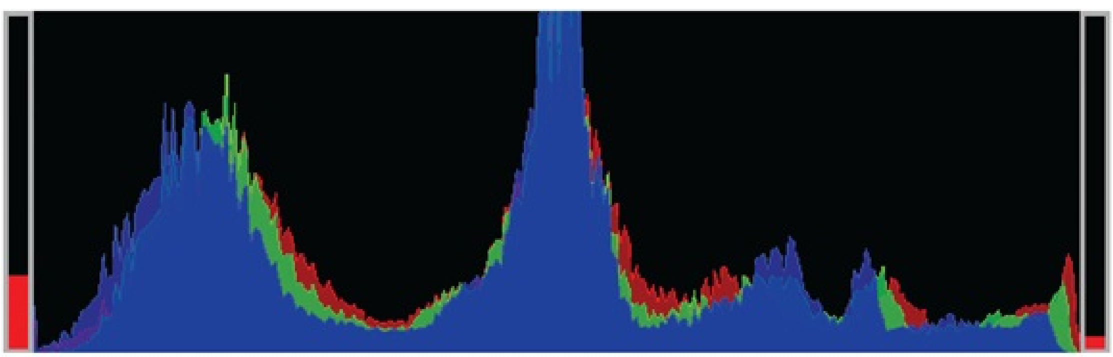


Figure 9.24. Red’s *Goal Posts* are also helpful in judging exposure. They are the two vertical stripes at the far right and left of the histogram. The height of the bar on the right indicates what percentage of pixels are clipped or in noise. The bar on the left indicates what percentage of pixels are in noise. Full scale on these indicators is only 25% of total pixels, not all of them as you might expect.

TRAFFIC LIGHTS AND GOAL POSTS

These are particular to Red cameras and provide very general but useful information. They are basically warning systems to alert the operator to percentages of the picture that are either in clipping or in “noise” at the bottom end—meaning underexposed. They may seem simplistic, but are in fact well suited to the new exposure needs of shooting RAW and log. Even though this method of shooting allows a good deal more room for error, that doesn't mean that making errors in exposure is any more of a good idea than it was with traditional HD recording.

GOAL POSTS

Red's explanation of their *Goal Posts*, (Figure 9.24) is this: "In order to quickly balance the competing trade-offs of noise and highlight protection, Red cameras also have indicators at the far left and right of their histogram. Unlike the histogram, though, these are not affected by the ISO speed or look setting, and instead represent RAW image data. The indicators are depicted as vertical bars to each side of the histogram and are often referred to as the "goal posts," since the aim is usually to achieve a histogram which doesn't hit either side.

"The height of each goal post reflects the fraction of overall pixels that have become either clipped (on the right), or near the capabilities of the camera to discern real texture from noise (on the left). The full scale for each goal post represents a quarter of all image pixels. In general, the left goal post can be pushed up to about 50% height and still give acceptable noise, but even a small amount on the right goal post can be unacceptable, depending on where this clipping appears in the image."

TRAFFIC LIGHTS

In addition to *Goal Posts*, Red provides another indicator of the crucial indicator of clipping—the so-called *Traffic Lights*, shown in Figure 9.25. These indicators show what color channels (Red, Green, Blue) have some areas that are being clipped. Some people assume they mean Go, Caution, Stop. Not so at all. Unfortunately, calling them traffic lights reinforces this misconception. Notice, for example, that the third color is not yellow, but blue. The realmeaning is that when about 2% of the pixels in a color channel have reached clipping, the corresponding light turns on. It's one of those things that are wonderfully precise in scientific terms but still require a great deal of human interpretation to be used properly.

According to Red: "When about 2% of the image pixels for a particular color channel have become clipped, the corresponding traffic light for that color channel will light up. This can be helpful in situations where just the red channel has become clipped within a skin tone, for example. In that case, the right side goal post would be much lower than it would appear otherwise, since all three channels haven't become clipped."

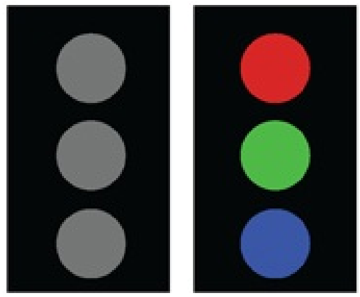


Figure 9.25. Two views of the *Traffic Lights* on a Red camera. It is important to note that they are not red, yellow, green as you would expect in real traffic lights. They are not the equivalent of *Go, Caution, Stop*. What they actually mean is that when about 2% of the pixels *in aparticular color channel* have reached clipping, the corresponding light turns on.

Adam Wilt has this to say about these tools, "The traffic lights seem interesting but in the end, how valuable is it really to know that '2% of pixels in that channel' are clipping? In my Red work, I find them useful as 'idiot lights': I can tell at a glance if there's a possibility I might be getting into trouble. They don't replace a careful study of the histogram; what they do is say, 'hey, buddy, you might want to take a closer look here…' and they say it even when I'm too busy to be focusing on the histogram, because I'm focusing instead on movement and composition.

"Same with the Goal Posts, they are halfway between the see-it-ina-flash 'idiot lights' of the traffic lights and the study-intensive histogram. They show me (a) I have stuff in the scene that exceeds the range of the capture system at either or both ends of the tonal scale, and (b) by comparing their relative heights, I can see quickly if I'm losing more shadow details, or more highlights, or if I've balanced the losses equally (assuming that's what I want, of course).

"I use 'em all: traffic lights as a quick-and-dirty warning, goal posts as a highlights/shadows balancing indicator, and the histogram or an external WFM to see in detail what the signal is doing. The traffic lights and goal posts don't show me anything I can't get from the histogram or WFM, but they show it to me very quickly, with a minimum of focus and concentration required on my part to interpret the results. It's nice to have choices."

FALSE COLOR EXPOSURE DISPLAY

Many pro cameras and field monitors now offer the choice of false color, which displays different tonal ranges coded in various “false” colors (Figures 9.26 and 9.36). As with any color code system, it’s worthless unless you know the key. Although different camera companies use their own set of colors, they usually have some commonalities. False color displays can usually be turned on or off either in menus or with buttons on the exterior of the camera that can be assigned to any one of several different camera controls (depending on the wishes of each individual user). Once you get to know them, they can be a useful guide to exposure, but they can also interfere with viewing the scene while operating the camera. For this reason, many cinematographers use them when lighting the scene and while determining the proper exposure for the scene and not while shooting the scene, when they might be a distraction for the operator.

Red False Colors

Red cameras have two false color selections: *Video Mode* and *Exposure Mode*. Exposure mode false colors are shown in Figure 9.28. Exposure Mode is a more simplified method which is used with RAW image viewing. Most of the image will appear as a grayscale but purple will be overlaid on any parts of the image that are underexposed and red will be overlaid on any overexposed regions of the frame. Since this applies to the RAW data, it indicates over and underexposed regions of the frame regardless of the current ISO or look settings. Since it is simpler, it can be less confusing to look at than video mode false colors; choosing which mode to use for viewing can depend on whether it is used only in preparing the shot (while lighting) or if an exposure mode or focus assist (peaking) is going to be used while operating the actual take.

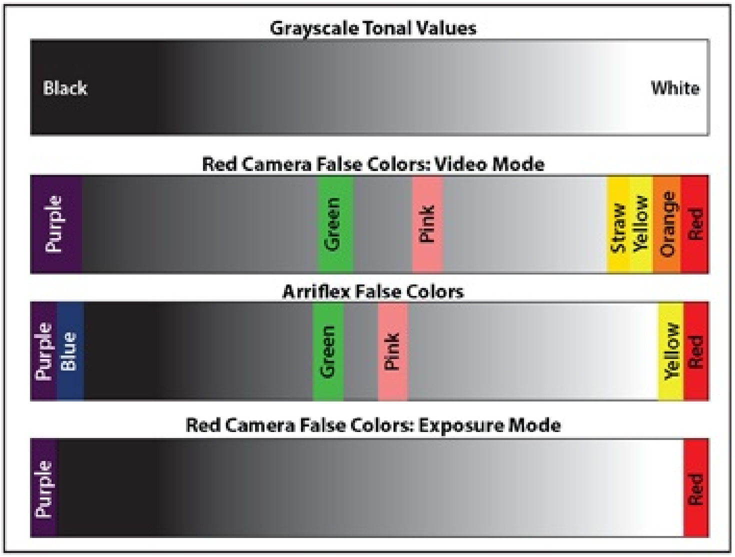


Figure 9.26. False colors can give more precise exposure information about individual portions of the image, but only if you know the code! At top is the grayscale including *superblack*and *superwhite*. Below that is the color code for Red camera false colors, then Alexa's color code and finally the Red camera *Exposure Mode* at bottom.

COMPARING RED EXPOSURE MODES

Table 9.2 shows the specifications of the three Red exposure modes—Video Mode, Zebra Mode, and Exposure Mode. Zebra, and Video Mode are based on IRE or RGB values, which is a relative scale based on the output signal sent to the monitor, not necessarily the actual values of the recorded scene.

Red puts it this way: "As with other IRE-based modes, zebra mode is only applicable for the current ISO and look settings (such as with HD-SDI output)—not for the RAW image data. If anything is changed in postproduction, the indicators won't be representative of the final output tones. In those situations, zebra mode is, therefore, more of a preview and output brightness tool than an exposure tool." Despite this, they can still be useful in some circumstances. In general, most exposure tools are measuring the image with the various adjustments to the look already applied.

RAW, in this context, is an absolute scale based on the output of the sensor. It is not necessarily related to the viewing image in terms of brightness values. Red says:"This is most useful when trying to optimize exposure and looking toward postproduction." This is, of course, the basic concept of shooting RAW vs. shooting video that is more or less "ready to go." Shooting RAW/Log is not about producing a final image, it's about producing a "digital negative" that has great potential further down the line. The downside is that the images are not directly viewable and this makes using exposure tools like zebras and histograms pretty much useless—they can only be used as approximation.

Table 9.2. Red's Exposure modes and specifications. Notice that *Video Mode* and *Zebra Mode* are only applicable in IRE (Rec.709, not RAW).

RED EXPOSURE MODES	**BASIS**	**LEVELS**	**ADJUSTABLE?**
Exposure Mode	RAW	2	No
Video Mode	IRE	9	No
Zebra Mode	IRE	1–3	Yes

Figure 9.27. A frame from a Red camera in standard mode. (Courtesy the Red Digital Cinema Camera Company).

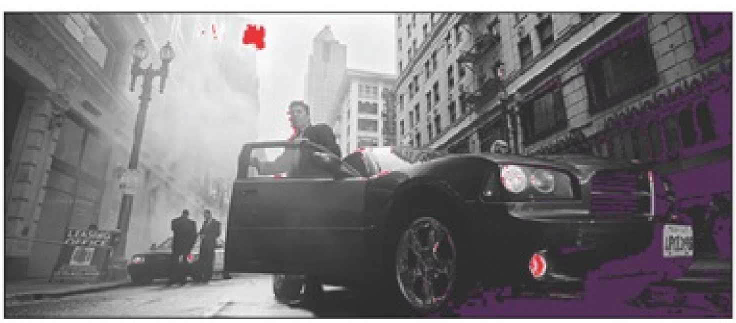


Figure 9.28. The same frame in *Exposure Mode*: red indicates clipping (overexposure) and purple shows parts of the frame in noise (under nominal exposure). (Courtesy the Red Digital Cinema Camera Company).

With a Red camera, the exposure mode you choose will determine what type of false color schemes you see displayed in the viewfinder. Red sums up their overall recommendation for using these tools: "First, in Exposure Mode, use the purple and red indicators to adjust your lighting or lens aperture. The strategy is usually to achieve an optimal balance between clipping from overexposure and image noise from underexposure. With most scenes, there can be a surprising range of exposure latitude before excessive red or purple indicators appear."

ARRI ALEXA FALSE COLORS

The Arri Alexa has similar false color codes but they are a bit simpler —Figure 9.26 and Table 9.3. Arri's color code has fewer steps which some find makes it easier to read in the viewfinder or monitor. Green is middle gray (38% to 42%) and Pink is average Caucasian skin tone (52% to 56%). Red (which they call White Clipping) is 99% to 100% and Purple, which they call Black Clipping, is 0% to 2.5%.

Table 9.3. Numerical values and colors of the *Arri Alexa False Color* system. (Courtesy of Arri).

What	Signal Level	Color
White clipping	100%–99%	red
Just below white clipping	99%–97%	yellow
One stop over medium gray (Caucasian skin)	56%%–52%	pink
18% medium gray	42%–38%	green
Just above black clipping	4.0%–2.5%	blue
Black clipping	2.5%–0.0%	purple

Figure 9.29. At top is a Red frame two-and-a-third stops underexposed.

Figure 9.30. Red's *FLUT* in use. A FLUT of 2.3 has been applied, bringing the shot back to fairly normal exposure. In this case, the FLUT has been applied in *Assimilate Scratch*.

STRATEGIES OF EXPOSURE

We've looked at the many tools available for judging exposure. But what about the basic philosophy of exposure—it's not a purely mechanical, by-the-book procedure—every experienced cinematographer has their own way of working, their own favorite tools and bag of tricks. As with just about everything in filmmaking, it's not about the right or the wrong way—it's about achieving the desired final product, which is always several steps away down the line. Ultimately, it's all about what appears to the viewer.

There are adjustments to be made for individual cameras, artistic preferences, and so on. We know the basic goal—to get an image that will yield the best results in the end. An individual cinematographer will develop methods that work for them based on experience, testing, and the feedback they get from viewing dailies or looking at the footage on the set.

DON'T LET IT CLIP, BUT AVOID THE NOISE

Homer (not Homer Simpson, the other one) wrote about two mythical sea monsters on each side of the Strait of Messina, a dangerous rocky shoal on one side and a deadly whirlpool on the other. Called Scylla and Charybdis, they are the origins of the terms "between a rock and a hard place." In shooting video, our Scylla and Charybdis are clipping at the brightest areas of the scene and noise in the darker parts of the scene. Technically, clipping is sensor saturation; camera manufacturers refer to it as *well overflow*, in reference to the wells of the photosites.

The noise floor is not the same as the lower black limit. It is the level of sensor output with the lens capped—no photons hitting the sensor at all. In this condition, there is still some electrical output from the photosites; simply because all electrical systems have some degree of randomness. There is noise everywhere in the sensor, but it is usually most noticeable in the darkest areas of the image.

The Red company summarizes: "Optimal exposure starts with a deceivingly simple strategy:

Clipping is not necessarily the same thing as video reaching 100%; in fact, the clipping level is adjustable on some cameras. Clipping means that the video device has reached the "saturation level" record as much light as necessary, but not so much that important highlights lose all texture. This is based on two fundamental properties of digital image capture:

"Noise. As less light is received, image noise increases. This happens throughout an image with less exposure, but also within darker regions of the same image for a given exposure.

"Highlight Clipping. If too much light is received, otherwise continuous tones hit a digital wall and become solid white. Alternatively, this might happen in just one of the individual color channels, which can cause inaccurate coloration. Unlike image noise, which increases gradually with less light, highlight clipping appears abruptly once the clipping threshold has been surpassed."

TEXTURE & DETAIL

Some terms you'll hear frequently when discussing exposure are texture, detail, and separation. For example, textured white, textured black, detail in the highlights, or separation in the shadows. These are all essentially the same thing and are important references in exposure. The concepts originated with Ansel Adams, who needed terms to describe how far exposure (negative density in his case as he worked with film) can go before they are just pure black or pure white; soot and chalk as he sometimes called them; just featureless regions of the image with no detail at all. Textured white is defined as the lightest tone in the image where you can still see some texture, some details, some separation of subtle tones.

Diffuse white is the reflectance of an illuminated white object. Since perfectly reflective objects don't occur in the real world, diffuse white is about 90% reflectance; roughly a sheet of white paper or the white patch on a *ColorChecker* or a *DSC* test chart. There are laboratory test objects that are higher reflectance, all the way up to 99.9% but in the real world, 90% is the standard we use in video measurement. It is called diffuse white because it is not the same as maximum white. Diffuse means it is a dull surface (and in this context, paper is a dull surface) that reflects all wavelengths in all directions, unlike a mirror which

and no longer shows gradations of white at the upper levels. It's easy to spot on the waveform trace—it is when the signal "flatlines" at the top. There can be clipping of the luminance and also clipping of chrominance, which can be due to oversaturation of a particular channel or overexposure of a color channel. A viewing/monitoring *LUT* may make a signal appear to be clipping when it really isn't.

reflects a beam of light at the same angle it hits the surface.

Specular highlights are things that go above 90% diffuse reflectance. These might include a candle flame or a glint off a chrome car bumper. As we'll see later, being able to accommodate these intense highlights is a big difference between old-style Rec.709/HD video and the modern cameras and file formats such as OpenEXR. Textured black is the darkest tone where there is still some separation and detail. Viewed on the waveform, it is the step just above where the darkest blacks merge indistinguishably into the noise.

Figure 9.31. The classic method of *incident metering*—hold the meter at the subject's position and point the dome at the camera. Technically it is called the *Norwood Dome*.

Figure 9.32. Using the same Sekonic meter as a *reflectance/spot meter* allows the DP to check the exposure levels of different parts of the scene based on a combination of the lights hitting the objects and their inherent reflectance. It is also the only way to effectively meter objects that generate their own light, such as a lampshade, a neon sign, or a campfire.

Figure 9.33. The Luxi dome on an IPhone enables the app *Cine Meter II* to do incident readings in addition to its reflectance metering and other functions. The dome also allows the app to work as a very accurate color meter.

THE DILEMMA

What is a great leap forward for shooting with these modern cameras is also something of a disadvantage—recording log-encoded video gives us huge benefits in terms of dynamic range, but it also means the images the camera is outputting and recording are in no way WYSIWYG (what you see is what you get). In fact, on the monitor, they look awful—low in contrast and saturation. Even worse, they mean that the waveform monitor and vectorscope are not showing us the reality of the scene as it will be in the end result. A commonly used method is to display a Rec.709 conversion of the image on the set monitors. This makes the scene viewable (what we might think of as human readable), but they are only a rough approximation of what is actually being recorded and even more distant representation of what the image will eventually look like. Likewise, in a scene with a Rec.709 viewing LUT applied, the waveform monitor isn't telling us the whole story. Not just that they don't always have the benefit of fine-tuned color correction, but that they don't show us what the image will look like after it has been "developed," using the metaphor that RAW data is like a film negative.

"Developing," in this case, is not a photochemical process, but is the deBayering and log to linear conversions that will take place outside of the camera. If you've ever looked at original camera negative (OCN) you know that it is nearly impossible to comprehend visually; not only is it a negative in that tones are reversed, but also the colors are all opposite and there is a heavy orange mask. Cinematographers have developed the skill of looking at camera negative and getting a sense of what is a thick (overexposed) or thin (underexposed) image, but any understanding of color is impossible. These concepts come into play as we consider exposure with cameras that record log data either internally or on an external recorder. Some DPs and DITs prefer to have the log-encoded image on the waveform monitor and a viewing LUT applied for the monitors.

But how to achieve these goals of having an ideal digital negative? What methods get you there reliably and quickly—speed is always a factor in motion picture production.

USING LIGHT METERS

Many DPs have returned to using their light meters, both incident and reflectance (spot) meters; this is after years of using them infrequently if at all when shooting HD video, where factors such as gamma, knee, black gamma, *etc*. altered the image enough to make light meter readings less relevant or even misleading. When shooting RAW/log, the waveform suddenly becomes less precise because the image is displayed at very low contrast. Art Adams puts it this way, "I find myself using an incident meter much more often now. I rough in the lighting and then check it on a monitor and waveform, and then use the incident meter for consistency when moving around within the scene. I still pull out my spot meter occasionally but I'm becoming less reliant on it. The incident meter helps me get my midtones right and keep them consistent, and the monitor and waveform tell me about everything else."

METER THE KEY

This is the age-old formula for exposing film: use an incident meter (with proper ISO, frame rate, filter factors, and shutter angle dialed in on the meter) to read the key light (usually right where the actor is) and set the aperture for that reading (Figure 9.31). This provides an overall average for the scene—it is usually remarkably successful. Art Adams says, "If I have a choice I work strictly by meter. If not I work off the waveform. I use my meter to set proper midtones, and the waveform tells me if I'm losing detail in either the highlights or the shadows."

Figure 9.34. Zones as shown by photographing a towel in sunlight. What's important here is the concept of *texture and detail.*

In the same vein, British DP Geoff Boyle states, "I've gone back totally to using my incident meter together with my old Pentax digital spot calibrated with the zone system. I decide where the skin will be and keep it there. Overall with the incident reading, spot checks of highlights, shadows, and skin, hang on! That's how I used to shoot film. I have expanded the zone system range by a stop at either end, *i.e.* where I knew I would get pure white or black, I now know I will have detail. I use an ISO for the cameras that I've established from testing works for the way that I work; that sounds familiar as well. Yes, I will use a waveform on some work; it's a great tool there or diamonds [diamond display], but otherwise it's a rare thing for me. For me, it's a question of dynamic range, once it gets to 12 stops or more I can relax and get into the pictures rather than the tech."

Here's Art Adams on shooting HD: "The big change for me is that I used to use nothing but a spot meter [when shooting film] but video gamma curves are so variable that trying to nail an exposure based on a reflected reading is the true moving target. I can use a spot meter to find out how far overexposed a window will be on a scout but it's tough to light using nothing but a spot meter in HD, the way I could in film. Film stocks had different gammas but we only had to know a couple of them; every HD camera has at least 7 or 8 basic variations, plus lots of other variables that come into play.”

USING THE WAVEFORM MONITOR

When shooting HD (Rec.709), the waveform monitor has always been an important tool for making exposure decisions. It was supplemented by zebras and histograms, but those are rough guides at best; the waveform is accurate, precise, and gives you information about every part of the scene. The problem, of course, is that if the camera is outputting log/RAW information, the waveform display doesn't reflect the actual image as it is being recorded and will be processed later down the line (Figure 10.23 in *Linear, Gamma, Log*). This output is difficult to judge—to make any sense of it takes a good deal of experience and mental calculation. As a result, monitors on the set generally display a converted image; most often the log image is converted to Rec.709 by a LUT either internal on the camera, externally through a LUT box, or with a monitor that can host LUTs. While this makes it easier to interpret, it in no way shows the real image, particularly the highlights and shadows. Adams says, "A LUT may not show the real image but LUTs almost always show a subset of the image that throws away information by applying gamma, *etc*. I have no problem working off a Rec.709 converted log signal with a monitor and a waveform because I know that if it looks nice on set I can always make it look a lot nicer later in the grade. For example, if the Rec.709 image isn't clipping then I know the log image really isn't clipping. I make the image look nice and then shoot. I do check the log image on occasion but not very often."

Figure 9.35. Adam Wilt's *Cine Meter II* is a smartphone app with reflectance and incident metering plus waveform and adjustable false color displays. (Photo courtesy Adam Wilt).

Cinematographer David Mullen, says this, "It would be nice to see a waveform display of the log signal while monitoring a Rec.709 image to know exactly how much clipping is going on… but most camera set-ups seem to involve sending Rec.709 from the camera to the monitors so any waveform on the cart would be reading Rec.709." (See Figure 10.1 for one solution to this problem).

PLACING MIDDLE GRAY

When shooting film negative, the prevailing practice is to use the incident meter for setting the f/stop on the lens and using the spot meter to check highlights such as windows, lampshades, *etc.* Reading with the incident meter is the same as placing middle gray at 18%. Some cinematographers use a similar method when shooting log/RAW video—placing middle gray at the values recommended by the camera manufacturer which we'll talk about in more detail in the next chapter.

Art Adams uses this method: "I go for accurate middle gray, or place middle gray where I want it, and see how the rest falls. Midtones are where our eyes are the most sensitive. We naturally roll off the extreme shadows and highlights, just as cameras have been designed to do, so it makes little or no sense to me to base a scene's exposure on the part of the image that our brains naturally compress anyway. I generally expose raw and log based around middle gray using a meter… unless I'm shooting doc-style, and quickly. In that case, I tend to look at the midtones and the highlights together on a waveform." See Figure 9.37.

Adams adds about the Alexa—"Middle gray stays at nearly the same value when toggling between Log C and Rec.709, with the upshot that the Log C image—which is not designed to be viewable on any kind of HD monitor—still looks okay when viewed on a Rec.709 monitor. The bottom line is that middle gray changes very little when toggling between Log C and Rec.709, and this seems to make Log C more 'monitor friendly' than other log curves."

Typically I expose through a LUT. Knowing where middle gray falls on a log curve is useful in certain circumstances, but log curves should almost never be viewed as an exposure reference. If someone is watching the log curve directly they should be looking for clipping and detail close to the noise floor—technical issues only, not artistic. Log is a storage medium only. It's not meant to be viewed. Knowing where a company

START AT THE BOTTOM OR START AT THE TOP

Placing something pure black in the scene at 0% on the waveform seems tempting but the catch is finding something truly black. At first glance, it seems quite a bit safer than trying to select something in the frame to place at 100% white. As we have seen, what is really white is subjective and highly variable. Especially if you are shooting RAW/log and viewing in Rec.709, it is extremely difficult to even determine where the clipping level really is. Even more confounding, is the white object you selected 90% diffuse white, 100% white or something else?

puts middle gray can be useful in knowing what they are emphasizing: are they storing more information in the highlights or in the shadows? That'll tell you where you have more latitude for risk taking.

Art Adams

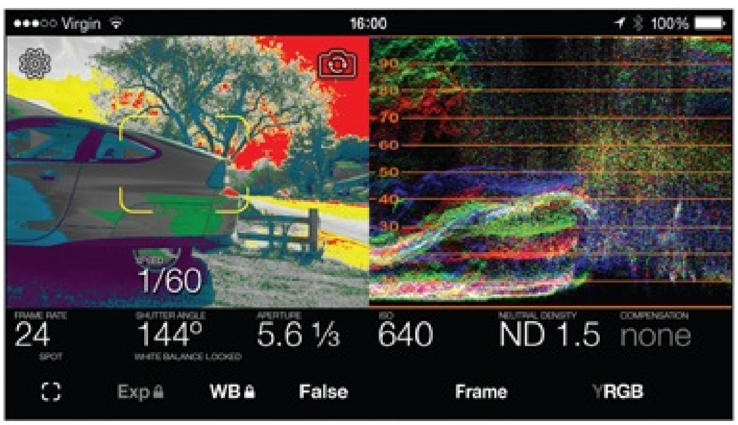


Figure 9.36. *Cine Meter II* with both an overlay waveform and false colors displayed. The yellow brackets represent the *spot meter* which can be moved, allowing the user to select what part of the scene is being exposed for. (Courtesy Adam Wilt).

When using the DSC Labs *ChromaDuMonde* chart (as discussed in the chapter *Measurement*), the *Cavi-Black* (Figure 9.42) is pure black but as we saw, it takes a good deal of innovation to make it truly black; a condition very unlikely to occur in a typical scene or even in an ordinary situation when testing or setting up a camera. Art Adams puts it this way, "Putting something black at the black point is similarly pointless because there's not a lot of real black out there unless it's a dark shadow. Also, if a camera exhibits wide dynamic range but it isn't equally split between highlights and shadows, you'll always have more stops in the shadows, which means putting something black at black results in pushing the exposure way down. Also, if what's black in one frame isn't black in another you end up with the same problems as exposing to the right: inconsistent noise and overall exposure."

EXPOSE TO THE RIGHT

Expose to the Right (ETTR) is popular with digital still photographers and is occasionally mentioned in connection with exposure in digital cinema. The idea is simple—since the dark areas of the image are where there is the most noise, we want to push the exposure as high as we can without clipping. On the histogram, the right side is the highlights, so those who use this method try to move the image toward the right on the histogram (Figures 9.43 and 9.44).

This method is not without its critics, however; most of them assert that it is no longer necessary as the noise level of cameras steadily improves. "Exposing to the right results in inconsistent noise from shot to shot, which can be jarring, and also tends to result in less consistency of exposure such that every shot needs its own grade," says Adams. He adds, "Exposing to the right or to the left is great for one shot that stands alone… which almost never happens. When your images sit adjacent to others why would you base their exposures on the things that change the most between them?" Geoff Boyle comments, "I understand the expose to the right camp and I have done this at times in the past but not anymore." He adds, "ETTR is not a practical method of working for us, every shot having to be graded individually and huge measures taken to match. Equally, whilst you can pull and push film you can't do it on a shot by shot basis." In practice, cinematographers rarely use ETTR on feature films or other long-form projects. As an exposure method, it might still be useful for isolated shots, such as landscapes or product shots, and on commercials which might consist of only a few shots in the day.

Figure 9.37. Waveform display of a *log-encoded* image of the DsC Labs *ChromaDuMonde* with exposure set by placing middle gray at the camera manufacturer's recommended level. The highlights are far below 100%, but the important aspect of shooting RAW/log is that you are not necessarily trying to create a final look for the scene—it is a *digital negative*, not the desired end result.

ZEBRAS

As we have previously discussed, zebras can be operator selected to appear in the viewfinder of many cameras and on some monitors and are a handy, always present (if you choose) check on highlight values and clipping. The problem is they are based on measuring the IRE (luma) value and are thus a bit more difficult to use when shooting log. In cases where you are shooting HD style (that is, basically in Rec.709 mode or WYSIWYG), they are very useful. Adams comments, “If I’m running around documentary style then I look at zebras and judge midtones in the viewfinder by eye. It’s not ideal, but I’m old school enough that I can do it well.”

THE MONITOR

During the HD years, you often heard "Don't trust the monitor!" Several advances have changed that. First of all, the kind of high-end monitors that are likely to be the DP's main monitor near camera and at the DIT cart have greatly improved in color and tone scale accuracy. Also, much more attention is paid to proper calibration.

David Mullen puts it like this: "I mainly come to rely on the monitor with occasional double-checks using various devices—meters, waveforms, histograms, just not on every shot. The main point is the feedback loop over time (if this is a long-form project), you check the footage again in dailies, in the editing room, etc., to see if your exposure technique is giving you good results, and sometimes you make adjustments when you find that your day work is a bit too hot or your night work is a bit too dark, *etc*. I also shoot tests before I begin to see how things look on the set versus later in a DI theater."

Viewing conditions are important—a monitor, standing in a brightly lit area outdoors or even on the set, isn't going to give you accurate information. This is why you'll see dark hoods around monitors on the set, or at least, the grips will set 4x4 floppies or other shades to prevent glare on the monitor. DITs often work inside a tent when setting up outdoors.

KNOW THYSELF AND KNOW THY CAMERA

Just as you get to know the characteristics of particular cameras, you also need to get to know your own inclinations. As David Mullen puts it: “Finally, the old saying ‘Know thyself’ can be applied to exposure technique; we know if we have a tendency to overexpose or underexpose in general so we can develop a technique to take that into account.” As you go through the feedback cycle of using your meters, waveform, zebras, or whatever it is you use, then setting exposure and viewing the results in dailies, you need to watch what works and what doesn’t. Do you have a tendency to overexpose night scenes? Underexpose day scenes? Whatever it is you do, learn from it and bring that self-knowledge back to the set with you next time you shoot. Perhaps you consistently interpret your incident meter in a particular way and tend to set exposure by the waveform in a slightly different way. Despite the accuracy of the tools, it’s never a straightforward, mechanical process; there is always an element of human judgment involved.

Figure 9.38. A normal “correctly exposed” frame leaves little detail in the deep shadows or in the highlights; it’s an average that doesn’t do justice to the extremes.

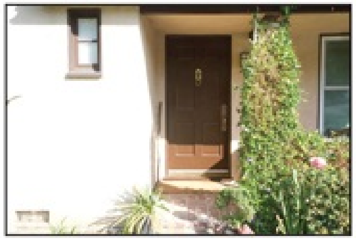


Figure 9.39. An overexposed image sees into the shadows.

Figure 9.4.0 The underexposed frame retains the highlight detail.

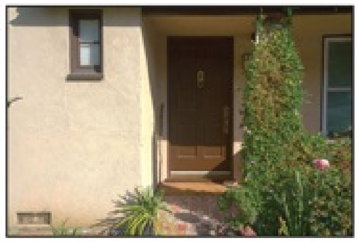


Figure 9.41. When combined as an *HDR* image, the frames produce an image with enough dynamic range to accommodate the original scene.

BLACKMAGIC CAMERA EXPOSURE ADVICE

Blackmagic Design, the maker of *DaVinciResolve* and video cameras, offers the following view on exposure with their cameras: “Why do my RAW shots look overexposed? Answer: The 100% Zebra level in the Display Settings helps you adjust your exposure to ensure that you don’t overload the sensor and clip your highlights. It is based on the full dynamic range capability of the Blackmagic Cinema Camera and not on video levels. A quick way to ensure you do not allow the sensor to clip any image data is to set your Zebra level to 100%, expose your shot such that zebras start to appear and then back it off until the Zebras disappear. If you have an auto iris lens on the camera, pressing the IRIS button will do this automatically for you by adjusting the lens aperture to keep the white peaks just below the sensor’s clipping point.

“If you normally expose your shots based on an 18% gray card at 40 IRE video levels, then your log images will look correct when imported into DaVinci Resolve. However, if you want to maximize your camera sensor’s signal to noise ratio, you might expose your shots so the white peaks are just below the sensor clipping point. This may cause your log images to look overexposed when a video curve is applied to the preview, and the highlights you thought were safe will look as though they have been clipped. This is normal and all the details are still retained in the file. If there is a lot of contrast range in the shot, the log images may look fine and not overexposed.

“Shooting in RAW/log captures a very wide dynamic range. However, you might only see the image in the more limited Video range (Rec.709) when you open the CinemaDNG files in a compatible application. If the camera is not exposed based on 18% or other video related exposure guides, the RAW files will look over or under exposed depending on the dynamic range of the scene. The good news is that you have not really lost any information in your shots. Based on the contrast range of your shot, you can creatively adjust the exposure settings of the DNG file for the look you want using software such as DaVinci Resolve, Adobe Photoshop or Adobe Lightroom. To recover the highlights not displayed in Resolve, use the RAW image settings and adjust the Exposure values so the details you need fit within the video range. Exposing your shot to the point just before the sensor clips, ensures you are getting the best signal to noise ratio for the maximum flexibility during postproduction.”

HDRX

HDR, or *High Density Range* imaging, is very popular with landscape photographers. It works by combining images that are overexposed, normally exposed, and underexposed to extend the luminance range that can be accommodated—how it works is shown in Figures 9.38 through 9.41. It can extend the brightness range that can be captured to far beyond what any technology is currently capable of. The disadvantage (and the reason it is used primarily by still photographers who do landscape work) is that if there is any movement in the subject between frames, there will be blur.

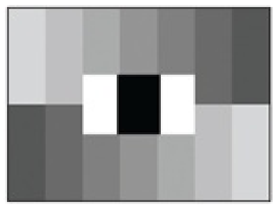


Figure 9.42. The *Cavi-Black* is an important and useful feature of the *ChromaDuMonde*. It is an open hole in the middle of the chart which is backed by a velvet-lined foldout box on the "back of the chart. It's a complete light trap and provides a reliable pure black reference in the frame, an invaluable tool for testing and camera setup.

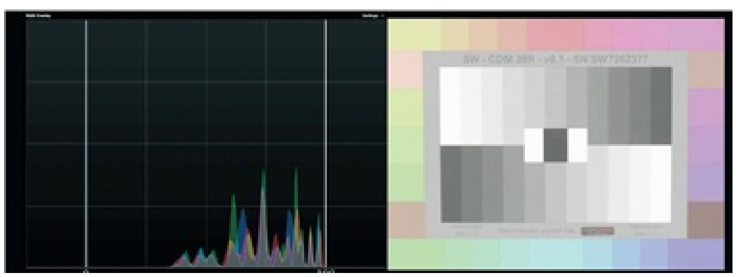


Figure 9.43. An example of the *Expose to the Right* method on the histogram. The chart looks blown out and desaturated, but in fact, nothing is clipping so the values can be brought back in color correction. The risk is obvious, even a slight increase in exposure will cause some values to clip.

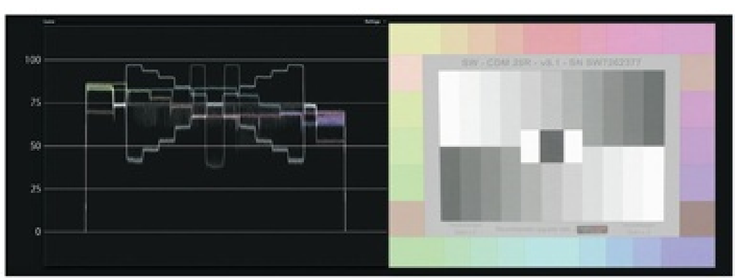


Figure 9.44. The same *Expose to the Right* frame as shown on the waveform. While the high values are dangerously close to clipping, all of the darker values have been pushed up the scale, well away from noise.

The Red camera company has a method that bypasses this shortcoming. Red's *HDRx* is not a separate file format, it integrates two images per frame: the primary exposure and also an underexposed capture of the same frame to preserve highlight detail. These are dealt with together in software such as *RedCine X Pro*. The primary exposure is called the *A Frame* and the secondary underexposed image is the *XFrame*. According to Red: "It works by recording two exposures within the interval that a standard motion camera would record only one: The primary exposure is normal, and uses the standard aperture and shutter settings (the 'A frame'). The secondary exposure is typically for highlight protection and uses an adjustable shutter speed that is 2—6 stops faster (the 'X frame'). For example, if the A frame is captured at 24 FPS and 1/50 second shutter speed, then specifying two stops HDRx causes the X frame to be captured at a shutter speed of 1/200 second." These two frames then need to be combined and the percentage of each that is used in the final shot needs to be variable. Since there is a difference in the motion blur within the frame between shots taken at very different shutter speeds, there is a need to adjust the apparent blur in the shot. This is provided for in Red camera companies software *RedCineX Pro* and is called *Magic Motion*. It allows the user to view the blend of the two frames and adjust the ratio between them, thus adapting to different situations.

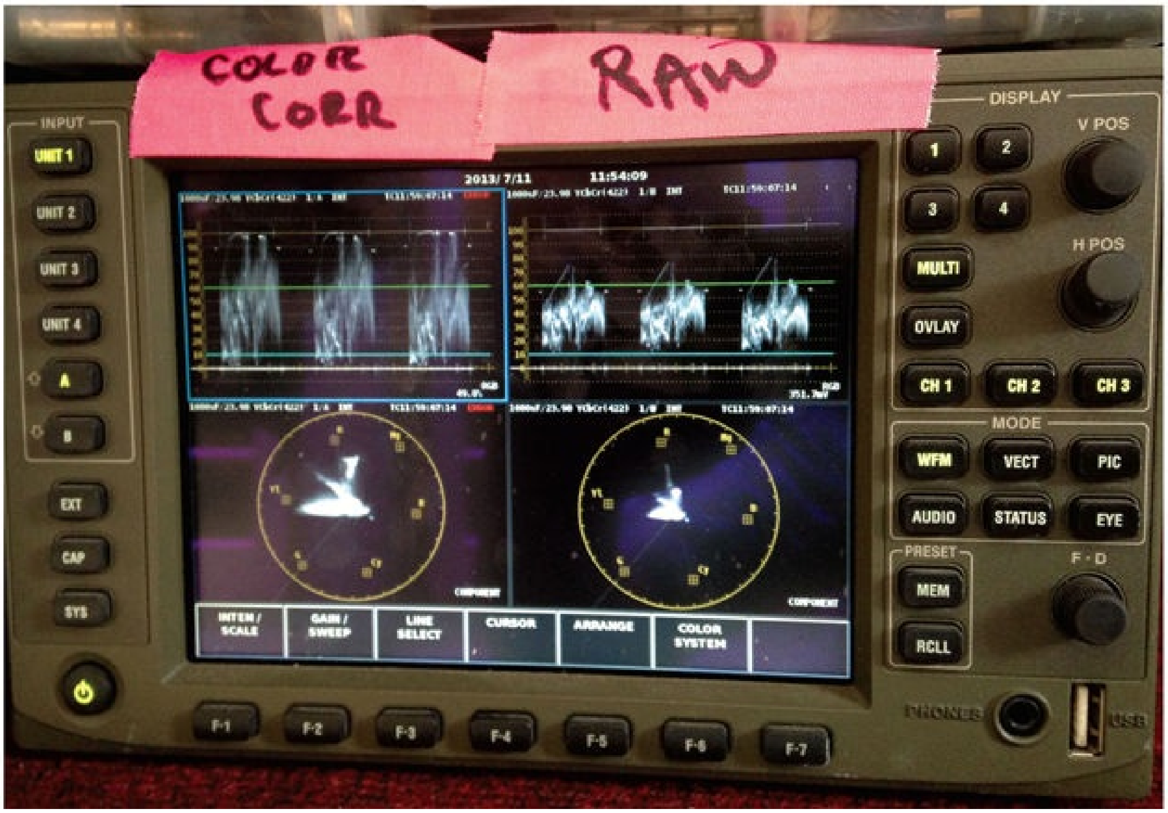


Figure 10.1. A method for viewing the image as both RAW/log-encoded and as color corrected at the same time using a quad display waveform monitor/ vectorscope. (Photo courtesy DIT Evan Nesbit).

linear, gamma, log

DYNAMIC RANGE

Brightness range, *dynamic range*, and *luminance range* are terms for the same concept: how much variation there is in the luminance levels of a scene and then how accurately the imaging system is able to reproduce those levels. Any scene we look at has a specific brightness range, which is a result of the combination of how much light is falling on the scene and how reflective the objects are. Also, some things in the scene don't reflect light so much as they generate their own light: lamps, a fire, windows, the sky, *etc.*

The difference between the darkest part of a scene and the brightest part can be enormous, especially in exterior scenes. If there is something dark and in shadows in the scene and then there are brightly lit clouds, the difference can easily be as much as 20 stops or more. Twenty stops is a ratio of 1,000,000:1. As with all scenes, how reflective the objects are is a key factor in addition to the different amounts of light falling on areas of the scene—think of a black panther in a cave and a white marble statue, in full sun, in the same frame. Even with the amazing range the human eye is capable of, there is no way you can really see both at the same time. You can shield your eyes from the glare of the marble statue and let them adapt to the dark and see the panther in the mouth of the cave or you can squint and let your eyes adapt to the light and see the marble statue, but you'll never be able to see both of them at the same time.

Film and video have dynamic ranges that are limited by technology. Color scientist Charles Poynton states, "*Dynamic Range* according to the definition used by sensor designers, is the ratio of exposure at sensor saturation down to exposure where noise fills the entire lowest stop. Consider whether that sort of dynamic range is a useful metric for you." In other words, your mileage may vary.

Until recently video was far more limited than film, but new cameras are rapidly closing that gap, even exceeding that range. Traditional HD video (up until the introduction of the *Viper*, *Red One Genesis*, *Alexa*, and now many others) was limited in range. The problem is illustrated in Figure 10.4. However, the camera can only pick up a limited portion of that brightness range (we're assuming that the camera exposure was set right in the middle). This means that something that was just very light gray in the scene will be recorded by the camera as being pure white, because that brightness value is at the top end of what the camera can “see.” At the low end, something that is just dark gray in the scene will be recorded by the camera as being pure black.

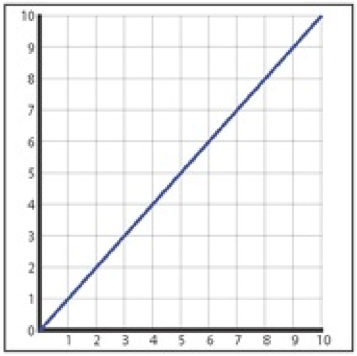


Figure 10.2. Linear response on a Cartesian diagram: every increment on the X-axis results in an equal change on the Y-axis.

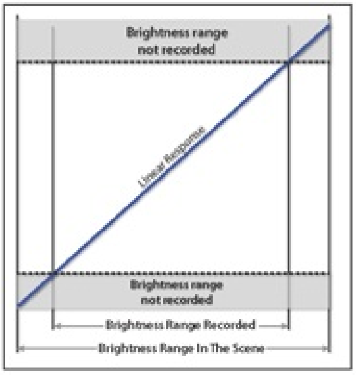


Figure 10.3. Unlike the gentle roll-off of highlights and shadows in the film S-curve, a purely linear representation means that the shadows and highlights fall beyond what the medium is capable of reproducing.

LINEAR RESPONSE

If an “ideal” film or sensor was truly *linear*, it would have an equal increase in density for every increase in exposure: doubling the amount of light in the scene would exactly double the brightness of the final image (Figure 10.2).The problem is that linear response means some brightness ranges exceed the limits of the film or sensor (Figure 10.3)—parts of the scene that are too bright just don’t get recorded: they come out as pure, featureless white on the film (in video, this is clipping): no detail, no texture, no separation. The same happens with the very dark parts of the scene: they are just a featureless dark blob on the negative. Instead of subtle shadows and gradations of black tones, it’s just pure black with no texture. Simply put, since the brightness range of many scenes exceeds what cameras and displays are capable of, a purely linear response puts some areas of the scene off the scale at the extremes—see Figure 10.2.

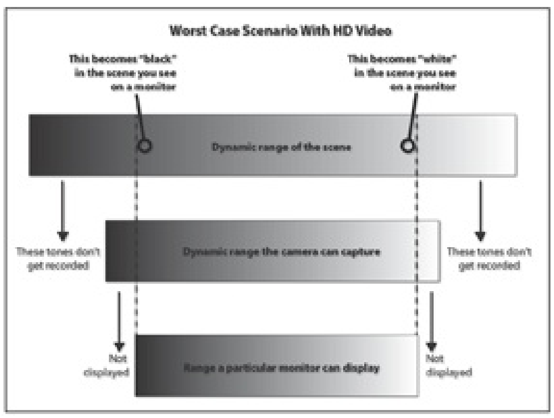


Figure 10.4. Because the camera and then the monitor are not always capable of reproducing the extreme dynamic range of some scenes, the tonal range is represented differently in each step of the process. Fortunately, there have been huge strides in making cameras that have amazing dynamic range.

AN IDEAL AND A PROBLEM

You may have heard that video sensors are “linear,” meaning that they have that one-to-one correspondence between the input (scene brightness values) and the output (pixel brightness values). It just means that there is no alteration of the data in the transition. At first glance this seems ideal—for every change of brightness levels within the scene, there is a corresponding change in the output levels from the photosites. Sound great, after all, accurate reproduction of the scene is what we’re after, right? If only life were so simple, everything would be easy.

Because the brightness range of the real world is often huge, no current sensor, monitor, or projector can accommodate that great a brightness range. The human eye can accommodate a ratio of 100:1 under static conditions (without adaptation with the iris or changing chemically from scotopic to photopic vision or vice versa). So we have certain hard limits to what brightness range we can record and use—as cameras and displays evolve, in the end, it will not be the equipment that is the limiting factor, it will be human vision. *Dynamic range* of the sensor is measured between black and the upper limit of clipping. With the best cameras, this can be quite an impressive range of up to 14, 15 stops or more, but even so, many scenes, (especially exteriors) exceed this dynamic range. At some point sensors may exceed the limits of what human vision can accommodate.

LINEAR AS SCENE REFERRED

We've talked about some of the problems with linear, but don't lose sight of the fact that it is still an ideal to which we aspire in image acquisition—the ultimate goal is accurate representation of the scene as it actually appears in the real world; artistic interpretations aside, of course. In this context, the term is *scene-referred*, which means that the tonal scale and color of the actual scene are reproduced in the image to whatever extent the sensor is capable of doing so.

THE CLASSIC S-CURVE IN THE IMAGE

Let's take another look at how film negative emulsion responds to light before we get into video. The reason for this is that it illustrates the concepts in a very simple way and also that video engineers have spent a great deal of time trying to get video to behave like film. Figure 10.5 shows the *response curve* of a typical film negative; they're always an S-shape. The reason for this is that on film, the highlights "roll off," meaning that after a certain point the graph is no longer a straight line. Adding more and more light eventually has less and less effect. This is because the silver crystals in the film emulsion get saturated and stop responding or when the photosites become saturated. This is just to say they are gradually more and more compressed.

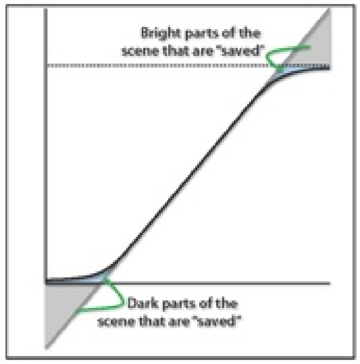


Figure 10.5. The S-curve in film. The gentle curve of the shadow reproduction and the fall-off of the highlights is a form of compression that extends the dynamic range. This works because human perception is far more sensitive to the middle range than to the extremes.

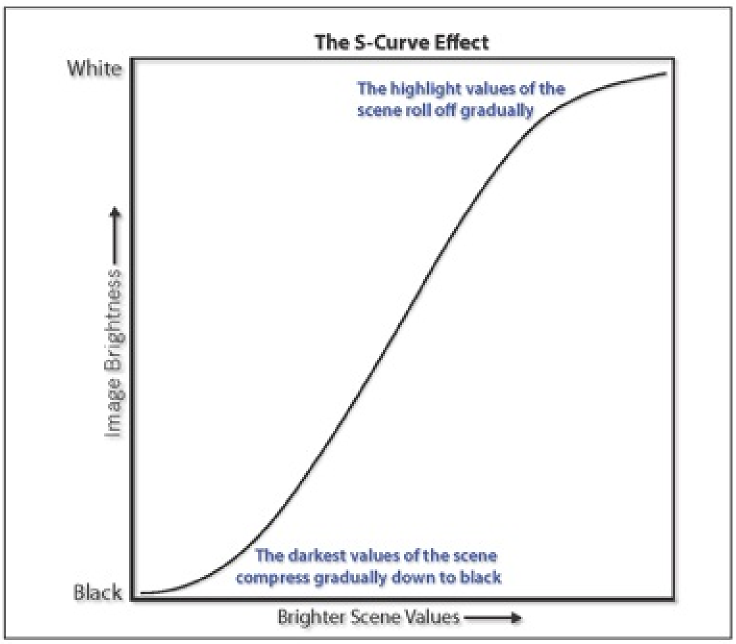


Figure 10.6. An illustration of how the S-curve "saves" the extreme shadows and highlights.

A similar phenomenon happens in the shadows. As photons begin hitting the silver crystals during exposure, the emulsion doesn't immediately respond, so the line stays flat for a while. This happens due to latency in the silver crystals' response to light: they don't immediately respond when a few photons fall on each crystal. It takes many photons to get the chemical change started and even then, it happens slowly. This causes the *toe* of the film curve to start out flat, then slowly curves up, eventually becoming the straight-line portion of the curve or the midtones.

Think of it like trying to push start a stalled car. When the car is at a stand-still, it takes a lot of effort to get it moving at all. Once it’s rolling along, fairly minimal effort will keep it going. In the highlights, the silver crystals eventually reach a saturation point, but they do so gradually; as more and more photons pour in, the chemical response starts to slow down, slows even more, and then stops entirely. The result is the *shoulder* of the film curve.

One would think that this inertia at the low end and fall-off in response at the high end would be a real problem because they make the response non-linear. After all, isn’t the goal of “ideal” exposure to reproduce the real-world scene as closely as possible? A non-linear response curve isn’t really “accurately” reproducing the scene in front of the camera.

As it turns out, this S-curve is one of the biggest advantages film has over video, and the lack of it is one of the biggest obstacles to overcome in video. As Art Adams puts it in his online article *Hitting the Exposure Sweet Spot*, “The S-curve does what our eyes do naturally: it stretches out the midtones, so they are the same distance apartthat they would be if the camera only captured six stops, and compresses the highlights and shadows, which is where our eyes are least sensitive to differences in tonality. We can cram the steps together in the highlights and shadows, making them less contrasty, because the midtones are where we pay the most attention.” See Figure 10.6.

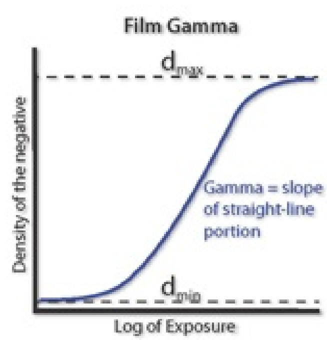


Figure 10.7. In film, *Gamma* is the slope of the straight-line portion of the curve , the midtones. Dmax and Dmin are the maximum and minimum densities of the film negative (see Figure 9.2 in *Exposure*).

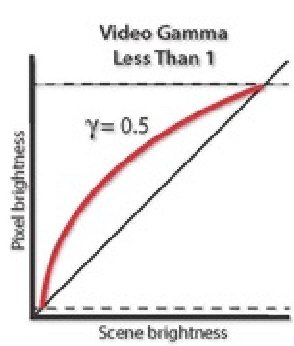


Figure 10.8. Video gamma is a power function, a curve. A gamma less than one results in an upward curve. This is just a typical value for illustration.

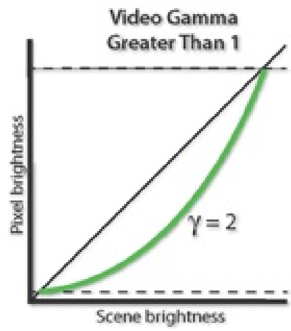


Figure 10.9. A video gamma of greater than one forms a downward curve. Again, just a typical value for illustration.

FILM GAMMA AND VIDEO GAMMA

What is *gamma*? It is an important concept in both film and video and something we deal with frequently at the camera, in post, in delivery—everywhere. Some people think that gamma just means contrast and nothing more, but this isn't really true. Certainly changing the gamma does affect the contrastiness of the image, but there's a lot more to it than that. Also, there are other factors that alter the contrast of an image; we'll talk about those a little later. First, we need to take a quick glance at gamma in film—it's a bit different. In film, gamma is the slope of the middle (straight-line) portion of the curve. Clearly a steeper line is more contrasty—the Y value (image brightness) changes more quickly for every unit of change in the X value (scene brightness). A slope that is less steep means that pixel brightness changes at a slower rate than image brightness, which results in mid tones, with less contrast.

VIDEO GAMMA

Video gamma is a *power function* (as in Y^x), which takes the form of a curve. As you can see in Figures 10.8 and 10.9, it can be an upward curve or a downward curve, depending on whether the value is greater than or less than 1 (a gamma of 1 would be a straight-line). For a visual illustration of the effects of changing gamma, see the chapter *Image Control & Grading*.

THE COINCIDENCE

Human vision perceives brightness in a non-linear fashion; it works out to a gamma of about .42, which is, by coincidence, the inverse of 2.4 (1/2.4=.42). Engineers realized very early in the development of television that cameras must include something at the front end to compensate for this: it is called *gamma correction* (Figure 10.14); the fact that *CRT (Cathode Ray Tube)* gamma and human visual gamma are the same is a complete accident. In short, gamma encoding at the camera is the inverse of the gamma characteristics of CRT monitors—the two cancel each other out. Modern flat-panel displays don't have this non-linear nature, and CRTs are no longer even being made, so it would seem that this gamma correction is no longer needed. While CRTs came by their gamma naturally, flat-screen displays need a *Look Up Table (LUT)* to achieve the proper gamma correction (see *Image Control & Grading* for more on LUTs).

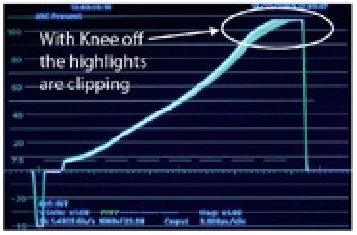


Figure 10.10. The image with the highlights clipping.

Figure 10.11. With *knee control* turned on to preserve the highlights without clipping.

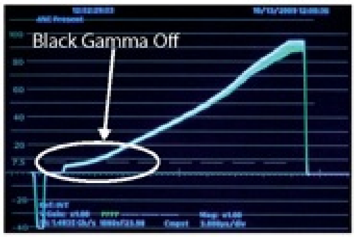


Figure 10.12. The signal with *Black Gamma* off.

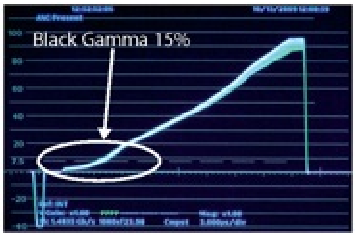


Figure 10.13. With *Black Gamma* at 15%, the dark areas of the scene have been made darker; what a DP might call "crunchier shadows."

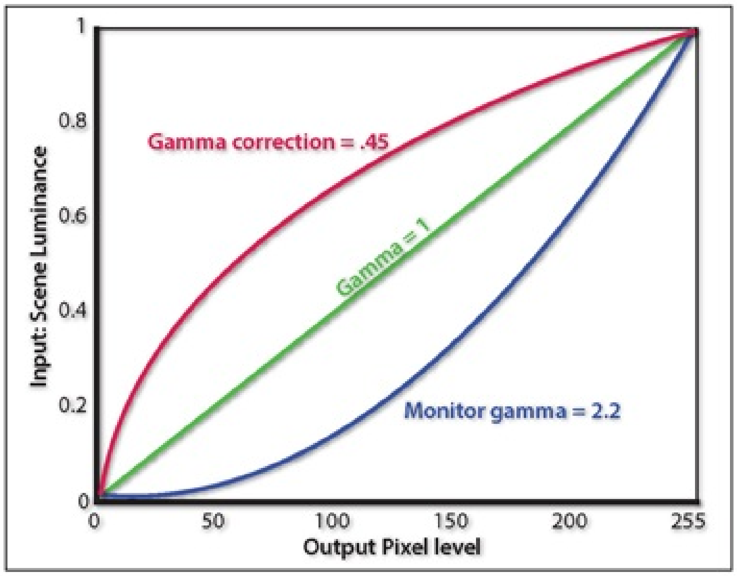


Figure 10.14. Gamma correction in traditional video—the gamma curves of the camera and the monitor are the inverse of each other and thus cancel out.

REC. 709

The term *Rec.709* appears in discussions of HD video all the time. It comes up in several different places in this book because it is not just one thing: it's actually a collection of specifications that define traditional High Definition video up to 1080. It is being replaced by *Rec. 2020*, designed for the wider gamut of UHD cameras, but it is still important to understand Rec.709 (Figure 10.15).

The official name is *ITU-R Recommendation BT.709* but most often it is referred to as *Rec.709*; but you'll also see it as Rec 709, Rec709 and Rec. 709. Rec.709 is WYSIWYG or "what you see is what you get." It was designed to be *display referred*, meaning that the contrast range that comes out of the camera sensor is *mapped* to standardized contrast range designed to suit specified display devices. To do this, it brings all color values into a fairly limited range—what could be accommodated by monitors when Rec.709 was standardized.

Because the dominant form of video display at the time was CRT monitors, Rec.709 correction "prepares" video so that it will appear correctly on that type of display. Technically, Rec.709 has only a less than six stop range but tweaks such as knee and black stretch cram more into this range.

Some cameras have a Rec.709 output either for viewing or for recording when little or no postproduction color correction is anticipated. These are usually not "true" Rec.709 but are designed to look reasonably good on a Rec.709 display. Arri offers their Rec.709 *Low Contrast Curve(LCC)*, which they explain like this, "To enable productions to shoot in Rec.709 color space without the sacrifice of too much highlight information, Arri provides a special *Low Contrast Characteristic(LCC) Arri Look File* that can be applied to change the standard Rec.709 output."

STUDIO SWING LEVELS, FULL RANGE, AND LEGAL VIDEO

Rec.709 also incorporates what are called *legal levels*; also known as *studio swing* or *video range*. *Range* or *swing* in this context really means *excursion*, as in how the signal level travels between *reference black* and *reference white*. In 8-bit video, the minimum code value is 0 and the maximum is 255. You would think that 0 represents pure black and 255 represents pure white. In *legal levels, video range*, or *studio swing*, however, black is placed at code value 16 and reference white is at 235 (64–940 in 10-bit). Code values from 0–16 and from

236–255 are reserved as *foot room* and *head room*. An example of this idea can be seen on the menu of an *Arri Alexa* (Figure 10.16). It offers three options for *Output Range: Legal*, *Extended*, and *RAW*. The *Legal* setting will output video at 0–100% and *Extended* goes from -9% up to 109%.

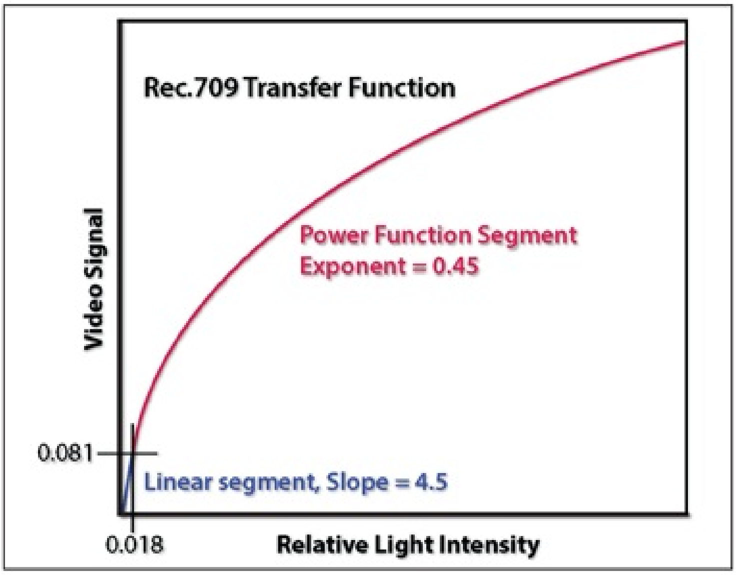


Figure 10.15. The Rec.709 transfer function is mostly a *power function* curve, but there is a small linear portion at the bottom.

GAMMA CONTROL IN TRADITIONAL HD

We have already discussed the meaning of gamma in the video signal and how it differs from film gamma. In HD cameras, *Gamma* (sometimes called *Coarse Gamma*) is a key adjustment that is available to the operator. Typically, the gamma was preset to .45 and could be adjusted up or down from there, depending on the desired image. As you would guess, raising the gamma to something like .55 gives an image that is overall contrastier, while lowering the Coarse Gamma to .35 gave you a lower contrast image.

KNEE CONTROL

Knee Control adjustment in older HD cameras consists of two separate adjustments: *slope* and *knee point*. *Slope* is the angle of the response in the highlights or knee, Figures 10.10 and 10.11. Obviously, a lower angle means that changes in brightness only slowly change the image brightness; you could call it lower contrast. A steeper slope means that image brightness changes very quickly, in other words, higher contrast. Most often this is used to accommodate for some bright highlights in the scene, such as a window or lampshade. The *Knee Point* control lets the operator select where on the curve the slope adjustment kicks in. Knee control is rarely used in UHD video.

BLACK STRETCH/BLACK GAMMA

In the toe (shadow regions) a similar strategy is used. Different camera companies use different terminology, but *black stretch* or *black gamma* are typical names for this function. It alters the slope of the curve at the lower end to make it more or less contrasty. Figures 10.12 and 10.13 show Sony's *Black Gamma* curves and resultant frames.

Figure 10.16. Output options on the *Arri Alexa. Legal* keeps everything in the range of 0–100%. *Extended* ranges from -9% to 109%. *Raw*, of course, outputs everything.

Table 10.1. Based on a 14-bit sensor, this chart shows that the first few stops down from maximum white hog most of the available code values, while the darkest part of the image contain so few code values that they are not able to accurately depict the subtle gradations of one—resulting in *banding* in the image. Experiments have shown that around 60 to 70 code values are needed per stop for proper representation of the image. This is linear output from the sensor, which is different from linear gamma. Derived from calculations made by Art Adams.

Value	**Code Range**	**Total # Values**
Max White	16,384	
One Stop Down	8,192–16,383	**8,191**
Two Stops Down	4,096–8,191	**4,095**
Three Stops Down	2,048–4,095	**2,047**
Four Stops Down	1,024–2,047	**1023**
Five Stops Down	512–1,023	**511**
Six Stops Down	256–511	**255**
Seven Stops Down	128–255	**127**
Eight Stops Down	64–127	**63**
Nine Stops Down	32–63	**31**
Ten Stops Down	16–31	**15**
Eleven Stops Down	0–15	

Eleven Stops Down	9–15	**6**
Twelve Stops Down	5–8	**3**
Thirteen Stops Down	3–4	**1**
Fourteen Stops Down	1–2	**1**

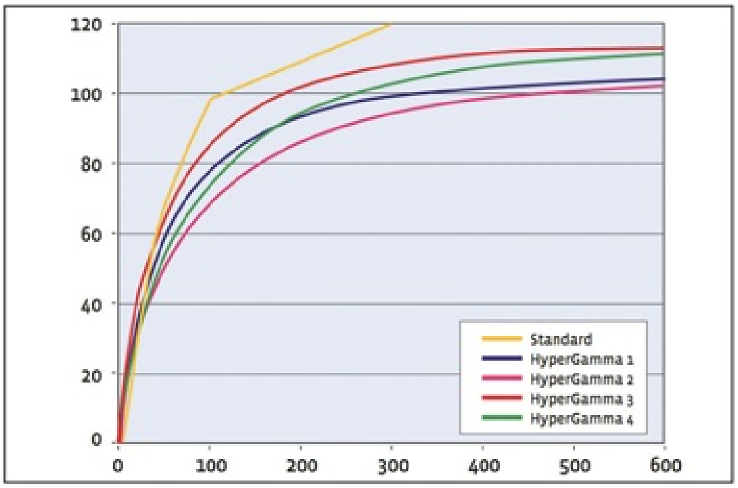


Figure 10.17. (right, below) Sony's *HyperGamma* curves as compared to video with the Rec.709 curve applied, which here they call *standard*—the yellow line. This chart uses Sony's older method of naming gamma curves; see the text for their new system. (Courtesy of Sony).

ANOTHER APPROACH

Just bending and stretching the knee and shadow areas can achieve a good deal but in the end, it is a limited approach and can result in some images that look a bit unnatural. Over the years, camera manufacturers have come up with even more sophisticated ways of extending the dynamic range of video cameras.

HYPERGAMMA/CINEGAMMA/FILM REC

Manufacturers have several versions of gamma encoding variously called *Hypergamma, Cinegamma, Video Rec, Film Rec*, or *low contrast curve*, which are designed to extend the dynamic range of the camera (Figures 10.17 and 10.18). These gamma curves are usually measured in a percentage, with the range of Rec.709 as a base 100%, with typical settings of 200%, 300%, 400% and so on. The higher the dynamic range, the greater the highlight value that can be captured. For example, 400% means it can capture a highlight that is 4X (two stops) higher than 100% reflectance. Using these curves can make the use of exposure aids such as zebras difficult.

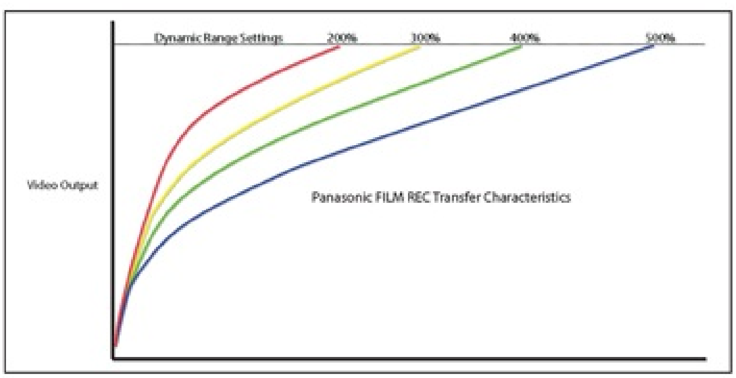


Figure 10.18. (left) Panasonic's *Film Rec* curves. They are denoted as the percentage by which they extend the dynamic range.

SONY HYPERGAMMA TERMINOLOGY

Sony now uses a naming format for hypergamma that includes the *range*. For example, HG8009G30 has a dynamic range of 800%, a middle gray exposure of 30%, and a white clip level of 109%. HG (HyperGamma) 800 (dynamic range), [10]9 white clip level and G30 (middle gray exposure level at 30%).

Sony HG4609G33 has an extended dynamic range of 460%, a white clip of 109%, and a middle gray exposure level of 33%. This means that the name of the HyperGamma actually includes Sony's recommendation for exposure: they want you to expose your middle gray at a particular IRE value (in this case 33 IRE), which will then give you the indicated percentage of dynamic range.

GAMMA IN RAW VIDEO

When shooting RAW, gamma is just metadata; you aren't really changing the image at all until you bake it in, which you do have to do at some point. An example of how this is done is how Red cameras handle this. Their color science offers several selections: *Red-Gamma2*, *RedGamma3*, *RedGamma 4*, and a log version: *Redlogfilm*. These are different look profiles for viewing on set and for conversion as the RAW files are imported to editing or color software.

THE INEFFICIENCY OF LINEAR

In addition to potentially losing data at the top and bottom of the curve, linear has another problem—it is extremely inefficient in how it uses *bits-per-stop*. Table 10.1 shows how Art Adams calculates the output of a 14-bit sensor, which has 16,384 bits per channel. It shows the code values in terms of f/stops. Recall that every f/stop is a doubling of the previous value (or half the previous value if you're going down the scale). The inefficiency is obvious in the table and the problem is clear—the four stops at the top end of the scale (the highlights) use up 15,356 bits, most of the available bits!

As Adams puts in his article *The Not-So-Technical Guide to S-Log and Log Gamma Curves (Pro Video Coalition)*, "As you can see, the first four stops of dynamic range get an enormous number of storage bits, and that's just about when we hit middle gray. This is the origin of the 'expose to the right' school of thought for 'RAW' cameras: if you expose to the right of the histogram you are cramming as much information as possible into those upper few stops that contain the most steps of brightness. As we get toward the bottom of the dynamic range, there are fewer steps to record each change in brightness, and we're also a lot closer to the noise floor." There's another problem. Experiments have shown that around 60 to 70 *code values* per stop is ideal. In this example, many stops at the bottom have less than this and stops at the top have much more. Figure 10.19 is a diagram devised by Steve Shaw of *Light Illusion*, which illustrates this problem. The top part of the figure shows that not only are there an excessive number of bits used up in the highlights, but also the divisions are too small for the human eye to perceive and so are wasted.

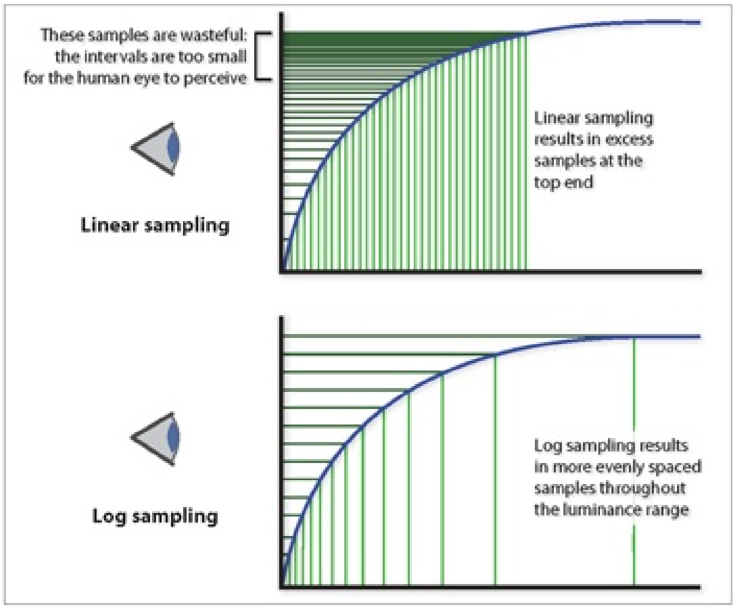


Figure 10.19. Linear sampling wastes code values where they do little good (upper diagram), while log encoding (1 ower tributes them more evenly—in a way that more closely conforms to how human perception works. Based on a diagram by Steve Shaw of *Light Illusion* and used with his permission.

LOG ENCODING

Fortunately, there is a solution to this inefficiency: *log encoding*. It is similar in concept to gamma in that it reduces the slope of the response curve to extend the dynamic range to stretch the brightness values that can be captured and recorded without clipping. Instead of applying a *power function* to the curve, it uses a *logarithmic* curve (Figure 10.20). The spacing of the values is not even, as we see here along the vertical Y-axis—every stop is compressed into a *perceptually* equal space with roughly the same storage space. A lot of problems are solved with this simple mathematical translation.

SUPERWHITE

Film and video have a crucial difference. In 8-bit video computer graphics, “pure white” is all channels at maximum: 255, 255, 255. But in the film world, what we might call pure white is just a representation of “diffuse white” or brightness of a piece of illuminated white paper (about 90% reflectance). Because of the shoulder of the S-curve, film is actually capable of representing many values of white much brighter than this. These are *specular* highlights, such as a light bulb, a candle flame, or the hot reflection of sun off a car.

If we stuck with 0-to-255, then all the “normal” tones would have to be pushed way down the scale to make room for these highlights that are above diffuse white. Kodak engineers decided on a 10-bit system (code values from 0-to-1023), and they placed diffuse white at 685 and black at 95—just as *legal video* goes from 16-to-235 (8-bit), 64-to-940 (10-bit), or -9%-to-109%. The values above *reference white* are thus allowed for and are called *superwhite*. Code value levels below *reference black* allow some *foot room*.

Just because something is log coded doesn’t make it any kind of a standard. Cineon Log is a standard because it was developed by Kodak and is based on print density. LogC is a variant that is very similar but slightly adjusted due to the specific response of the sensor that Arri is using. RedLogFilm is an application of the Cineon Log curve that is used by Red. Unlike any of those things, Canon Log is a “mild” log curve that is used for the sole purpose of retaining more information than you would get if you coded to Rec709 type video space.

Mike Most, colorist and workflow designer

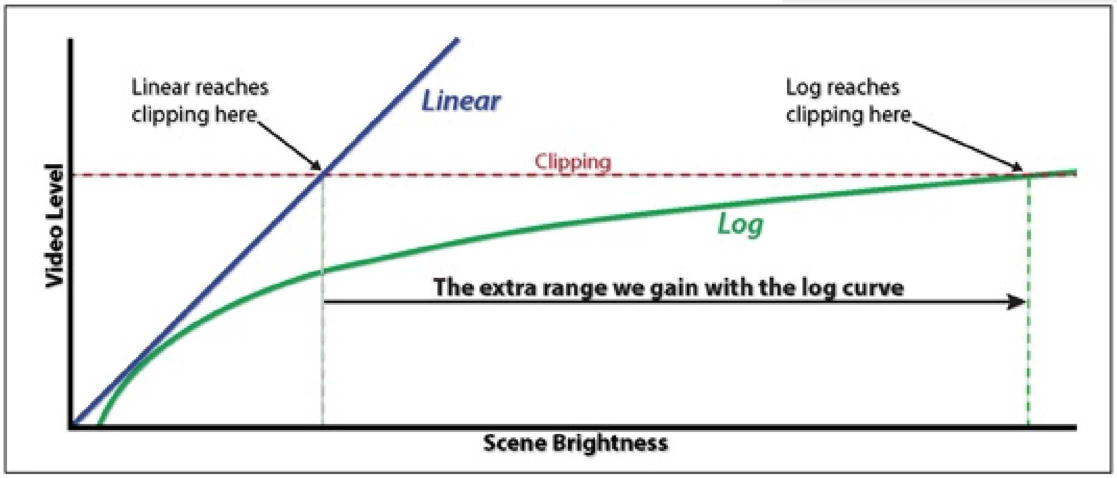


Figure 10.20. How log encoding provides extra dynamic range.

WHAT YOU SEE IS NOT WHAT YOU GET

One important aspect of log-encoded video is that it is *not* an accurate representation of the scene when viewed on a monitor—this is both its strong point and a limitation. Since it is essentially compressing scene values in order to get them to fit into the recording file structure, a log-encoded image on a monitor will look washed out, pale and low contrast (Figure 10.23). It is difficult, if not impossible to make judgments about the image. Also, it tends to freak out directors and will not be useful for other crew members. It can also make lighting decisions more difficult and affect other departments.

Of course, the fact that the log-encoded images are not really "ready for prime time," means that the image must be color corrected at some later time, certainly at the time of final grading (Figure 10.24). It is often useful to have some sort of temporary correction for viewing purposes. There are good reasons to have an accurate view on the set monitors—or, at least, one that is close to how the scene will appear. Rec.709 is WYSIWYG because it is *display referred*, meaning it is set up to be compatible with most monitors and projectors; for this reason, just doing a quick, non-permanent conversion to Rec.709 is output for use on the set. Some cameras have a Rec.709 monitor viewing output just for this purpose—it has no effect on the recorded files. Dealing with this is an important job for the DIT.

LOG AND RAW—TWO DIFFERENT THINGS

Log and RAW are two different things; however, many cameras that shoot RAW actually record the data log-encoded—in most highend cameras, the sensors produce more data (higher bit depth) than is feasible to record using current technology. Just keep in mind that you can record RAW that isn't log or log that isn't RAW, but for the most part, they go hand-in-hand. Keep in mind that like RAW, log-encoded video is for storage only, it is not meant to be viewed.

PROPRIETARY LOG CURVES

Camera companies employ log curves extensively in recording image data; each manufacturer has designed one or more log encoding schemes which are part of their "secret sauce" in the quest for a better camera. Red cameras have *RedlogFilm*, Arri uses *Log C*, Canon cameras employ *C-Log*, and Panavision has *Panalog*. The manufacturer's graphs of these encoding schemes are shown here and actual results of some of them are shown in Figures 10.26 through 10.29.

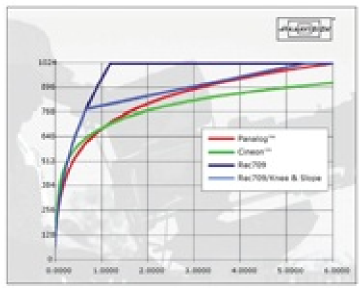


Figure 10.21. Arri's *Log C* is not a single function but is actually a set of curves at different ISOs. (Courtesy of Arri).

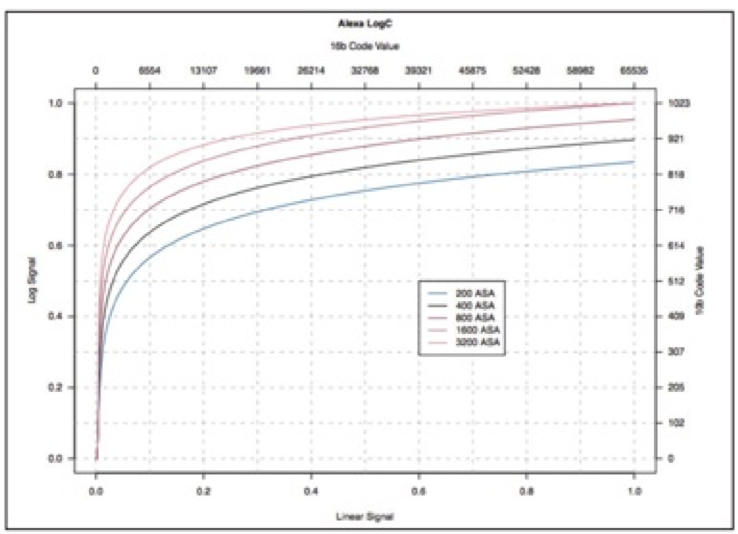


Figure 10.22. A comparison of Panavision's *Panalog, Cineon, Rec.709* and *Rec.709* with *Knee* and *Slope* adjustments.

SONY S-LOG

S-Log comes in three versions, *S-Log1*, *S-Log2*, and *S-Log3*. DP Art Adams on

S-Log: "Because code values never quite reach the extremes of black and white S-Log looks really flat because normal shadow values in a scene never reached the minimum code number for black. For that reason, they looked too bright, or milky. S-Log2 appears to rectify that problem by storing shadow values farther down the curve so that the darkest tone the camera can possibly see is mapped very close to the log curve's minimum recordable value. By making blacks black again, the log image actually looks fairly normal on a Rec.709 monitor. The highlights are still crushed because they are heavily compressed by the log curve for grading, but the image otherwise looks 'real.' It's less likely to cause people to panic when walking by the DIT's monitor." Sony says, "S-Log3 is a log signal with 1300% dynamic range, close to Cineon Log curve."

	0% Black		18% Gray		90% White	
	IRE	10-Bit CV	IRE	10-bit CV	IRE	10-bit CV
S-Log1	3%	90	38%	394	65%	636
S-Log2	3%	90	32%	347	59%	582
S-Log3	3.5%	95	41%	420	61%	598

SONY S-GAMUT

S-Gamut is a color space designed by Sony specifically to be used with S-Log. S-Gamut3 is the most recent verson. Since an S-Gamut conversion to Rec.709 can be a bit tricky, Sony has several conversion LUTs to be used with color correction software and makes them freely available on their website.

ARRI LOG C

According to Arri, "Material recorded in Rec.709 or P3 has a display specific encoding" or in other words "what you see is what you get" characteristics or display referred. "These characteristics map the actual contrast range of the scene to the total contrast range the display device is able to reproduce. The purpose of these encodings is to directly provide a visually correct

The difference between "log" and "RAW" is that RAW preserves photo site information (it records whether a specific photo site saw red or green or blue, and how much) whereas what we call log stores that information in pixel form, after the RGB values from individual photo sites have been combined. Log does not preserve representation of the captured material, when it is screened on HDTV monitors (Rec.709) or digital cinema projectors (DCI P3).”

original photo site data. Of course, then it gets even more confusing because log refers to a method of storing tonalities in perceptually equal steps. Some forms of RAW save data in linear gamma form, which means that just about every last bit of information is saved from the sensor, no matter how inefficient that is. It’s possible to apply log encoding to the brightness values of each photo site, which throws away a lot of largely-useless highlig ht data , while still preserving individual RGB values for “log-encoded RAW.”

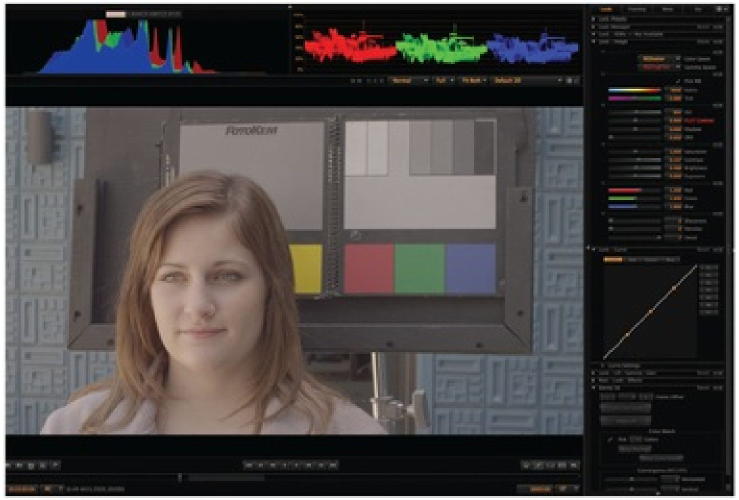


Figure 10.23. A Red camera shot displayed in *RedLogFilm*—a log space. The image is dull and low contrast by design. Note the waveforms in upper center: nothing reaches 0% at the bottom or 100% at the top; they don't even come close. This also shows in the histogram in the upper left. As shown here, the log image is not really viewable insofar as it is not an accurate representation of the scene—it is not intended to be.

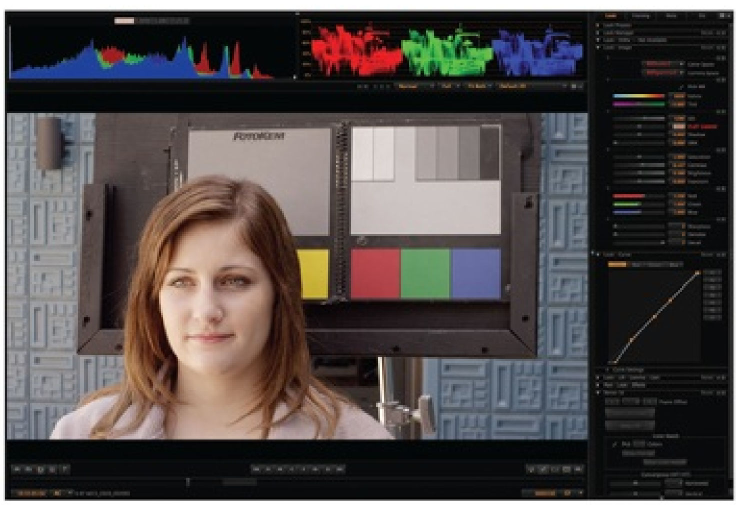


Figure 10.24. The same shot with *RedColor* and with *RedGamma3 LUT* applied. This LUT is Rec.709 compatible, meaning it is designed to look good on a Rec.709 display. Notice especially the difference in the parade waveforms. This is a problem as it means that the log image is not only dull and low contrast but also the waveform monitor and vectorscope are no longer accurate as relates to the actual scene values.

Arri's *Log C* is not a single transfer function—it is a set of curves that behave in slightly different ways for different *ISO* (*EI* or *Exposure Index*) settings (Figure 10.21). All of these curves map 18% middle gray to code value 400 (out of 1023 on the 10-bit scale). Arri goes on to say:"The maximum value of the Log C curve depends on the EI value. The reason is quite simple: When the lens is stopped down, by one stop, for example, the sensor will capture one stop more highlight information. Since the Log C output represents scene exposure values, the maximum value increases.” Arri is adamant that, in their implementation of log encoding, changing the *EI* (*Exposure Index*, more commonly referred to on a working set as the *ISO*) does not change the dynamic range; however, it does affect how the total range is distributed above and below middle gray. This can be a useful tool for the cinematographer who may need to accommodate scenes where there is some crucial detail either in the highlights or in the shadows. See Figure 9.37.

Arri says,“Choosing an EI setting higher or lower than the optimal setting will result in a sometimes surprisingly large loss of exposure latitude. Alexa is unique in that its exposure latitude of 14 stops stays constant from EI 160 to EI 3200.”

Middle gray stays at nearly the same value when toggling between LogC and Rec 709, with the upshot that the LogC image—which is not designed to be viewable on any kind of HD monitor—still looks okay when viewed on a Rec 709 monitor. The bottom line is that middle gray changes very little when toggling between LogC and Rec 709, and this seems to make LogC more “monitor friendly” than other log curves.

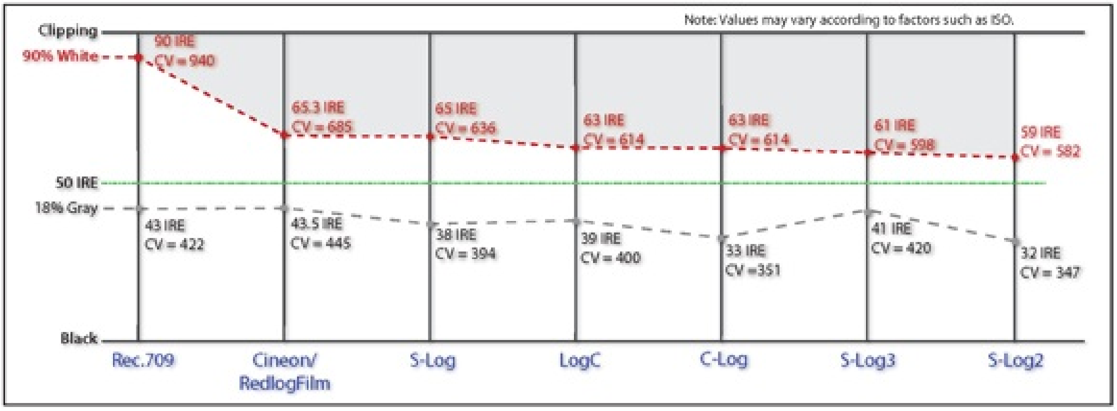


Figure 10.25. Relative values for 90% diffuse white and middle gray of *Rec.709, Cineon, LogC, C-Log, S-Log 1* and *2*. The values for where 90% diffuse white (the red dotted line) is placed change as do the values for 18% middle gray. Values are shown in *IRE* and *Code Values (CV)*.

CANON-LOG

Commonly referred to as *C-Log (Canon-Log)*, Canon's log solution behaves in slightly different ways depending on the ISO setting. "As a result of its operation, exposure latitude/dynamic range can be extended up to a maximum of 800% by raising the camera's *Master Gain* setting. Canon states that this will yield a still acceptable noise level of 54 dB." (Larry Thorpe, *Canon-Log Transfer Characteristics.)*

REDCODE

Red cameras record using *Redcode RAW* codec, which has the file extension .*R3D* and is, as the name states, a RAW format. It is a variable bit rate lossy (but visually lossless) wavelet code with compression ratios selectable from 3:1 to 18:1.

RED LOG

Red has gone through several generations of their software/firmware for Red cameras. This is from the company: "*Redlog* is a log encoding that maps the original 12-bit R3D camera data to a 10-bit curve. The blacks and mid tones in the lowest 8 bits of the video signal maintain the same precision as in the original 12-bit data, while the highlights in the highest 4 bits are compressed.

While reducing the precision of highlight detail, the trade-off is that there's an abundance of precision throughout the rest of the signal which helps maintain maximum latitude. *RedlogFilm* is a log encoding that's designed to remap the original 12-bit camera data to the standard Cineon curve. This setting produces very flat-contrast image data that preserves image detail with a wide latitude for adjustment, and is compatible with log workflows intended for film output." See Figure 10.29.

18% GRAY IN LOG

If you ever studied still photography, you probably learned that 18% gray (middle gray) is half way between black and white and that light meters are (theoretically) calibrated to 18% gray as being the average exposure of a typical scene. Now, why is middle gray 18% and not 50%? Because human perceptual vision is logarithmic, not linear.

How middle gray reads on the waveform is a more complex topic, but important to understand. Despite a lack of precision, middle gray/18% is still a very important part of judging exposure and testing cameras, and gray cards, in particular, are widely used and trusted, although they have their limitations as we discussed in the chapter *Measurement*. In Rec.709, the transfer function placed middle gray at 43%. It assumes a theoretical 100% reflectance for "white"—which is placed at 100 IRE (100% on the waveform monitor), but as we know, that isn't possible in the real world, where the 90% reflectance is roughly the high end. If you put a 90% reflectance (such as a white card) at 100% on the WFM, 18% gray will wind up at 43.4%; OK call it 43%. Red values are higher? Alexa values are lower? Neither Red's 709 nor Alexa's 709 curves precisely follow the Rec.709 transfer function. In neither case can we assume that 18% gray hits 43% when we set the camera up to its nominally correct exposure level.

In both the Red and the Alexa cases the recommended values are those the manufacturer says will render the optimum exposure for the way they've set up their cameras to work. Likewise Alexa, which rolls off from the 709 curve quite early on—which gives that excellent tonal scale rendering, but again it isn't the straight Rec.709 curve. Since log curves aren't meant to be WYSIWYG, the manufacturer can place 18% gray wherever they think they get the most dynamic range out of the curves. More often than not they place it farther down the curve to increase highlight retention, but this is not always the case.

The bottom line is that, barring artistic considerations, no matter where the manufacturer places middle gray it will most likely be moved toward about 43% in the grade, because the grade is where we make the image look good on a Rec.709 display.

VARIATION IN LOG CURVES

When it comes to log-encoded video, however, all bets are off as far as white point and middle gray—the engineers at camera manufacturers have made considered decisions about what seems to work best for their sensors. The point of log is to push the highlight values down to where they can be safely recorded, leave room for specular highlights and bring the darkest values up above noise, and this naturally has an effect on the mid tones as well. Where 18% falls in terms of the waveform monitor and code values varies according to camera manufacturers. Figures 10.26 through 10.29 show the waveform and code values for middle gray and 90% white for several log encoding schemes. None of them places 18% middle gray even close to 50%. Not surprisingly, the white point is much lower than it is in Rec.709. Several log and Rec.709 curves from various cameras are shown in Figures 10.26 through 10.29. Of course, the log curves from each camera are quite different in how they reproduce the grayscale; none of them puts the brightest white step at 100% or the pure black at 0%. The sample grayscales, which were created by Nick Shaw of *Antler Post* in London, show five stops above and five stops below middle gray, with a pure black patch in the center; each step of the scale goes up or down by a full stop. He says that he created these samples because "many people were not aware that the same level on a waveform meant something different depending on what camera was being used and what monitoring LUT was loaded."

For additional camera manufacturer grayscales in this manner as well as much more on linear, gamma, and log, see *The Filmmaker's Guide to Digital Imaging For Cinematographers, DITs and Camera Assistants*, also from Routledge.

Figure 10.26. Rec.709 doesn't have the dynamic range to represent all eleven steps of this grayscale. All of the grayscales are copyright Nick Shaw of *Antler Post* in London and are used with his permission. For more examples like this see *The Filmmaker's Guide to Digital Imaging* also by Blain Brown.

Figure 10.27. Arri's *LogC* is a much flatter curve, with the brightest patch (five stops above 18%) down at 75% and 18% gray well below 50% (as is true of all of these curves).

Figure 10.28. *S-Log2* crushes the black a bit more but still doesn't let pure black reach 0% and keeps the brightest white patch well below 100%.

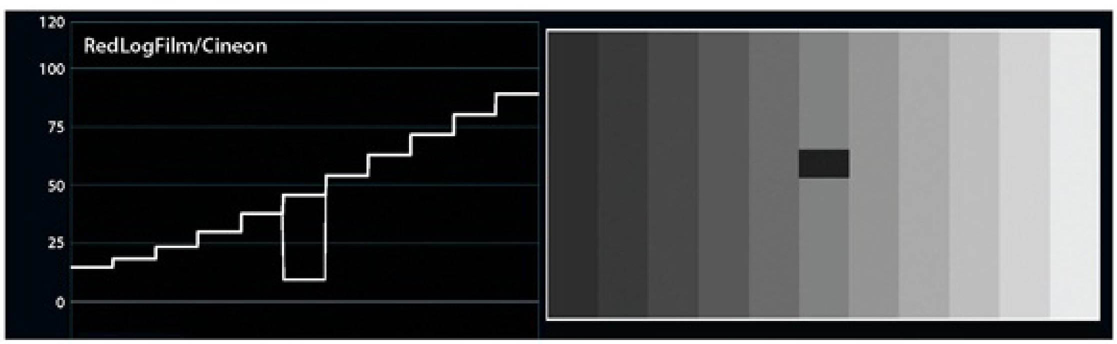


Figure 10.29. RedLogFilm/Cineon keeps the black level well above 0% and the brightest white well below 100% with steps that are fairly evenly distributed.

Figure 11.1. Image grading is an essential part of the look of *Mad Max: Fury Road*.

image control & grading

So far we've been looking at digital images from a purely technical point-of-view, which is important—if you don't master the technical side of imagemaking, the odds of creating powerful and meaningful shots are slim at best. Now it's time to start thinking creatively, but first a bit more on the technical side—a look at the tools we have available to control images.

In front of the camera:

- Lighting.
- Choice of lens.
- Filters.
- Mechanical effects (smoke, fog, rain, etc.).
- Choosing time of day, direction of the shot, weather, *etc*.

In the camera:

- Exposure.
- Frame rate.
- Shutter speed.
- Shutter angle.
- Gamma.
- White balance.
- Color space.
- Knee control.
- Black stretch.
- Matrix.

And of course, in shooting film, you have the option of choosing the film stock and perhaps altering the processing and changing the look by color correcting during printing. These options are not only available (in different form) when shooting HD or Ultra HD video, we now actually have much more control than before.

As always, we can dramatically change the nature of the image in the camera and afterwards. This has been true since the early days of film but with digital images, the amount of control later on is even greater. As one cinematographer put it, "The degree to which they can really screw up your images in post has increased exponentially.” But notice that the first sentence of this paragraph didn’t say “in post.” The reason for that is there is now an intermediate step.

Figure 11.2. Sliders in *Red-Cine-X Pro* offer control over every aspect of the image. Since Red cameras shoot RAW, controls include ISO and White Balance as well as selections for color space and gamma space; in this example, *RedColor2*, and *RedGamma2*.

AT THE DIT CART

A relatively new position on the crew is the *DIT—Digital Imaging Technician*. The DIT cart is not really postproduction, but it's not "in the camera" either—it's an in-between stage where there are all sorts of options. On some smaller productions, the DIT may be concerned with nothing more than downloading media files; in this case, they are more properly a *Data Manager, Digital Acquisition Manager, Data Wrangler* or similar terminology. On other productions the DIT cart might be a central hub of the creative process where looks are being created, controlled, and modified; where camera exposure and lighting balance are being constantly monitored or even directly controlled; and where the director, DP, and DIT are involved in intense conversations and creative back-and-forth concerning all aspects of visual storytelling.

These aspects of the visual image are what we are concerned with in this chapter: they are both camera issues and postproduction/color correction issues. In digital imaging, the dividing line between what is "production" and what is "post" is indefinite at best.

Figure 11.3. The DSC Labs *OneShot* photographed in daylight with the camera on Tungsten setting. Notice how the blue channel is very high and the red channel is very low on the waveform.

Figure 11.4. *DaVinci Resolve* has the ability to automatically color correct the *OneShot* and other test charts. After correction, the three color channels are at the same levels in the highlights and midtones and the color ofthe shot is normalized.

WHAT HAPPENS AT THE CART DOESN'T STAY AT THE CART

In some cases, the images from the camera receive no processing at all as they pass through the DIT station, and the process is more clerical and organizational—a matter of downloading, backing up, and making shuttle drives to deliver to postproduction, the production company, archives, *etc.* In other cases, the DIT spends a good deal of time rendering dailies for use by the director, different ones for the editor, and a third set for the VFX process. As previously noted, in some instances, there are substantial changes to the appearance of the image and even color correction and creating a *look*. In short, there is a wide range of functions at the DIT cart. In this chapter we're going to talk about only processes that affect the look of the images: in some cases just making them viewable and in other cases, applying creative choices that are part of the visual story.

So let's add to our list of image controls and bring in some of the topics we're going to talk about here:

- Changing *lift*, *gamma*, and *gain*.
- *Color correction*.
- Creating *LUTs* and *Look Files*.
- Applying *LUTs* to the camera.
- Applying *LUTs* to the monitors on the set.
- Creating *Color Decision Lists (CDLs)*.

Figure 11.5. How the hue offset wheels operate. This wheel is for *Lift*, so rotating the outer ring raises or lowers Lift and moving the trackball in the center alters the hue. Moving toward green raises green while Towering red and blue. The colors are laid out just as they are on the vectorscope. Now you see why it's so important to understand the color wheel. The trackball colors are essentially the same setup as a vectorscope: if the white balance is too blue, then pushing away from blue will work to make the color balance more neutral.

Figure 11.6. The *Tangent Wave* control surface for color correction. Instead of rings around the trackballs, this control has separate dials for *Lift*, *Gamma*, *Gain*, and *Offset*.

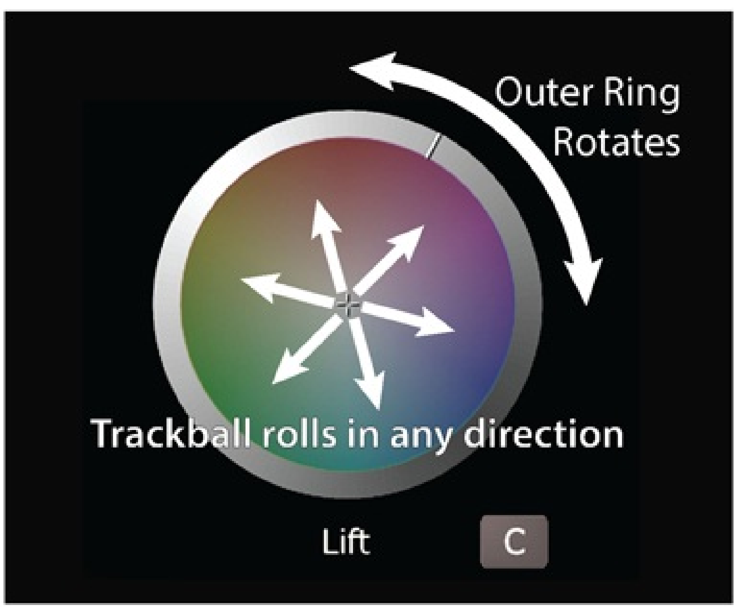


Figure 11.7. *Color Finale* from *Color Grading Central* is a plug-in for *Final Cut Pro X* that offers color wheels and other controls you would find in typical color correction software and "hardware. It can also do automated color correction with some test charts plus it has curve controls and a built-in LUT utility.

A few of these processes are the same as controls we have in the camera. The beauty of file-based digital workflow is that there is considerable choice not only in the type of image alterations available to the filmmakers but also a great deal of flexibility in choosing *when* to apply them to the image. Deciding when a look gets "baked in" is something to be thought through carefully and should be agreed to by all parties involved. Another consideration is deciding when the time and conditions are right for certain decisions to be made: sometimes the situation on the set is just not right for making these types of creative decisions, sometimes they are; the same may be true of a first-pass color correction or even the editing process— having the latitude to make creative choices without being stuck with them forever is a great thing, it means the creative process can be an ebb and flow of ideas instead of an endless series of relentless high-pressure deadlines.

COLOR CORRECTION AND COLOR GRADING

Although most people use the two terms interchangeably, some professionals do make a distinction between what is *color correction* and what is *color grading*. *Color correction* is a process where each clip (shot) is adjusted for "correct" exposure, color, and gamma. This is a slightly more straightforward process, but is an art form in its own way. The waveform monitor, vectorscope, histograms, and other evaluation tools are critical to this step, and most editing and color correction software have them built-in.

Grading is a creative process where decisions are made to further enhance or establish a new visual tone to the project including introducing new color themes, films stock emulations, color gradients, and a slew of other choices—in other words, the final look of the project. Since it is purely creative, there is no wrong or right, only what the DP, director, and colorist feel is appropriate for the story. The essential difference is that the color correction is more or less temporary while grading is more artistic, creative, and final, and by final we mean the *baked-in* result which is sent out for mastering and distribution.

Figure 11.8. The *Lift*, *Gamma*, and *Gain* controls on the *3 Way Color* page of *DaVinci Resolve*.

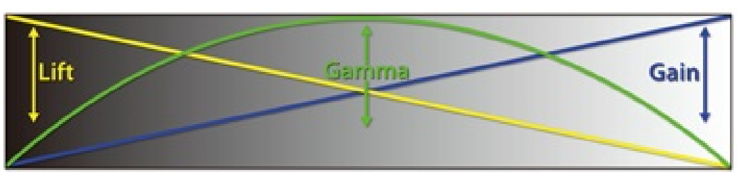


Figure 11.9. The effect of *Lift*, *Gamma*, and *Gain* controls. Although they affect different aspects of the image, there is always some overlap. Notice the "gate" effect with *Lift* and *Gain*—one end stays anchored while the other end is free to move through the entire range.

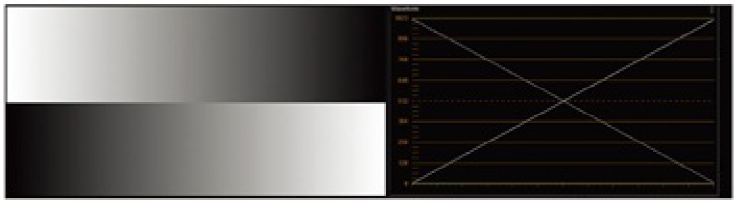


Figure 11.10. *Lift* at normal—no adjustments made to the crossed grayscale gradients— everything normal.

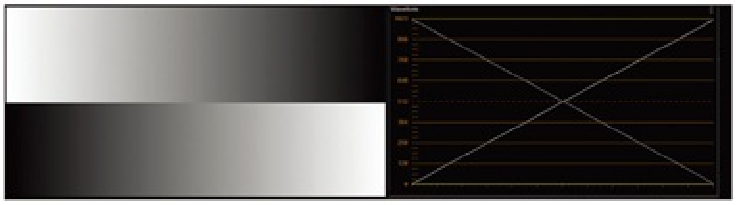


Figure 11.11. Raising *Lift* lightens the shadows but has little effect on the highlights, but some effect on the midtones— middle gray is raised substantially.

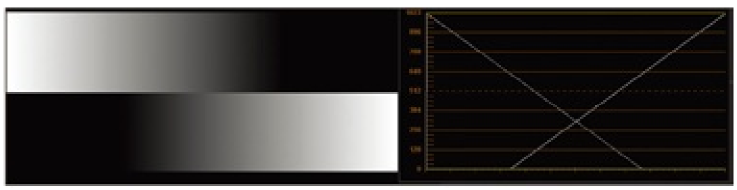


Figure 11.12. Lowering *Lift* depresses the dark tones; has some effect on lowering the midtones, but little effect on the highlights; middle gray is lowered.

CONTROLLERS AND CONTROL SURFACES

Video controls have been around since the earliest days of television; the types of controls we use today date from the introduction of film-to-video transfer which was originally called *film chain* (used for showing film footage and movies on television), but has been replaced by *telecine*, which transfers film to video, usually with color correction. Video to video has always been called *color correction*. The front ends of these systems are somewhat standardized with some elements common to all of them, especially the arrangement of three trackballs with surrounding rings as shown in Figure 11.5.

CONTROL PARAMETERS

All video grading software share some basic features, most prominent among these are the controls. They fall into certain basic groups:

- Lift/Shadows
- Gamma/Midtones
- Gain/Highlights
- Offset

Figure 11.13. Crossed gray gradient curves with *gamma* at normal. The gradients display normal contrast with even distribution of tones from black to white.

Figure 11.14. The same gradients with *gamma* raised; the effect is lower contrast and raised midtones. This mirrors the gamma curves we saw in the chapter *Linear, Gamma, Log*.

Figure 11.15. The gradients with *gamma* lowered; the effect is raised contrast. In both cases, there is still pure black at one end and pure white at the other end, but the midtones are altered significantly.

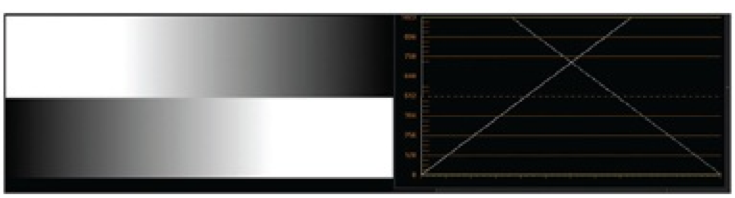


Figure 11.16. *Gain* raised; in this case, it causes clipping. This is just an example, raising the gain does not always cause clipping, although it is always a danger. Just as witn lift, the midtones are also changed.

Figure 11.17. *Gain* lowered. Highlights become gray. Note that in both examples, middle gray also moves up or down.

This may seem like a confusing profusion of terminology, and in fact, it is—there is no industry-wide standardization. Although there are some subtle differences in how various software packages implement them, in practice they are largely the same things with different names. It is important to remember that all these controls interact with each other to some extent. There are methods such as *power windows*, *secondary correction*, and *qualifiers* which target specific parts of the image or specific color but those are beyond the scope of this discussion as they are used in postproduction—here we are only introducing basic concepts as they might be used at the DIT cart.

LIFT/SHADOWS

Lift or *Shadows* affect the darkest areas of the scene. As you can see in Figures 11.10 through 11.12, *Lift* raises or lowers the darkest areas while being anchored at the pure white end; this means that it has the ability to take the shadows fully up or down the scale. While it will always have some effect on the midtones, the change it makes to the highlights is minimal. Think of it like a swinging gate seen from above: the part of the gate attached at the hinge hardly moves at all, while the part of the gate farthest from the hinge has complete range of movement. This applies to other aspects of image control as well, except in *log grading*, as we will see.

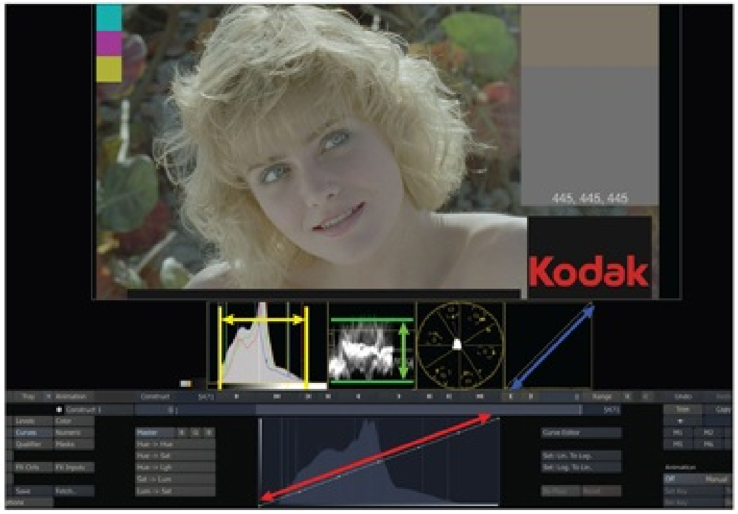


Figure 11.18. The Kodak *Marcie (LAD)* test chart in log space— dull and low contrast. Note how the waveform monitor (green notation) doesn't reach black on the low end or 100% on the high end. The effect indicator (blue notation) is a straight line showing that no changes have been made. The curve tool (red indicator) is also a straight line. This is in *Assimilate Scratch*.

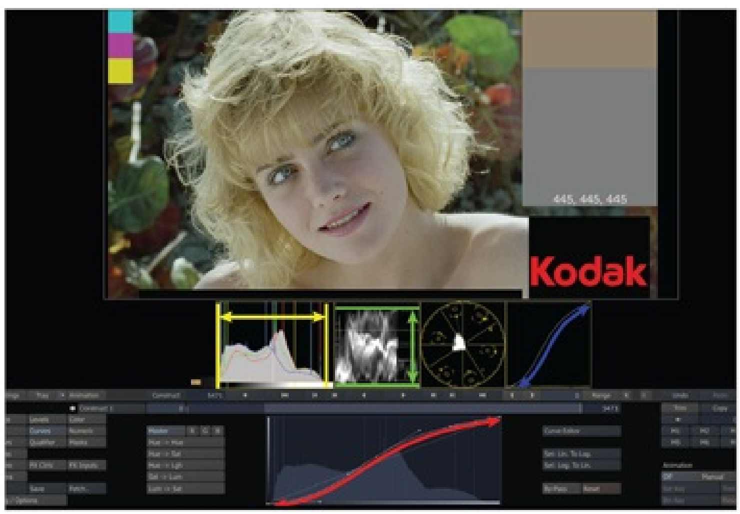


Figure 11.19. The curve tool has been used to create the classic S-curve, which takes the shadows down and the highlights up to bring the image back to normal contrast. The waveform (green) now fills the full range from 0% to 100%, the histogram (yellow) is now much wider and the effect indicator (blue) shows the changes that have been made.

GAMMA/MIDTONES

Gamma/Midtones affects the medium tones of the picture. In practice, they can be seen as contrast adjustment. As we noted in *Linear, Gamma, Log*, the term gamma is used a bit loosely in the video world, but it is largely the same concept here. In Figures 11.13 through 11.15, you can see how *Gamma* affects the middle range of the gray scale: it can take these tones up or down while pure black and pure white remain anchored; this gives it the bowed shape.

GAIN/HIGHLIGHTS

Gain (sometimes called *Highlights*) affects the brightest areas of the image the most (Figures 11.16 and 11.17). Similar to Lift, it is anchored at the dark end and so has very little effect there, while at the highlight end, it has freedom to range up and down the scale.

CURVES

In addition to separate controllers for each segment of the grayscale, most applications allow you to draw curves for the image—to independently manipulate the response curve, usually with *Bezier* controls. This can be a fast and efficient way to work. Figures 11.18 and 11.19 show an image adjusted by using *Curves* in *Assimilate Scratch*.

Figure 11.20. The *Log* controls in *DaVinci Resolve: Shadows*, *Midtones*, *Highlights* and *Offset* —which raises or lowers all tones at the same time.

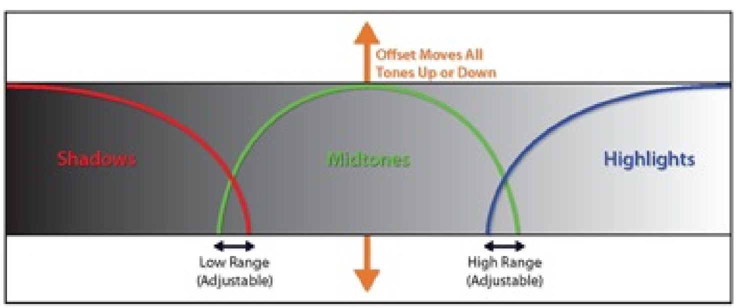


Figure 11.21. How log controls work: there is relatively little overlap between the control areas and how much they overlap is variable. Complete separation between them would leave gaps and create some odd images.

LOG CONTROLS

Some color correction software applications have a mode called *Log*. In *Resolve*, the Log mode has the controls *Shadow, Midtone, Highlight*, and *Offset*. It also includes *Low Range/High Range, Contrast, Pivot, Saturation*, and *Hue*. (As we have seen, the other mode in Resolve is *Three-Way Color*, which includes the wheels *Lift*, *Gamma*, *Gain*, and also *Saturation*, *Hue*, and *Luma Mix*.)

Three Way Color in Resolve has been described as "painting with a broad brush," while *Log* mode (Figures 11.20 and 11.21) allows much more targeted adjustments with far less overlap between shadows, midtones, and highlights. *Low Range* and *High Range* determines where the separation point will be for the shadows, midtones, and highlights. The following discussion focuses mostly on DaVinci Resolve—discussing every color correction software in detail is far beyond the scope of this book but the fundamental concepts remain the same, even though there are variations in specific applications. A version of *Resolve* is free, so it is readily available for anyone who wants to learn, experiment, and test. Of course, there are many other software packages and complete systems that offer control over the image parameters we're talking about here.

LOG OFFSET COLOR AND MASTER CONTROLS

The Log controls have one other difference from Lift/Gamma/Gain, and that is a fourth set of color balance and master wheel controls: the *Offset* control, which lets you make adjustments throughout the entire tonal range of the RGB channels. Offset raises or lowers the level of the entire scene equally. This means that you could take it into clipping at the top or below zero at the bottom. Offset is sometimes accompanied by a *Contrast* control which allows the user to alter the contrast of the signal around a selectable pivot point. In other words, the user can select a center pivot point and stretch or squeeze the entire signal above and below this point to allow for staying within limits while still moving everything up or down with the Offset control.

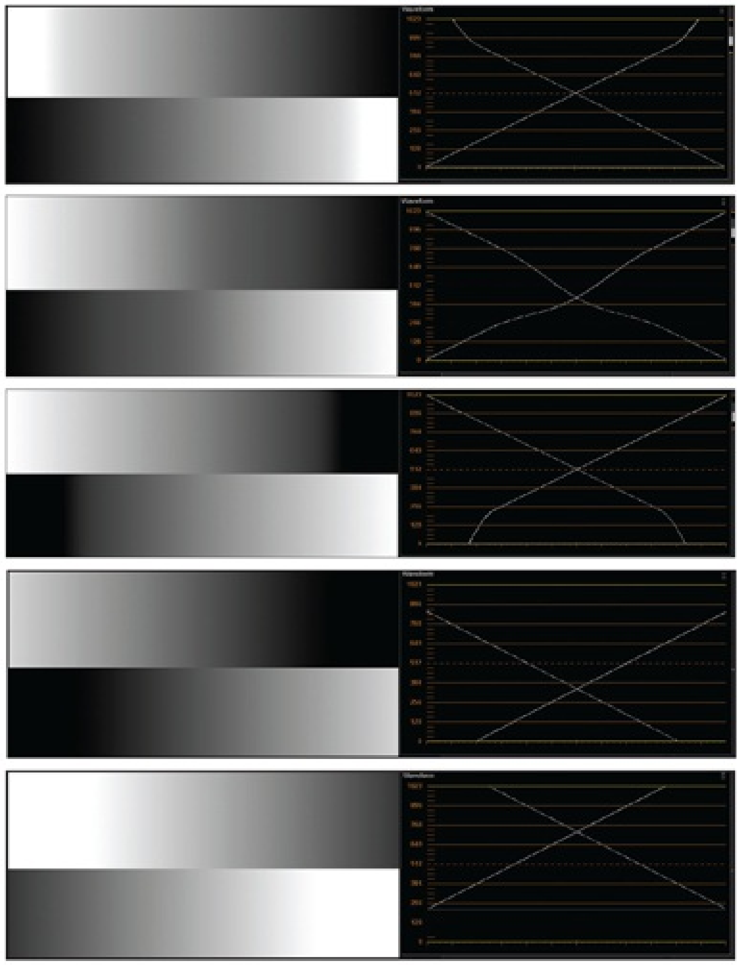


Figure 11.22. *Log* controls in *DaVinci Resolve*: (Top) *Highlights* raised. (Second from top) *Midtones* lowered. (Third from top) *Shadows* lowered. (Fourth from top) *Offset* lowered. (Bottom) *Offset* raised. Note that the three regions are affected with little change to the other parts of the image.

Low Range moves the border where the Shadows and Midtones meet. Lowering this parameter widens the range affected by the Midtones, and narrows the range affected by the Shadows. Raising this parameter narrows the Midtones and widens the Shadows.

High Range moves the border where the Midtones and Highlights meet. Lowering the High Range parameter narrows the range affected by the Midtones, and widens the range affected by the Highlights. Raising it narrows the Highlights and widens the Midtones.

Contrast allows the user to increase or reduce the distance between the darkest and lightest values of an image, raising or lowering image contrast. The effect is similar to using the Lift and Gain master controls to make simultaneous opposing adjustments. Bright and dark parts of the image are pushed apart or brought together around a center point defined by the *Pivot* parameter. Raising the contrast adds the familiar S-curve to the image: raising the highlights and lowering the dark tones while mostly leaving the midtones alone.

The *Pivot* control changes the center point around which dark and bright parts of the image are stretched or narrowed during contrast adjustment. Darker images may require a lower Pivot value to avoid crushing the shadows too much when stretching image contrast, while lighter images may benefit from a higher Pivot value to increase shadow density adequately.

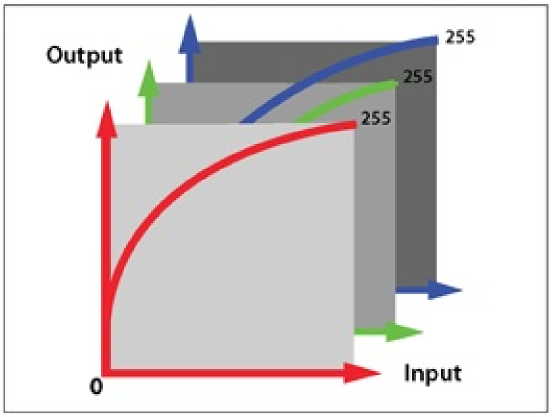


Figure 11.23. A 1D LUT has separate tables for each color channel, however for imaging purposes, it is almost always three 1D LUTs; one for each color channel. (Illustration courtesy of Light Illusion).

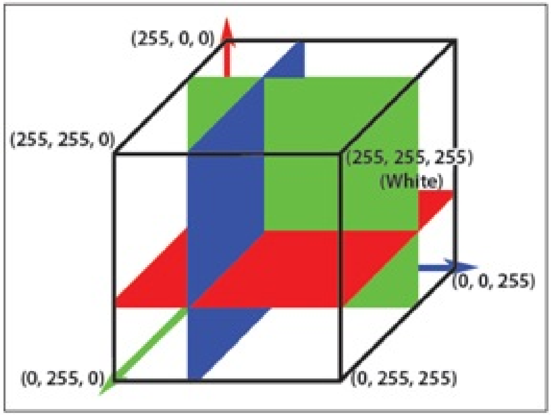


Figure 11.24. A *3D LUT* is a cube or lattice. The values of 0 to 255 in both of these are the digital color values. (Illustration courtesy of *Light Illusion*).

EXPORTING AND REUSING GRADES

Image manipulation in the camera or at the DIT cart is generally,(but not always, intended to be non-permanent and more of a rough draft. A few DP/director teams insist on making the look they develop on the set the final, but this isn't usually possible. Given the limitations of time, equipment, and viewing conditions, to do more than a quick dailies correction can be a risky operation, and it is seldom needed anyway. However, since dailies grading is usually going to incorporate the ideas of the DP and director, they need to be exportable and reusable. Exportable so that they can be sent on down the line to dailies for the producers or other parties and to various parties involved in postproduction—an important factor in keeping everybody "on the same page" for a production.

Unprocessed RAW dailies would give essentially no guidance to post houses as to what the DP and director intended for the scene, and they might start off in an entirely different direction, which may waste time, resources, and possibly lead to creative confusion. The *ASC-CDL* system is an attempt to address this idea of transporting the DP and director's ideas forward through the rest of the process. We talked about the ASC-CDL system and how it fits into the workflow in the chapter *Color*.

Being reusable is also important so that the on-set grading doesn't need to be repeated from day to day or scene to scene; especially useful if only certain types of scenes get a particular color correction, as is often the case. Repeatability is also necessary because our perception of a particular look can "drift" over time. This is a phenomenon often noticed in color grading a long project such as a feature. The first time a particular type of scene gets graded, the director and DP may go for a fairly extreme look. As the days go by, eyes and brains tend to adjust to that look and the next time that type of scene comes up; it is not unusual for them to want to push it to a more and more extreme look. The result can sometimes be more than they really intended when they first started and worse, can create an inconsistency in the look.

LUTS AND LOOKS

A *LUT* is a *Look Up Table*, a way to associate (or replace) one value with another value without mathematical calculation. You can think of it as an algorithm for all the pixel values already precalculated and stored in memory. The biggest difference between a LUT and a Look is that Looks are primarily intended for use in the camera; also, it is usually not possible to change individual parameters on a LUT.

1D LUTS

A basic type of LUT for video is three 1D LUTs, one for each color channel (Figure 11.23). There is no interaction between color channels. As an example a 3X (three channels) 1D LUT could be like this:

R,G,B
3, 0, 0
5, 2, 1
9, 9, 9

This means that:
For input value of 0 for R, G, and B, the output is R=3, G=0, B=0.
For input value of 1 for R, G, and B, the output is R=5, G=2, B=1.
For input value of 3 for R, G, and B, the output is R=9, G=9, B=9.
LUTs consist of long lists of these sets of numbers.

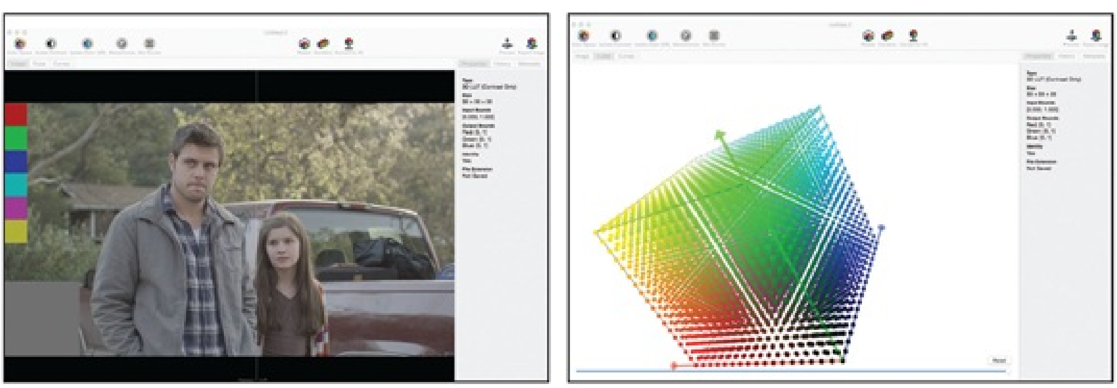


Figure 11.25. A log image ungraded as shown in Lattice, a versatile LUT creation, and manipulation application. (Top, right) The cube shows the unaltered distribution of color tones in the image.

Figure 11.26. The same image with a warm LUT applied. The split-screen display shows the unaltered image on the left and the image with a warm LUT applied on the right. (Above, right) The resulting cube shows how the LUT changes the distribution of color tones in the image. (Courtesy Greg Cotton at Lattice/VideoVillage.co)

3D LUTS

A 3D LUT is more complex but also allows for more control of the image (Figure 11.24). 3D LUTs are useful for converting from one color space to another. It applies a transformation to each value of a *color cube* in RGB space (Figures 11.25 and 11.26 show color cubes). 3D LUTs use a more sophisticated method of mapping color values from different color spaces. A 3D LUT provides a way to represent arbitrary color space transformations, as opposed to the 1D LUT where a value of the output color is determined only from the corresponding value of the input color. A 3D LUT allows for *cross-talk* between color channels: a component of the output color is computed from all components of the input color providing the 3D LUT tool with more power and flexibility than the 1D LUT tool. Because it would be impossibly large to include every single value for each channel, the number of *nodes* is limited. With 17 coordinates per axis (a typical size) there are 4,913 nodes total. Increasing to 257 per axis results in 16,974,593 total. For this reason, only nodes are precisely calculated; between nodes, the value is interpolated, meaning it is less precise. While 1D LUTs are useful for adjusting contrast and gamma per color channel, 3D LUTs are usually more flexible— 3D LUTs can cross-convert colors between channels, alter saturation, and independently control saturation, brightness, and contrast. A 1D LUT only remaps values: you can shift red from an input value of 112 to 124, for example, but you're only changing red's brightness for that one value. A 3D LUT uses three coordinates per color, so rather than change the strength of only one channel it is instead changing the hue entirely. Instead of more or less red gain, a 3D LUT may change red from orange-ish to blueish.

Figure 11.27. Pomfort *LiveGrade* is a widely used application for creating ana managing LUTs. It can also control devices such as LUT boxes and monitors—the panel on the left. (Courtesy Pomfort).

LUT FORMATS

As is typical with new technology, there is little to no standardization between LUTs devised by different parties and so they come in a variety of formats, some of which are mutually compatible and some of which are not. As a result different software packages can read some types of LUTs and not others; although application designers generally strive to be more inclusive with each iteration of their programs.

PROPER USE OF LUTS IN COLOR CORRECTION

Mike Most says this about LUTs: “The LUT approach is often misunderstood by those who feel, for some reason, that what a LUT is supposed to do is yield a ‘perfect’ starting point for every image. That is not the case. What a LUT does is transform the log curve back to a proper gamma corrected curve based on the particular display device being used, most often a monitor. In the case of an image that is a bit underexposed, this will likely cause the blacks to be crushed by the LUT, and in the case of an overexposed image, it will cause the whites to be clipped. This is where the misunderstanding comes into play. The LUT is not meant to be used as the first correction in a grading pipeline. If you place the LUT after an initial correction, you can then raise the blacks or lower the whites on the original log image prior to it being transformed by the LUT. The LUT will still do what it’s supposed to do, and you then have the option of grading prior to the LUT or after it as needed. This is the ‘secret’ that many professional colorists (especially those who work in the digital intermediate world) know, and few inexperienced ones seem to understand. A LUT is not a color correction, just as a log image is not an image. It is a transform, and the log image is a container. The image needs to be ‘processed’ by the LUT in order to appear properly to the eye.”

Figure 11.28. Pomfort’s ASC-CDL and LUT controls. (Courtesy Pomfort).

VIEWING LUTS

One variety is the *Viewing LUT*, which is designed to make a camera's output look good during shooting or in the case of RAW and log footage to make it viewable so that it makes sense to people who are not accustomed to viewing scenes in RAW or log mode. Often they are as simple as converting a flat, low-contrast S-Log, C-Log or LogC feed into a normal-looking Rec.709 image, while other LUTs also will reflect the creative decisions of the DP. The DIT on or near the set often will create a Viewing LUT for the DP and director's monitors. These LUTs can then be sent to postproduction to create dailies and to give the colorist a starting point for the final grade. The DP can also create an *ASC Color Decision List*, which essentially says to post "This is what we intended with this image."

It is important to remember that viewing LUTs, particularly those that convert log to Rec.709, are not going to be perfectly representative of the picture because you are fitting a high dynamic range image into a smaller dynamic range. While it may make for a pretty picture on the monitor, it may be misleading in terms of exposure and tonal rendering. When viewing a log image without a viewing LUT, unless you have a lot of experience with log space, it can be difficult to evaluate exposure because there is very little contrast in these images and, of course, even if you have a lot of experience, you will be mentally adjusting for what you see on the screen—another term for this might be *guessing*. The nice thing about log is that it is more forgiving in terms of highlights. You still need to ensure an overall baseline for consistency and continuity. Using a LUT as a color space transformation of the log stream to non-destructively put it into a more normal contrast range is one method of doing this.

Viewing LUTs on the set are very useful tools, not difficult to create and are easy to apply in most situations; also, some cameras have built-in viewing LUTs. The real problem is employing them on the set; in particular getting them to show up on the monitors used by the DP, director, and the rest of the crowd at *video village*. Some cameras allow for the application of a LUT or Look to the monitor output, but frequently, a piece of hardware, called a *LUT Box*, is used in between the camera and a monitor to insert the LUT into the viewing stream; also, some monitors have built-in LUT boxes. Examples include *Blackmagic Design HDLink Pro, Cine-tal Davio*, and *Pandora Pluto*. Software like *Pomfort LiveGrade, cineSpace* from *THX* and *Light Illusion LightSpace CMS* can be used to combine Calibration LUTs and Viewing LUTs, which can be a tricky process.

LUTS AND LOOKS: WHAT'S THE DIFFERENCE?

Some cameras have the ability to load in special files, called *Looks*, that essentially are LUTs. The distinction between a *Look* and a *LUT* is that these *Look Files* are used in-camera, whereas LUTs can generally be applied anywhere in the workflow. It is mostly just a matter of manufacturer terminology.

Figure 11.29. An 85B. (Photo courtesy Hoya Filters).

Figure 11.30. An *80B* blue filter. (Photo courtesy Hoya Filters).

Figure 11.31. *81A* for slight warming effect. (Photo courtesy Hoya Filters).

Figure 11.32. A scene shot through glass with no polarizer. (Photo courtesy of Tiffen).

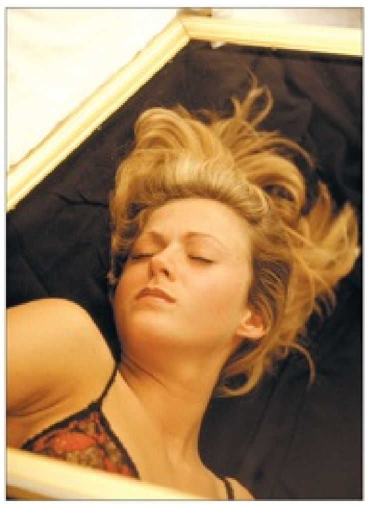


Figure 11.33. With a polarizer—in this case, the Tiffen *UltraPol*®. (Photo courtesy of Tiffen).

CONTROLLING THE IMAGE IN FRONT OF THE LENS

Let’s talk about some of the non-digital methods of achieving the specific look you’re going for.

- Lighting
- Choice of lens
- Filters
- Mechanical effects (smoke, fog, rain, etc.)
- Choosing time of day
- Direction of the shot
- Weather

CAMERA FILTER TYPES

There are a few basic types of filters:

- Diffusion
- Exposure (neutral density)
- Focus (diopters and split-diopters)
- Color balance
- Color alteration
- Effects

DIFFUSION AND EFFECTS FILTERS

There are many types of diffusion filters, but they all have one common purpose: they slightly alter the image to make it *softer* or more diffuse or to reduce the contrast. They do it in a number of ways and with a variety of effects (Figures 11.41 through 11.49). Nearly all diffusion filters come in *grades*: 1, 2, 3, 4, 5, or 1/8th, 1/4, 1/2, 1, 2, and so on. Most rental houses will send them out either as a set or as individual rentals. All types of filters usually come in a protective pouch and often have some soft lens tissue wrapped around them inside the pouch to make it easier to handle the glass without adding fingerprints that need to be removed later.

Diffusion filters are a very personal and subjective subject. Besides glass or resin filters, which are placed in front of the lens (or in some cases behind the lens or even in a slot the middle of it), other methods such as nets can be used. An older type of filter that dates back to the early days of the studio system but that is still popular today are the Mitchell diffusions, which come in grades A, B, C, D, and E.

There are some things to be aware of when using diffusion filters. They will give different degrees of diffusion depending on the focal length of the lens being used—a longer focal length lens will appear to be more heavily diffused. Some DPs drop down to a lower degree of diffusion when changing to a longer lens. Tiffen, a major manufacturer of camera filters, has created digital filters in its *Dfx* software, which can be used in postproduction to reproduce the effect of their glass filters. Be careful about judging the effect of diffusion filters on a small on-set monitor, which can be deceiving.

NETS

Another form of diffusion is *nets* or *voiles* (a coarser mesh). Many cinematographers use silk or nylon stocking material, which can have a very subtle and beautiful effect. Nets vary in their diffusion effect according to how fine their weave is. Nets can come in filter form sandwiched between two pieces of optical glass, or they might be loose pieces cut and attached to the front or rear of the lens. Camera assistants always have scissors in their kit for this and other tasks. Attaching a net to the rear of the lens has several advantages. A net on the front of the lens can come slightly into focus with wider lenses that are stopped down. A net on the rear of this lens is less likely to do this, although it still can happen. Also, the diffusion effect will not change as the lens is stopped down or the focal length changes on a zoom. Attaching a net to the rear of the lens must be done with great caution as there is danger of damaging the exposed rear element of the lens or of interfering with the spinning reflex mirror. A hidden tear or run when mounting the lens will make the diffusion effect inconsistent. Putting a net on the rear should be done with easily removable material such as *transfer tape*—also sometimes called *snot tape*—a two-sided soft, sticky tape that is also used for attaching lighting gels to *open frames* (Figure 11.34).

CONTRAST FILTERS

Various filters are used to reduce or soften the degree of contrast in a scene. These typically work by taking some of the highlights and making them "flare" into the shadows. Traditionally these were called "lo-cons." There are a number of varieties.

NEUTRAL DENSITY FILTERS

Neutral density filters are used to reduce overall exposure without affecting color rendition. They can be used in extremely high-illumination situations (such as a sunlit snow scene or a beach scene) where the exposure would be too great or where less exposure is desired to reduce the depth-of-field. Also known as *Wratten #96*, the opacity of ND filters is given in *density units* so that .3 equals one stop, .6 equals two stops, .9 equals three stops, and 1.2 equals four stops. If you combine ND filters, the density values are added.

Neutral density filters combined with 85 correction filters (*85N3*, *85N6*, and

85N9) are a standard order with any camera package for film exterior work. In video, of course, we can use presets or custom color balance the camera to suit individual lighting conditions. NDs stronger than 1.2 are quite common now. They commonly go up to 2.1. This is necessary when shooting with HD cameras with high native ISOs. Unless NDs are made using a process that employs thin layers of metal coatings (*Panchros, Formatt Firecrests, Mitomo Tru-eNDs*), there will be color shifts, especially beyond 1.5 where the amount of light passes drops below 1/1,000,000th.

Figure 11.34. The steps of applying a net to the rear element of a lens using *snot tape* demonstrated by veteran camera assistant Mako Kowai. (Photos courtesy MakoFoto).

Table 11.1. Conversion factors for the 85 series of warming filters.

FILTER	CONVERSION	MIRED	EXP. LOSS
85A	5500 >3400	+112	2/3 stop
85B	5500 >3200	+131	2/3 stop
85C	5500 >3800	+81	1/3 stop

Table 11.2. Conversion factors for the 80 series of cooling filters.

FILTER	CONVERSION	MIRED	EXP. LOSS
80A	3200 >5500	−131	2 stops
80B	3400 >5500	−112	1 2/3 stops
80C	3800 >5500	−81	1 stop
80D	4200 >5500	−56	1/3 stop

Figure 11.35. Various grades of diffusion—the Schneider *Black Frost*® series. (Photo courtesy of Schneider Optics).

EFFECTS FILTERS AND GRADS

There are many kinds of special effects filters, ranging from the most obvious to the more subtle. *Sunset* filters, as an example, give the scene an overall orange glow. Other filters can give the scene a color tone of almost any sort imaginable: from moonlight blue to antique sepias (Figures 11.36, 11.38, and 11.39).

In addition to filters that affect the entire scene, almost any type of filter is also available as a *grad*. A grad is a filter that starts with a color on one side and gradually fades out to clear or another color (11.39). Also commonly used are *sunset grads* and blue or magenta grads to give some color to what would otherwise be a colorless or “blown-out” sky (Figure 11.40). Grads can be either *hard edge* or *soft edge*, denoting how gradual the transition is.

The most commonly used types of grads are *neutral density filters*, which are often used to balance the exposure between a normal foreground scene and a much hotter sky above the horizon. ND grads come in grades of .3 (one stop at the darkest), .6 (two stops), .9 (three stops), 1.2 (four stops), and higher. Be sure to specify whether you want a hard or soft cut because there is a considerable difference in application. Whether you need a hard or a soft cut will also be affected by what focal length lens you are going to be shooting with. A longer focal length lens is better suited to a hard edge grad, while the hard edge would be visible on a wider lens. Grads can be used either horizontally or vertically. If the matte box has a *rotating stage*, they can even be diagonal.

Figure 11.36. A landscape scene without a filter (left) and with a LEE Sepia 2® and .75ND filters. (Photo courtesy David Norton and LEE Filters).

Figure 11.37. No polarizer (left) and with polarizer. (Photo courtesy David Norton and LEE Filters).

Figure 11.38. With a *LEE Sunset 2*® filter. (Photo courtesy David Norton and LEE Filters).

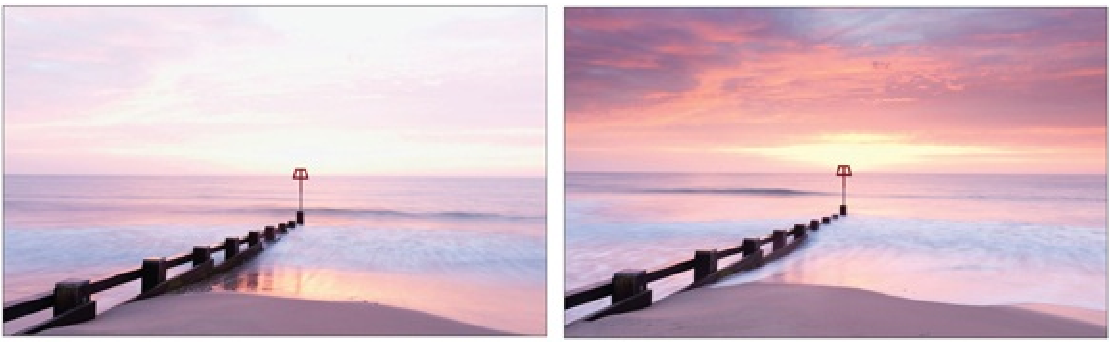


Figure 11.39. Without (left) and with (right) a *LEE 0.9 Neutral Density Hard Grad*®. (Photo courtesy David Norton and LEE Filters).

Figure 11.40. Using an *ND Grad* to bring the sky and hill into balance with the foreground objects and reflections. Right is without a filter and far right is with a polarizer. (Photo courtesy Tiffen).

CONVERSE FILTERS

Conversion filters work with the blue and orange ranges of the spectrum and deal with fundamental color balance in relation to the color sensitivity of the emulsion. Conversion filters affect all parts of the spectrum for smooth color rendition. (*LB) Light Balancing* filters are for warming and cooling; they work on the entire *SED (Spectral Energy Distribution*) as with the conversion filters, but they are used to make smaller shifts in the Blue-Orange axis.

CAMERA LENS FILTERS FOR COLOR CORRECTION

Color compensating filters (CC) are manufactured in the primary and secondary colors. They are used to make corrections in a specific area of the spectrum or for special effects, although there is always some overlap into adjoining wavelengths. Don’t make the mistake of trying to correct color balance with CC filters. Primary filters work in a limited band of the spectrum and correct within a narrow range of wavelengths centered on the key color. Since CC filters are not confined to the Blue-Orange axis, they can be used to correct imbalances in the Magenta-Green axis, such as occur with fluorescent lamps and industrial lamps. CC-30M (M for magenta) is a good starting point for most uncorrected fluorescent sources. As a lighting gel, it is known as *Minus-Green*—it’s still magenta, but it is used to reduce the amount of green in the light.

WARMING AND COOLING FILTERS

The *80 series*, which are blue conversion filters, are used to convert warm sources such as tungsten lights so that they are suitable for use with daylight film (Figure 11.30). The 81 series of warming filters (81, 81A, 81B, 81C) increase the *warmth* of the light by lowering the color temperature in 200K increments (Figure 11.31). For cooling, the 82 series works in the same fashion, starting with the 82, which shifts the overall color temperature by +200K. As with most color temperature correction filters, excess magenta or green are not dealt with and must be handled separately. Table 11.1 show the Wratten 85 for warming, and Table 11.2 shows the 80 series filters for cooling. Wratten is a system of filter classification by Eastman Kodak. *Corals* are also a popular type of filter for degrees of warming.

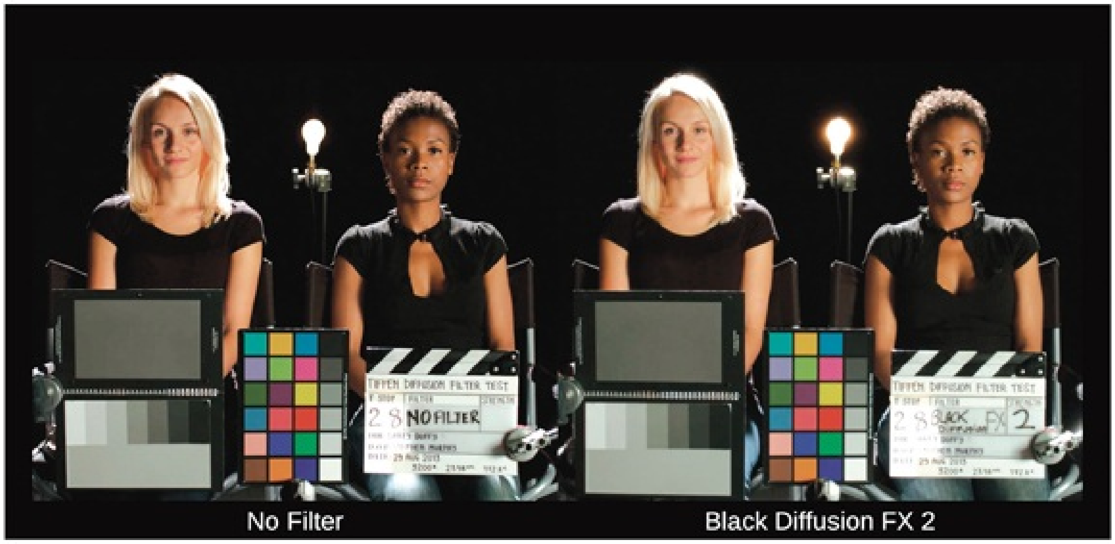


Figure 11.41. Tiffen's *Black Diffusion/FX®* series gives a silky-smooth look to textured surfaces. Suppresses facial blemishes and wrinkles, while maintaining a clear, focused image on the outline of larger objects. They produce minimal highlight flare. Caution is advised if you stop down with lights in the image area as the filter's pattern may be seen. (Photo courtesy Tiffen).

Figure 11.42. Tiffen's extremely popular *Black Pro-Mist®;* in this example a grade 1/2. The Pro-Mist family of filters creates an atmosphere by softening excess sharpness and contrast and creates a beautiful glow around highlights. The filters also come in warm and regular Pro-Mist. Some people call the regular version "white Pro-Mist." The Black version shown here provides less contrast reduction in the shadow areas, producing a more subtle effect. (Photo courtesy Tiffen).

Figure 11.43. The *Warm Black Pro-Mist*® combines *Black Pro-Mist*® and an *812* filter to add a warming effect. (Photo courtesy Tiffen).

Figure 11.44. The Tiffen *Digital Diffusion/FX*® series are resolution reducing filters which don't introduce color characteristics into the image. They are designed to reduce high-frequency resolution, to make people look great in HD/UHD without evidence of filtration as only the fine detail is removed or reduced, while the larger elements within the image remain sharp. (Photo courtesy Tiffen).

Figure 11.45. Tiffen's *Warm Soft FX*® series of filters combines *Soft/FX*® and the Tiffen *812*® warming filter. It smooths facial details while adding warmth to skin tones. (Photo courtesy Tiffen).

CONTRAST CONTROL IN BLACK-AND-WHITE

Since color filters transmit some colors and absorb others, this makes them useful in controlling contrast in black-and-white images. Most scenes contain a variety of colors. The sky may be the only blue area in a landscape shot, a field of grass may be the only largely green element in a scene, and so on. We can use this to advantage even though the shot is black-and-white.

The basic principle of contrast control filtration in black-and-white cinematography is that a filter *lightens* colors in its own area of the spectrum and *darkens* the complementary (opposite) colors. A filter passes light that is its color and absorbs light that is not its color. How strong an effect it has is the result of two factors: how strong the color differences of the original subject are and how strong the filter is. The scene we are shooting is the result of the colors of the objects themselves and the colors of the light that falls on them. Color filters only increase or decrease contrast on black-and-white film when there is color difference in the scene. When a filter is used to absorb certain colors, we are reducing the total amount of light reaching the film. We must compensate by allowing more overall exposure. The exposure compensation necessary for each filter is expressed as the *filter factor*. The simple rule for black-and-white filters is: expose for the darkest subject in the scene that is substantially the same color as the filter and let the filter take care of the highlights.

POLARIZERS

Natural light vibrates in all directions around its path of travel. A *polarizer* transmits the light that is vibrating in one direction only. *Polarizers* serve a variety of functions. Glare on a surface or on a glass window is polarized as it is reflected. By rotating a polarizer to eliminate that particular direction of polarization, we can reduce or eliminate the glare and surface reflection (Figures 11.32 and 11.33). *Brewster's angle*—56° from normal, or 34° from the surface — is the zone of maximum polarization. A polarizer can be used to darken the sky. Maximum polarization occurs at about 90° from the sun. Care must be taken if a pan or tilt is used because the polarization may change as the camera moves. If the sky is overcast, the polarizer won't help much. Polarizers reduce transmission, generally at least 1 2/3 to 2 stops.

Circular polarizers aren't really circular—some cameras (in particular, prism cameras, or DSLRs that use prisms for exposure and auto focus) don't like linear (regular) polarizers because prisms introduce some amount of polarization, and stacking polarizers can do bad things. Circular polarizers basically de-polarize the light on the back side of the filter by giving it a 1/4 wave spin. Messing it up in this way means that it passes through prisms without any side effects.

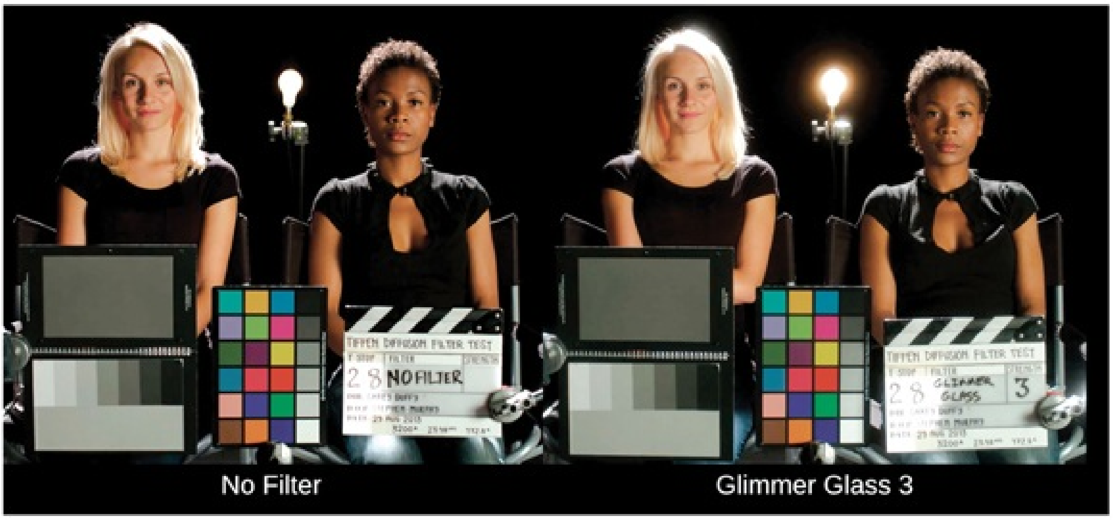


Figure 11.46. Tiffen's *Glimmer glass®* is a diffusion filter that softens fine details by adding a slight reduction of contrast while adding a mild glow to highlights. Ira Tiffen comments that, "in addition to the Glimmerglass diffusion effect, it also glitters visibly on the front of the lens, which can sometimes add confidence to an actor's performance, since they can clearly see that the filter is in place on the lens to make them look their best. This was an original concept by Bill Wages, ASC." Many of the filters shown here were developed by Ira Tiffen. (Photo cour tesy Tiffen).

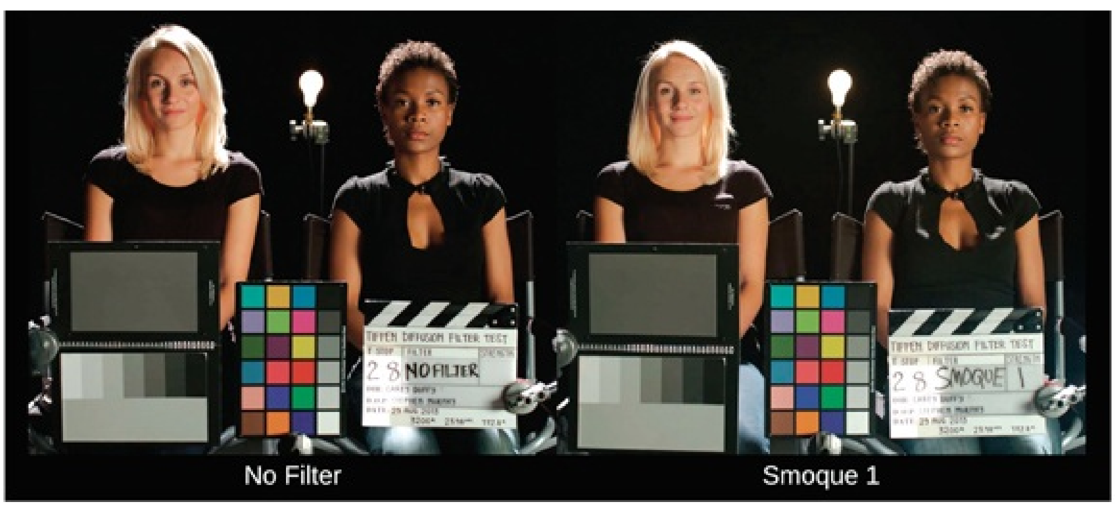


Figure 11.47. The *Smoque®* set of filters creates the look and feel of a smoky veil over the image. This look cannot produce the effect of that of real smoke that introduces the ability to create shafts of light when real smoke is backlit, but it adds a subtle touch of atmosphere where special efx smoke machines or hazers can not be used. (Photo courtesy Tiffen).

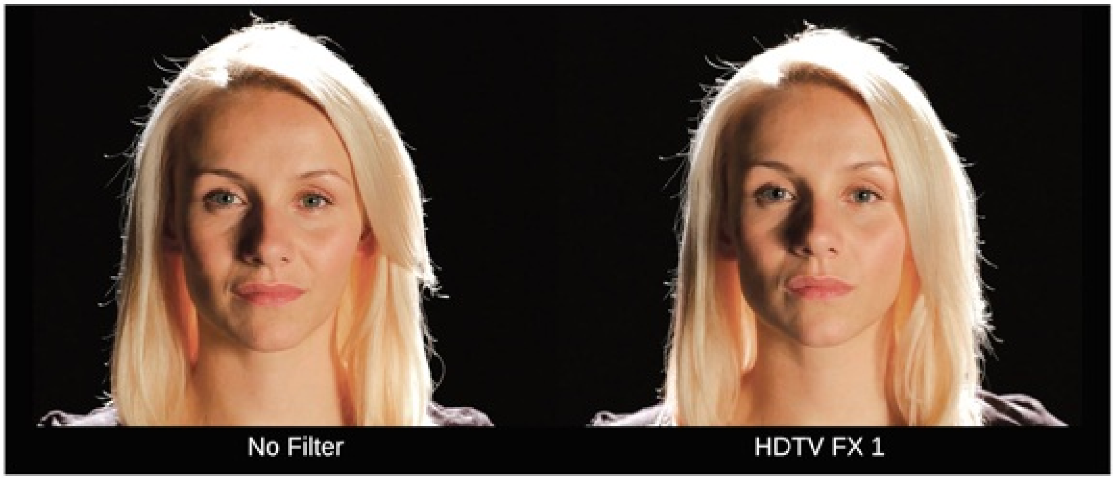


Figure 11.48. HDTV FX® filters are designed to address contrast and sharpness issues associated with HD and UHD shooting. (Photo courtesy Tiffen).

Figure 11.49. Sometimes combinations of filters are needed to produce the exact effect the DP is going for. This example shows a *Soft FX® 1/2* together with an *Ultra Con® 1*. Tiffen's *Ultra Cons®* work by lowering contrast uniformly throughout the scene, so that shadow areas reveal more detail without flare or halation from light sources or bright reflections. (Photo courtesy Tiffen). Registered trademarks are the property of their respective owners.

IR FILTERS

As we discussed previously, some digital sensors are subject to IR contamination, which means that they are sensitive to infrared wavelengths to an extent that can significantly affect the look of a shot, particularly in day exteriors. IR density filters prevent this by blocking the wavelengths that cause problems. Called *Hot Mirror* or *IR* filters, they are available in varieties that start cutting off infrared at different points of the spectrum—they were mostly needed by early Red cameras. Some cameras have built-in IR protection; see Figure 7.23 in *Cameras & Sensors*. It's not so much that sensors are subject to IR contamination as sensors need to see a certain amount of far red (red on the edge of the visible spectrum) to make flesh tone look rich and healthy. Cutting that out makes people look slightly dead. ND filters cut visible light, but their effect drops off at the edge of visible light, and that's where far red lives. The upshot is that ND filters block most visible light but are transparent to far red. Putting in an ND 1.2 filter blocks four stops of visible light but doesn't block far red at all, so opening up the stop allows four stops more of the far red to pass to the sensor. This isn't a camera issue but a dye filter issue.

Figure 12.1. Twelve light *Maxi Brutes* (a PAR group light) and *HMI PARs* on a bridge for the film *I Am Legend*. At the far left are *Alpha 18K* HMIs. (Photo by Michael McDonough).

THE TOOLS OF LIGHTING

Cinematographers do not need to know all the details of how each piece of lighting equipment works, but it is essential that they know the capabilities and possibilities of each unit, as well as the limitations. A great deal of time can be wasted by using a light or piece of grip equipment that is inappropriate for the job.

Motion picture lights fall into several general categories: *HMIs*, tungsten *Fresnels*, tungsten *open face lights*, *LED* lights, *color-correctflu- orescents*, *practicals*, and *sunguns*. Fresnel means a light that has a Fresnel lens, capitalized because it is named for its inventor, Augustin-Jean Fresnel. There are also variations, such as HMI PARs and LED Fresnel units.

Figure 12.2. Two *Cineo Mavericks* with their *remote phosphor* screens, in this case, 5600K or daylight balance. (Photo courtesy Michael Sanders).

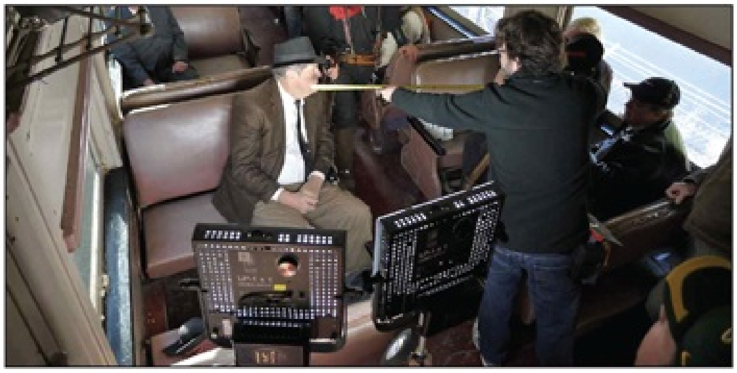


Figure 12.3. Two LED light panels in use on a moving train. Not only are they compact and generate almost no heat, they can also run off of batteries for extended periods of time—especially useful for situations like this where AC power may not be available. (Photo courtesy Adam Wilt).

COLOR BALANCE

Lighting units can generally be divided into those that output *daylight balance* (5500K) or *tungsten balance* (3200K) light. In lighting "K" has two meanings—when discussing color temperature, it means *degrees Kelvin* (see the chapter *Color*), and when talking about a lighting unit, it means one thousand, for example, a *2K* is a 2,000-watt light, a *5K* is a 5,000-watt light, and so on.

COLOR RENDERING INDEX

Lights are classified according to *Color Rendering Index (CRI*), which is a measure of the ability of a light source to reproduce the colors of various objects faithfully in comparison with a natural light source. This means that a light with a low CRI will not render colors accurately. A CRI of 90 or above (on a scale of 0 to 100) is considered necessary for film and video work, and also for still photography. CRI is an older standard and is not well adapted to modern singlesensor cameras; also, it was only designed to measure continuous spectrum light. Two new standards have been developed: *CQS (Color Quality Scale*) and *TLCI (Television Lighting Consistency Index*) and they perform the same function as CRI, although neither one solves all the problems of measuring the quality of discontinuous spectrum lights.

DAYLIGHT/TUNGSTEN SOURCES

While most lighting units are inherently either daylight or tungsten, some types of lighting units can easily be changed to either color or, in some cases, changed to greenscreen, fluorescent, or many other color balances. This is generally done by changing the bulbs. *Bicolor* LEDs have both tungsten and daylight bulbs and color is changed by dimming one group up or down. With *remote phosphor* LEDs, it is done by changing the phosphor screens (Figure 12.2).

LED LIGHTS

A new and very popular source are *LED* lights (Figures 12.2, 12.3, 12.4, and 12.5), which are small and extremely energy efficient, which also means that they produce much less heat than tungsten lights (where the electricity produces 90% heat and only 10% light). LEDs have been incorporated into all types of units. For lighting fairly close to the scene, they have many advantages. Their compact size means they can be hidden in many places on the set and also makes them easier to handle and rig on location. There are also many LED lights that run on batteries—these can be very useful for handheld work, camera mounting, and other conditions where AC power may not be available. LED units now come in a wide variety of types—from small units that can mount on the camera, up to large units with very high output and nearly every type of fixture, and even Fresnel units up to the equivilent of a 10K (Figure 12.4).

REMOTE PHOSPHOR LEDS

All LED lighting units for filmmaking contain multiple *light-emitting diodes*. However, variations in manufacturing processes can result in LEDs having differences in their color and output. LED manufacturers have used *binning* to deal with this. LEDs are tested and then categorized into one of a number of groups, or bins, according to the characteristic of light produced—since there are many rejects, this is one of the reasons for the high cost of LED lights.

To get away from the need for binning, some manufacturers came up with *remote phosphor* technology. While conventional white LEDs offer the advantage of providing an integrated device with a known white-light output, they operate as bright point sources of light, which causes the uniformity problems alluded to above in applications with a large light-emitting surface.

Remote phosphor technology employs a transparent surface onto which a phosphor coating is applied. These phosphors are excited at precise wavelengths; in this case, with LEDs completely separated from the phosphor substrate, resulting in very stable high-CRI white light. Color temperature remains consistent because the phosphors are not subject to heat degradation, unlike typical white LEDs.

Figure 12.4. This Mole-Richardson LED unit matches the output of a Fresnel 10K but uses only a fraction of the power.

Figure 12.5. Like many bicolor LED panel lights, this unit from CAME-TV features a dimmer and also a color temperature control. This one also has an LED panel that displays the dimmer and color status of the light. (Photo courtesy CAME-TV).

Figure 12.6. *Wall* units by *Fill-Lite* on a commercial for exercise equipment. The extremely thin profile of these lights makes it easy to get them into tight spaces or rig on stands as shown here while their large radiating area makes a *Chimera* style soft box unnecessary. (Photo courtesy Fill-Lite).

Figure 12.7. An 18K HMI with a *Chimera softbox* in use on a day exterior location.

Figure 12.8. An electrician prepares a 12K HMI head for mounting. (Photo courtesy of Christiana Wairegi).

HMI UNITS

HMIs generate three to four times the light of tungsten lamps but consume up to 75% less energy for the same output. When a tungsten bulb is color corrected to match daylight, the advantage increases to seven times because a great deal of the spectrum is absorbed by the blue gel (*color temperature blue* or *CTB*). Because HMIs (Figures 12.7 and 12.8) are more efficient in converting power to light, they generate less heat than a tungsten lamp with the same output.

HMI stands for the basic components: *H* is from the Latin symbol for mercury (Hg), which is used primarily to create the lamp voltage. *M* is for medium-arc. *I* stands for iodine and bromine, which are halogen compounds. The halogen serves much the same function as in a tungsten halogen lamp in prolonging the useful life of the bulb and ensures that the rare earth metals remain concentrated in the hot zone of the arc.

HMI lamps have two electrodes made from tungsten, which project into a discharge chamber. Unlike tungsten bulbs, which have a continuous filament of tungsten wire, HMIs create an electrical arc that jumps from one electrode to another and generates light and heat in the process. *Color temperature* as it is measured for tungsten bulbs or sunlight does not technically apply to HMIs (or to other types of discharge lighting such as fluorescents) because they produce a quasi-continuous spectrum; instead, the measure *Correlated Color Temperature* (CCT) is used. In actual practice, though, the same measurements and color temperature meters are used for all types of video and motion picture lighting sources. Our eyes are unreliable in judging color because our brain adjusts and compensates; it will tell us that a wide variety of colors are “white.” A *color meter* or *vectorscope* is a far more dependable ways of judging color; however, most do not measure CRI.

BALLASTS

All HMIs require a ballast, which acts as a current limiter. The reason for this is simple: an arc is basically a dead short; if the current were allowed to flow freely, the circuit would overload and either blow the fuse or burn up. The electronic ballasts also allow the unit to operate on a *square-wave* (unlike the *sine wave* of normal alternating current electricity).

Figure 12.9. *Chicken Coops* hanging from the grid create an overall ambient light on this *green screen* shoot. A *Chicken Coop* is a rectangular box containing six 1000-watt bulbs. Notice that some of them have duvetyne skirts to control the spill. As we'll discuss in *Technical Issues*, lighting the green or blue screen evenly is essential to getting a proper *key*. This shoot has a camera mounted on an extending Techno-crane and another on a sled dolly.

Flicker-free ballasts use square-wave technology to provide flicker-less shooting at any frame rate. With some units there is a penalty paid for flicker-free shooting at frame rates other than sync sound speed: it results in a significantly higher noise level. If the ballasts can be placed outside or if you're not recording audio, this is not a problem. It is not usually an issue as high-speed shooting rarely involves recording audio.

Header cables are the power connection from the ballast to the light head itself. Many larger HMIs can only use two header cables; a third header will usually result in a voltage loss too great to get the lamp to fire up. *Square-wave* refers to the shape of the sine wave of the alternating current after it has been reshaped by the electronics of the ballast. Flicker is discussed in more detail in the chapter on *Technical Issues* (and in *Motion Picture and Video Lighting* by the same author as this book) but suffice it to say here that the normal sine wave of AC current leaves too many "gaps" in the light output that become visible if the camera shutter is not synchronized to its rhythm. By *squaring* the wave, these gaps are minimized and there is less chance of flicker. This is especially important if you are shooting at anything other than normal speed; high-speed photography, in particular, will create problems. It is important to note that flicker can be a problem in video also, just as with film cameras.

Figure 12.10. Kino Flo's *Celeb* LED panels in use for a twilight car shot. (Photo courtesy of Kino Flo).

Voltages as high as 12,000 *VAC* (volts AC) or more are needed to start the arc, which is provided by a separate ignitor circuit in the ballast. This creates the power needed for the electric current to jump across the gap between the two electrodes. The typical operating voltage is around 200V. When a lamp is already hot, much higher voltages are needed in order to ionize the pressurized gap between the electrodes. This can be from 20 *kV(kiloVolt*) to more than 65 kV. For this reason, some HMIs can not be restruck while they are hot— which means you may have to wait for the light to cool before you can start it again. This can be a major hindrance when the whole film crew is waiting on it. *Hot restrike*, which generates a higher voltage to overcome this resistance, is a feature on most newer HMIs. HMI bulbs can change color temperature as they age. It is important to check the color temperature of HMI bulbs periodically with a color meter to see if they need correcting gels to keep them consistent with other lighting units in use on the project.

18K AND 12K HMI

The 18K and the 12K HMIs are the most powerful Fresnel lights currently available. Like all HMIs, they are extremely efficient in light output per watt of input power. They produce a sharp, clean light, which is the result of having a very small source (the gas arc) which is focused through a very large lens

(Figure 12.8).

These big lights are invaluable where very large areas are being covered or there is a need for high light levels for high-speed shooting. They are also a natural for sunlight effects such as sunbeams through a window or any other situation where a strong, well-defined beam is needed. They are also among the few sources (along with HMI PARs) that will balance daylight and fill in the shadows sufficiently to permit shooting in the bare sun without silks or reflectors. The fact that they burn approximately “daylight blue” (5600 degrees Kelvin) is a tremendous advantage in these situations: no light is lost to filters. Often when a 12K or 18K is used to fill in sunlight, it is the only unit operating on a generator. If it was drawing on one leg only, the load would be impossible to balance and might very well damage the generator. In this case, a *ghost load* on the other legs is necessary to prevent problems.

Figure 12.11. A 20K Fresnel tungsten mounted on a motion control crane. A rig like this might be used for a sunrise or sunset effect, for example—any shot where a moving light effect is needed. (Photo courtesy of Brad Greenspan).

Most 12K and 18Ks are 220-volt lights, but some are 110-volt units which can make *load balancing* on the power supply difficult. Lights that run on 220-volts require *three-phase* power. Most power available on a movie set, or in most buildings, is 110 volts in the United States. In Europe, Great Britain, and most of the rest of the world, 220-volt power is the standard. For more on electricity and power supplies for lighting, see *Motion Picture and Video Lighting*, by the same author and also from Focal Press.

As with any large light, coordinate with the *gennie* (generator) operator before firing it up or shutting it down. The power surge when they start up can be a significant strain on the power supply. Don't start up all the large lights at the same time. Be sure to clarify with the rental house what type of power connectors are used on the lights when you are placing your lighting and grip order for the job.

6K & 8K

6K and 8K HMIs can handle many of the same jobs as the bigger lights, particularly where the area covered is smaller. Although they generally have a smaller lens, they still produce a sharp, clean beam with good spread. In many applications, they perform admirably as the main light: serving as the key, window light, sun balance, and so on. Some 6Ks and 8Ks accept 110-volt input and some require a 220-volt power supply. They may require a variety of connectors or a set of *Siamese splitters*, (called *Y-cords* in Great Britain).

When ordering any large lamp, it is crucial to ask these questions and be sure the rental house will provide the appropriate distribution equipment or adapters—remember, if you don't order it, it won't be there. You must be very thorough when placing an order. Failure to do so may result in the light not being functional. Some makes of HMIs provide for head balancing. This is accomplished by sliding the yoke support backward or forward on the head. This is a useful feature when adding or subtracting barn doors, frames, or other items that alter the balance of light.

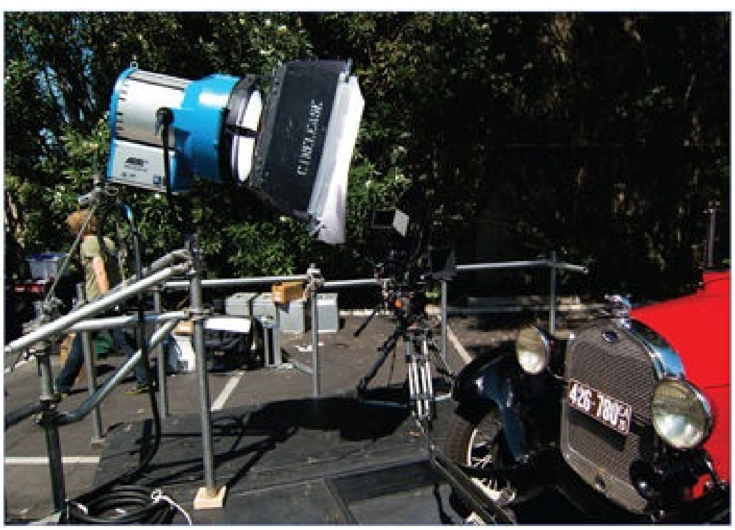


Figure 12.12. An *HMI PAR* providing fill light for a rolling shot. The car, camera, and lighting are set up on a *low-boy*—a type of low trailer used for these kinds of shots. A normal trailer would place the car much

higher and the shots would look unnatural. (Photo courtesy E. Gustavo Petersen).

4k AND 2.5k

The smaller HMIs, the 4K and 2.5K, are general purpose lights, doing much of the work that used to be assigned to 5K and 10K tungsten lights. Slightly smaller than the bigger HMIs, they can be easily flown and rigged and will fit in some fairly tight spots.

1.2K AND SMALLER UNITS

The smallest lamps, the 1.2K, 575, 400, and 200 watt HMIs, are versatile units. Lightweight and fairly compact, they can be used in a variety of situations. The electronics ballasts for the small units have become portable enough to be hidden in places where larger units might be visible. They can also be *wall-plugged*, which means no generator or other supplemental power supply is needed on location.

HMI PAR UNITS

Some of the most powerful, intense lights available are *HMI PARs*; they have the high output of HMIs and the tightly focused beam of the PAR reflector (Figure 12.12). The largest units are 12K and 18K, but HMI PARs are made in smaller sizes as well, down to 125 watts. *Arri Lighting* (part of the *Arri* group) makes a popular unit called the *Pocket PAR* in these smaller sizes.

One particularly versatile unit is the 1.2K HMI PAR, made by several manufacturers. What makes it special is that it is small enough (in wattage) to be plugged into a 20-amp household circuit, but being PARs they have a healthy output, which in conjunction with their daylight balance means they have a wide variety of uses in daylight situations: fill when bounced or through diffusion or for a small shaft of light through a window. The Arri M18 is extremely efficient and is the brightest light that can be plugged into a household circuit (Figure 12.13).

RULES FOR USING HMI UNITS

- Keep the ballast dry. On wet ground, use apple boxes, rubber mats, or other insulation material.
- Check the stand and ballast with a meter for leakage by measuring the voltage between the stand and any ground. There will usually be a few volts, but anything above 10 or 15 volts indicates a potential problem.
- Avoid getting dirt or finger marks on the lamps: oil from the skin will degrade the glass and create a potential failure point. Many lamps come provided with a special cleaning cloth.
- Ensure that there is good contact between the lamp base and the holder. Contamination will increase resistance and impair proper cooling.
- The filling tip (nipple) should always be above the discharge, or there is a risk of a cold spot developing inside the discharge chamber.
- Running at above rated voltage may result in failure.
- Very long cable runs may reduce the voltage to a point that affects the output and may result in the lamp not firing.
- Excessive cooling or direct airflow on the lamp may cool the lamp below its operating temperature, which can result in a light with a high color temperature and inferior CRI.

Figure 12.13. The Arri M-Series M18 can be powered from 20 amp household outlets but is 70% brighter than a typical 1.2K HMI PAR. (Photo courtesy Arri Group).

POTENTIAL PROBLEMS

HMIs (or any light with a ballast) may sometimes fail to function properly. Be sure to have a few extra header cables on hand: they are the most common cause of malfunctions. The safety switch on the lens can also cause trouble. Never try to bypass it, however; it serves an important function. HMIs should never be operated without the glass lens, which filters out harmful ultraviolet radiation that can damage someone’s eyes. When they do fail to fire:

- Check that the breakers are on. Some HMIs have more than one breaker.
- *After* killing the power, open the lens and check the microswitch that contacts the lens housing. Make sure it is operating properly and making contact. Wiggle it, but don’t be violent—the light won’t operate without it.
- If that fails, try another header cable. If you are running more than one header to a light, disconnect and try each one individually. Look for broken pins or dirt in the receptacle.
- Check the power. HMIs won’t fire if the voltage is low. Generally they need at least 108 volts to fire. Some have a voltage switch (110, 120, 220); be sure it’s set properly.
- Try the head with a different ballast and vice versa.
- Let the light cool. Many lights won’t do a hot restrike.

XENONS

Xenons are similar to HMIs since they are a gas discharge arc with a ballast. They feature a polished parabolic reflector that gives them amazing throw and an almost laser-like beam. At full spot they can project a tight beam several blocks with a small amount of spread. Xenons are very efficient with the highest lumens per watt output of any light. They come in five sizes: a 1K, 2K, 4K, 7K, and 10K. There is also a 75-watt sungun unit. The 1K and 2K units come in 110 and 220-volt models, some of which can be wall-plugged. This produces a high-output light that can be plugged into a wall outlet or a small portable generator. Larger xenons are extremely powerful, and must be used cautiously: they can quickly crack a window. Seventy five-watt xenon sunguns can be used for flashlight effects. As with larger xenons, there is a hole or a hot spot in the center of the beam (depending on the focus) that cannot be eliminated. Xenon bulbs do not shift in temperature as they age or as voltage shifts.

Figure 12.14. A Mole-Richardson *Baby Junior* 2K. This is a 2,000-watt tungsten Fresnel. It is a *baby* in that it is smaller than the studio version of the light; *junior* is the old studio term for 2,000-watt Fresnels.

Figure 12.15. The Mole-Richardson *open face 2K* or *Mighty Mole*.

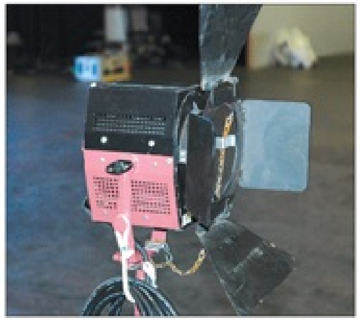


Figure 12.16. A Mole *Baby 1K Fresnel*, commonly called a *Baby Baby*. Baby because it is smaller than the studio version of this type and also the term baby is the traditional name for a 1,000-watt Fresnel.

TUNGSTEN LIGHTS

Tungsten lamps arejust bigger versions of ordinary household bulbs; they all have a filament of tungsten wire. There are two types of tungsten fresnels: *studio* and *baby*. The *studio* light is the full-size unit, and the *baby* is a smaller housing and lens, making it more compact for location use (Figures 12.14 and 12.16). As a rule, the baby version is the studio housing of the next smaller size (the body of a baby 5K is similar to the body of a studio 2K). In most countries outside the United States, the electrical supply is 220 volts—different bulbs are used that are suited to the appropriate voltage.

FRESNELS

Fresnel units are lights with lenses. Most film lights employ the stepped Fresnel type lens, with a few exceptions that use a simpler *plano-convex* lens such as a *Dedo* or an *ellipsoidal (Leko*). A Fresnel lens is a stepped ring design that reduces the thickness of the lens to save on cost and also prevent heat buildup in the center of the glass, which can cause cracking. The primary advantage of Fresnels lights is their ability to produce clean, well-defined shadows.

TWENTY

The biggest tungsten light now in use is the *20K*. It is a large unit with tremendous output. Many jobs that were formerly done by the 10K are now done with this light. Most 20K units use bulbs that run at 220 volts (which may require special electrical distribution), and several models come with a built-in dimmer (Figure 12.11).

TENNERS

The 10K tungsten Fresnel comes in three basic versions:

- The baby 10K provides high-intensity output with a fairly compact, easily transportable unit with a 14-inch Fresnel lens.
- The basic 10K, known as a “tenner” or studio 10K, has a 20-inch Fresnel.

- The largest light of this group is the *Big Eye* tenner, which has a 24-inch lens. The Big Eye is a very special light with quality all its own. The DTY (10K) bulb provides a fairly small source, while the extremely large Fresnel is a large radiator. The result is a sharp, hard light with real bite but with a wraparound quality that gives it almost a soft light quality on subjects close to the light. This is a characteristic of all very big lights that gives them a unique quality.

It is important to never use a 20K, 10K, or a 5K pointing straight up (this applies to large HMIs and xenons as well). The lens blocks proper ventilation, and the unit will overheat. Also, the filament will not be properly supported and will sag and possibly touch the glass.

SENIOR/5K

Although it is available in both versions, the *Baby 5K* is far more popular than the larger unit. It can work as a general purpose big light and a fill used against a 10K. The 5K is also called a *senior*.

JUNIOR/2K

The *2K Fresnel* is also known as a *deuce* or a *junior*. It has enough power to bring a single subject or actor up to a reasonable exposure, even with diffusion in front of the lens. Juniors are also useful as backlights, rims, and kickers. *Baby juniors* (called *BJs*) are more compact and are extraordinarily versatile units.

BABY/1K

Thousand-watt units are known as *1Ks* (one K) or *babies*. The 1K is used as a key light, a splash on the wall, a small back light, a hard fill, and for dozens of other uses. The baby can use either a 750-watt bulb (EGR) or a 1,000-watt bulb (EGT). Most are now used with the 1K quartz bulb, but are still sometimes called *750s*. The *Baby 1K*, also called a *Baby Baby*, is the small size version (Figure 12.16). Because of its smaller lens and box, it has a wider spread than the studio baby.

TWEENIE/650

The *Tweenie* is "between" the 1K and the Inky. The Tweenie is often just the right light for the small jobs a baby used to do, even as a key light. It is very useful for a number of small jobs and easily hidden or rigged above the set.

BETWEENIE, INBETWEENIE, INKY, AND PEPPER

These are similar to Tweenies but smaller. The *Betweenie* is a 300-watt unit and the *InBetweenie* uses a 200 watt bulb and is often used instead of an *Inky* (also 200 watts). At 100, 200, or 300 watts (depending on the bulb and size of the housing), the *Pepper* is a smaller unit, but up close it can deliver a surprising amount of light. The Inky at 200 watts is great for a tiny spritz of light on the set, as an eye light, a small fill, or for an emergency last-minute light to just raise the exposure a bit on a small area.

OPEN FACE

Some 2K, 1K, and 650 units are available as *open face* lights—that is, they have no lenses, but they do have some spot/flood focusing (Figure 12.15). Their light is raw and can be uneven, but they do have a tremendous output for their size. They are good for bounce or shooting through diffusion. They are a good source when all you need is raw power and the control that a Fresnel affords isn't needed.

PARS

PAR stands for *parabolic aluminized reflector*. A parabola is an ideal shape to collect all of the light rays and project them out in the same direction. It is the shape of reflector that is going to give the narrowest, most concentrated beam. In conjunction with this, all PAR units have a lens, which functions primarily to concentrate or spread the beam. Tungsten PARs generally come with a fixed lens that is part of the unit: they are pretty much the same as a car headlight. HMI PARs come with a set of interchangeable lenses: these go from a very wide beam to a very narrow beam. The disadvantage of PARs is that the beam generally covers only a very small area and is not a very complimentary light for actors because it tends to be uneven and raw, but it is useful for many purposes that call for just raw light power.

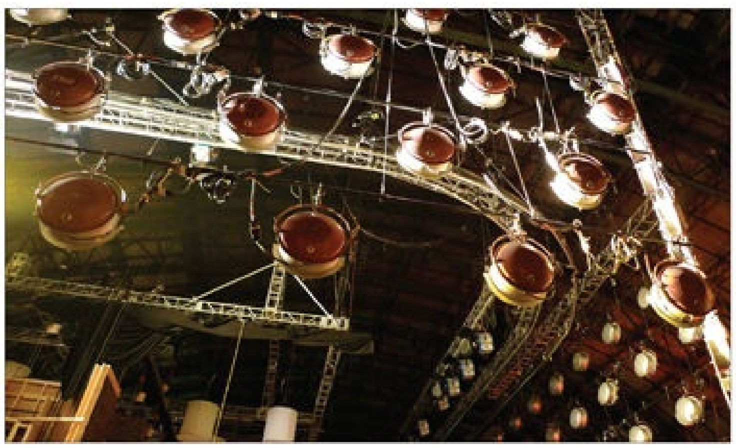


Figure 12.17. Two *Mole FAY* lights *boxed in* with some 4x8 floppies for control.

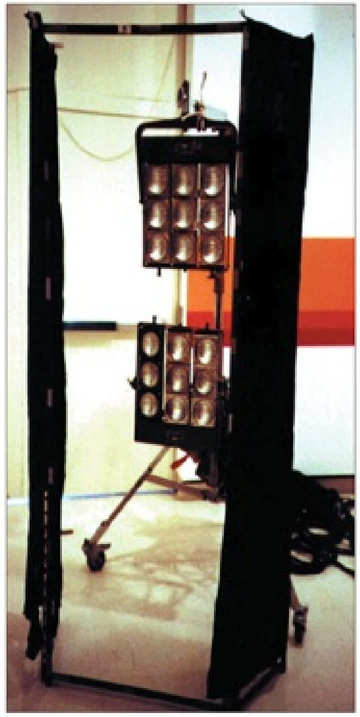


Figure 12.18. A Mole-Richardson *2KZip Softlight. Zip* means it is more compact than a regular softlight. It is mounted on a *set hanger* (also called *wall hanger*). 2K Zips are very popular for just this sort of use: they fit into small spaces, and when put up near the ceiling of a set or location, they don't hang down so far that they interfere with the shot.

Figure 12.19. *Skypans* rigged on a large set by gaffer MichaefGal-lart. Skypans are very simple lights—just a socket for the bulb anda pan reflector. They can use 5K, 10K, or 20K bulbs. Also on the trusses are 5K Fresnels and space lights. (Photo courtesy Michael Gallart).

Figure 12.20. A *scrim set* for a *Betweenie*—a 300-watt tungsten unit. Most lights come with a scrim set to control intensity. A *double* (red rim) reduces the output by one stop, and a *single* (green rim) reduces it by one-half stop. Also included are a *half-double* and a *half-single*. This is called a *Hollywood scrim set* because it includes two doubles.

Figure 12.21. (above) A 1K *MolePar*. The bulb is changed to achieve different beam spreads from very narrow to wide.

PARs come in two basic varieties: film versions come in a solid rotatable housing such as Mole-Richardson's *MolePar* (Figure 12.21), which feature barn doors and scrim holders, and in a flimsier theatrical version called a *PAR can*. Theatrical lights are not generally as sturdily built because they are usually hung in a theater and then left alone. They don't get the rough treatment and adverse conditions that film and video lights do. PARs (especially the very concentrated VNSP bulbs) can quickly burn through even the toughest gels, melt bead board, and set muslin diffusion on fire. PARs with a *dichroic* coating have an output that is very close to daylight (blue) balance. Small PAR 48s and 36s are also available at lower voltages, as well as 110 and 220 volts.

PAR GROUPS

PARs are also made in groups, one of the best known being the *Maxi Brute*, a powerful unit with tremendous punch and throw. They are used for large night exteriors and in large-scale interior applications: aircraft hangars, arenas, and so on. They can also be used directly or through gel, muslin, and so on, when very high light levels are needed to get through heavy diffusion. All PARs generate very intense and concentrated heat; use caution when setting them up— they can crack windows and char wood and other materials.

Maxi Brutes and *Dinos* are similar in design but different in size. Maxis come in configurations of 6, 9, or 12 x PAR 64 lamps, the most common being the 9 lamp head. A *Dino* or *Moleeno* is 36 PAR 64 lamps. Other variations of this design exist as well.

Fay lights are clusters of 650-watt PAR 36s and come in configurations up to 9 or 12 lamps (Figure 12.17). *Wendy lights*, developed by cinematographer David Watkin, come in large panels with the same PAR 36 lamps (usually DWE).

All the bulbs on most multi-PARs are individually switchable, which makes for very simple intensity control. All PAR group lights allow for spot, medium, and flood bulbs to be interchanged for different coverages. The *FAY* bulbs are dichroic daylight bulbs; tungsten bulbs (*FCX*) can also be used. They can be used as daylight fill in place of HMIs. They are not exactly daylight balance but are very close to and can be corrected with gels if necessary.

Most people refer to any PAR 36 dichroic bulb as a FAY, but in fact, there are several types. FAY is the ANSI code for a 650-watt PAR36 dichroic daylight bulb with ferrule contacts. If the bulb has screw terminals, it is an FBE/FGK. With diffusion, these units can be used as a large-source soft light.

SOFT LIGHTS

Studio soft lights consist of one or more 1,000-watt or 1,500-watt bulbs directed into a *clamshell* white painted reflector that bounces light in a random pattern, making a light which is apparently as large as the front opening. They vary from the 1K studio soft (the Baby soft, also known as a 750 soft) up to the powerful *8K Studio Soft*, which has eight individually switchable bulbs. See Figure 12.18—a 2K soft light hanging on the wall of a set.

Soft lights have certain basic problems: they are fairly inefficient in their light output; they are bulky and hard to transport; and like all soft sources, they are difficult to control. While the large reflector does make the light "soft," the random bounce pattern makes the light still somewhat raw and unpleasant and most people add a little light diffusion.

Big *studio softs* through a large frame of diffusion is a quick way to create a large soft source in the studio. Often used with the studio soft is the *eggcrate*, which minimizes side spill and does make the beam a bit more controllable. Soft lights see most of their use in television studios where they provide a soft source without additional rigging. However, tungsten softlights in television news studios have been almost entirely replaced by Kino Flo units for one simple reason: to save on air conditioning costs. The color-correct fluorescent lights generate substantially less heat, which can be a real problem for studios, where they might be in use 24 hours a day. Since they are more or less permanently flown, their bulkiness is not a problem. Small compact versions of the 2K and 1K soft lights are called *zip lights* (Figure 12.18). They have the same width but half the height of a soft light of similar wattage. Because of their compactness, zips are great for slipping into tight spaces.

Figure 12.22. *Barger Baglights* with Chimera softboxes in use on a hair product commercial. The reason there are so many lights is that they are dimmed up and down for different shots or when the model moves. Also, since this is a hair commercial, light coming from any directions makes for more reflections and sheen on the hair, so it looks its best. This is a key advantage of tungsten lights: they can be controlled from a dimmer board. In comparison to a 5K with a Chimera, the Bargers have wider, more even throw and take up less real estate on the set. (Photo courtesy of Barger Baglights).

Figure 12.23. A reverse angle of the scene; DP Tom Denove is taking an incident reading at the model's position and using his other hand to shield the backlights from influencing the reading: this is correct procedure for taking an incident reading, which is the reading that determines what f/stop the lens will be set at. In most cases you don't want the backlight to influence that reading. (Photo courtesy of Barger Baglights).

Figure 12.24. A *China ball (Chinese Lantern*) suspended from a C-stand. These are a cheap and extremely lightweight source of soft light and are easily rigged or even floated on a boom pole to be mobile in a scene.

Figure 12.25. Rigging two *SoftSun 50K* units on a Condor crane. (Photo courtesy Attitude Specialty Lighting).

BARGER BAGLIGHTS

Barger makes a type of softlight that is compact and efficient; it consists of several 1K tubular bulbs in a housing. It is always used with a *Chimera*, which is a self-contained softbox that fits on the front of the light. This has many advantages. Normally to make a light soft, it is necessary to put a diffusion frame in front of it; then to control the spill, several flags are needed. This means there might be as many as six stands. This becomes a real problem when you need to move the light quickly. A softbox such as a Chimera makes the entire unit fit on one stand. They are often used with a soft *eggcrate* on the front, which helps control the spill. Figures 12.22 and 12.23 show *Barger Baglights* in use on a commercial. The reason there are so many lights on the shot is that the model is constantly in motion. Every light is on a dimmer, and they were constantly being dimmed up and down for different shots. The fresnels were controlled by a dimmer board, but the Barger Baglights were controlled by turning switches on and off, which is a real advantage of the Barger. Each bulb inside has its own switch on the back of the unit, making intensity control quick, easy, and repeatable.

COLOR-CORRECT FLUORESCENTS

Color-correct fluorescent tubes are lightweight, versatile, and have very low power consumption. Pioneered by the Kino Flo company, they are extremely lightweight, compact, and portable sources. Achieving a truly soft light can be difficult and time-consuming, whether it's done by bouncing off a large white surface or by punching big lights through heavy diffusion. Either way takes up a lot of room and calls for a lot of flagging to control it.

Kino Flos had their origin in 1987. While working on the film *Barfly*, DP Robby Mueller was shooting in a cramped interior that didn't leave much room for a conventional bounce or diffusion soft source. His gaffer Frieder Hochheim came up with an answer: they constructed high-frequency fluorescent lights. By using remote ballasts, the fixtures were maneuverable enough to be taped to walls, and mounted behind the bar—Kino Flos were born (Figure 12.26).

Unlike conventional fluorescent ballasts, which can be quite noisy, especially as they age, their ballasts were dead quiet and their light was flicker-free due to the higher than normal frequency. There are now several companies that make these types of lights, including Mole-Richardson.

The ballasts are high-frequency, which reduces the potential problem of flicker that is always present with fluorescent type sources. Second, the bulbs are truly color correct. Colored bulbs are also available for various effects, as well as for greenscreen, bluescreen, or redscreen. Kino makes a variety of extremely large rigs that can either frontlight or backlight an effects screen. An added bonus of color-correct, high-frequency fluorescents is that they generate considerably less heat than either tungsten or HMI, which is a great advantage in small locations.

OTHER TYPES OF UNITS

Besides Fresnels, open face, LED, and fluorescent sources, there are a number of other kinds of lights that are commonly used for film and video lighting.

SOFTSUN

Lightning Strikes makes the *SoftSun* series of lights in a variety of sizes from 3.3K to an amazing 100K (Figure 12.25). SoftSuns require no warmup time. They achieve maximum power and proper color temperature the moment they are turned on. SoftSuns are also the only large daylight color light source that can be dimmed with minimal shift in color temperature.

Figure 12.26. Color-correct fluorescents by *Kino Flo*. Their light weight makes rigging them easier and quicker. Notice how the large window at left rear has been *blacked out* with a large *solid* of black *duvetyne*. A pipe nas been rigged to the ceiling to support some of the lights. Note also the *snoot boxes* on the two tungsten *zip lights*. (Photo courtesy Kino Flo).

Figure 12.27. Rigged for a night on *Madam Secretary*. The beach always has a breeze, so a traditional balloon was too hazardous. This “balloon box,” uses the same bulb envelope as a balloon but on a rigid frame. Diffusion is affixed to a Speed Rail frame, attached to an 80-foot articulating boom lift. This rig contains two 2.5k HMI, and four 2k Halogen bulbs— a hybrid. The dimmer and ballast stay on the ground; a single multi-cable conductor supplies power to the lamps. Rollers attached to the arm allow the cable to pay out. The lamp operator stays at ground level to control the entire fixture. It’s cool and safe. (Photo courtesy Michael Gallart).

CYCS, STRIPS, NOOKS, AND BROADS

When just plain output is needed, *broad lights* are strictly no-frills, utilitarian lights. They are just a box with a double-ended bulb. As simple as it is, the broad light has an important place in film history. In classical Hollywood hardlighting, the fill near the camera was generally a broad light with a diffuser. The distinctive feature of the broad light is its rectangular beam pattern, which makes blending them on a flat wall or cyc much easier: imagine how difficult if would be to smoothly combine the round, spotty beams of Mighty Moles or Fresnel lights.

The smallest version of the broad is the *nook*, which, as its name implies, is designed for fitting into nooks and crannies. The nook light is a compact, raw-light unit, usually fitted with an FCM or FHM 1000-watt bulb. The nook is just a bulb holder with a reflector. Although barn doors are usually available, nooks aren’t generally called on for much subtlety, but they are an efficient and versatile source for box light rigs, large silk overhead lights, and for large arrays to punch through frames. A number of units are specifically designed for illuminating cycs and large backdrops. For the most part, they are open face 1K and 1.5K units in small boxes; these are called cycs, cyc strips, or *Far Cycs* (which create a more even distribution up and down the background).

CHINESE LANTERNS AND SPACELIGHTS

Chinese lanterns (China balls) are the ordinary paper globe lamps available at houseware stores (Figure 12.24). A socket is suspended inside that holds either a household bulb or a 1K or 2K lamp. Just about any rig is possible if the lantern is large enough to keep the paper a safe distance from the hot bulb. Control is accomplished by painting the paper, or taping gel or diffusion to it. Similar in principle are *spacelights* (Figure 12.29), which are basically big silk bags with 1, 2, 6, or 12 1K *nook lights* inside. For establishing an even overall base level on a set, they can be quite useful. When cabling, you will want to separate them into different circuits to give you some degree of control over the level. China balls are inexpensive and easy to rig.

SELF-CONTAINED CRANE RIGS

There are a number of units that consist of several large HMIs rigged on a crane. Most also carry their own generator. Musco was the first of these, but now there are several to choose from. These units can provide workable illumination up to a half mile away.

ELLIPSOIDAL REFLECTOR SPOTS

The *ellipsoidal reflector spot (ERS*) is a theatrical light, but it is used as a small effects light because of its precise beam control by the blades. Called *lekos* in the theater, on a film set you will frequently hear them referred to as *Source Fours*, manufactured by *Electronic Theater Controls (ETC)*—Figure 12.28. Because the blades and gobo holder are located at the focal point of the lens, the beam can be focused sharply and patterned gobos can be inserted to give sharply detailed shadow effects. These lights come in a size defined by their beam angle. The longer the focal length, the narrower the beam. They also make a unit that has a zoom. Some ERS spots have a *gobo* slot that holds a metal disk that will project a pattern. These patterns come in a vast array of designs from random breakup patterns to very specific things such as the outline of a window or a tree.

BALLOON LIGHTS

Balloon lights provide a powerful and flexible new tool for night exteriors. They can be either HMI or tungsten sources or even a hybrid of the two as in Figure 12.27. They generate a soft, general fill light for large areas. Perhaps their greatest advantage is that they are much easier to hide than a crane or scaffolding. They are also faster to set up and to move. The disadvantage is that they can be very time-consuming and expensive to gel.

Figure 12.28. A *Source Four* leko (ellipsoidal reflector spot or ERS) rigged in the grid with a *pipe hangar*.

Figure 12.29. Two sizes of *space lights* rigged on *Speed Rail* (aluminum tubing often used for grip rigs of all sorts). (Photo courtesy Jon Fauer, *Film and Digital Times*).

Figure 12.30. Knowing how to rig lights on a crane or lift is essential for all electricians and grips. In this rig, two Mole-Richardson *Maxi Brutes* are mounted on *candlesticks* which are secured to the basket of the crane. (Courtesy P&G Lighting).

Figure 12.31. A day exterior with *negative fill* (the black *12x12 solid* that creates a shadow side) and *shiny board* reflectors that are aimed through 4x4 frames with diffusion. The fill is an *8x8 frame* with *Ultrabounce*, a reflective material. This setup reverses the direction of the light source (the sun). The shiny boards are necessary in order to raise the level of the actors so that they are not significantly darker than the background, which would otherwise be seriously overexposed.

Wind can always be a factor when flying balloon lights. The smaller the balloon, the lower the acceptable wind speeds. A good reference is to observe flags: if they're flapping straight out, it's too windy. This introduces an element of uncertainty into their use. Larger balloon lights usually come with an operator.

HANDHELD UNITS

Portable handheld, battery-operated units are generally called *sunguns*. There are two basic types: tungsten and HMI. Tungsten sunguns are either 12 volt or 30 volt and powered from battery belts— due to their inefficiency and short battery time; they are seldom used nowadays. Typically, a tungsten sungun will run for about fifteen minutes. Sunguns with HMI bulbs are daylight balance and more efficient in output than tungsten units. These have largely been replaced by LED light panels, many of which can operate off batteries for extended periods of time. Small LED units and even some of the larger light panels can easily be carried by hand or on a grip arm making them every bit as mobile as a traditional sungun.

DAY EXTERIORS

Direct sun is extremely harsh and contrasty and also is moving throughout the day. To deal with this, day exteriors can be approached in three ways: filling with large daylight balance units such as a large HMI, bouncing the existing light with reflectors, or covering the scene with a large silk to control the contrast. Sometimes it is some combination of several of these techniques (Figures 12.31, 12.32, and 12.39).

Much of the time, lighting day exteriors will depend more on grip equipment such as silks, nets, and flags in addition to whatever lights or reflectors may be working on the scene. Although artificial silk is one covering for large frames, it is also a generic term and coverings such as Half Soft Frost, Hi-Lite, and 1/2 or 1/4 Grid Cloth are more frequently used for these situations. *Reflectors* are often used inext eriors—they are cheap, don't need power, and match the sun as it changes in intensity due to such factors as cloud cover. Any time reflectors are used, a grip needs to stand by to "shake it up" before every take. The reason is simple—the sun is constantly moving and they need to be re-aimed before every take. Sometimes it can be difficult to tell exactly where the reflector is aimed—a simple trick is to aim it down at the ground in front of you. This lets you more easily follow the reflected beam as you focus it on the action.

Figure 12.32. A *6x6 silk* and some 4x4 *floppies* control the sun on this rooftop location. The stands holding the silk are called *daddy long legs— hi hi risers* (*highboys*) but without the wheels. (Photo courtesy Vertical Church Films)

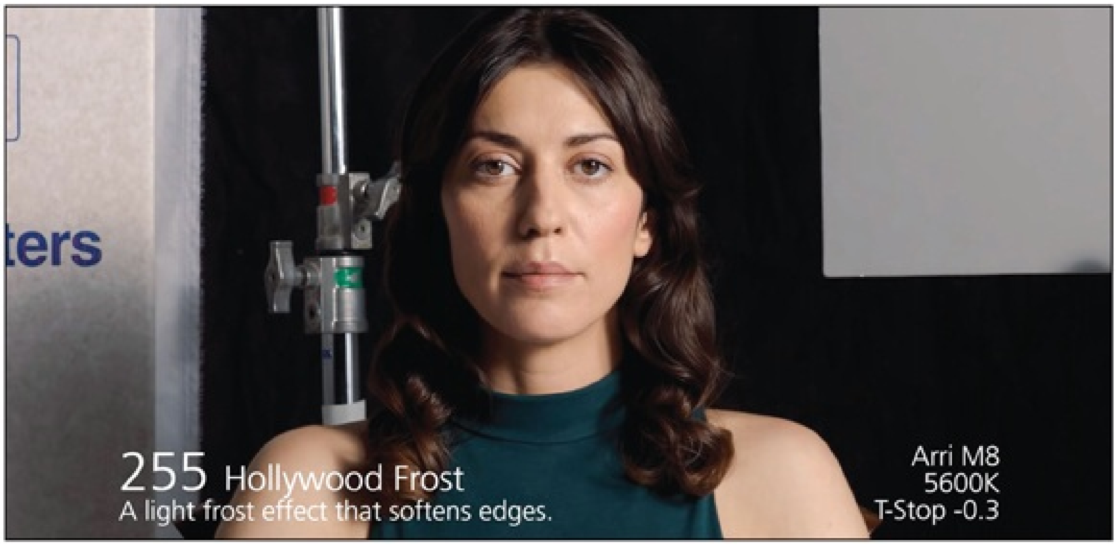
CONTROLLING LIGHT WITH GRIP EQUIPMENT

Once you have a light working, you have to control it. As soon as you get beyond what can be done with the barn doors, it becomes the province of the grip department. Grip equipment is wide and varied, but in relation to lighting control, it falls into three basic categories: reduction, shadow casting, and diffusion.

Reducing the amount of light without altering the quality is done with *nets*, which are frames covered with a netting material; the purpose is the same as a metal scrim on a light: it reduces intensity without changing the color or hard/soft quality of the light.

Just as with metal scrims, a *single net* (color coded green) reduces the light by one-half stop and a *double* (color coded red) reduces the light by a full stop. The same frames used for nets can be covered with white silk-like material that is a medium heavy diffusion. When they are covered with black *duvetyne*, they are *flags* or *cutters*, which can control spill, cast shadows, or block off flares from the lens. The same silk-like material or solid black duvetyne (a fire-resistant cloth) also comes in larger sizes for *butterflies* and *overheads*. These come in various sizes, denoted in feet: 4x4, 6x6, 8x8, 12x12, 20x20, and 20x40 or even larger in some cases.

Figure 12.33. to 12.38. Several examples of lighting diffusion from *LEE Filters*. The captions list the type of diffusion and also the light loss in T-Stops. Arri M8 is the type of light used for the test. (Photos courtesy LEE Filters).


ters
255 Hollywood Frost
A light frost effect that softens edges.
Arri M8
5600K
T-Stop -0.3


ters
250 Half White Diffusion
A medium diffusion used for soft light effects.
Arri M8
5600K
T-Stop -0.6


ters
216 White Diffusion
A strong diffusion used for soft light effects.
Arri M8
5600K
T-Stop -1


ters
430 Grid Cloth
A waterproof textile, ideal for attaching to large frames.
Produces a strong diffusion effect.
Arri M8
5600K
T-Stop -1.2

Figure 12.39. A grip stands by to “shake up” a reflector before each take. This reflector has some 85 gel clipped to it to warm up the light.

FOR MORE INFORMATION ON LIGHTING

Lighting is a vast subject; here we have room only to cover the basics. For more on lighting techniques, photometric data, grip equipment and rigging, electrical distribution, bulbs, and scene lighting examples, see *Motion Picture and Video Lighting* by Blain Brown, also published by Routledge.

Figure 13.1. Dramatic shafts of light punching through rain and smoke make this frame from *9 1/2 Weeks* a powerful and striking visual.

Figure 13.2. This shot from *O Brother, Where Art Thou*? demonstrates the importance of *lighting from the upstage side* (his key from the left) and *motivated* lighting—the *kicker* coming in from the right. It appears to be coming from the table lamp (its "motivation") but it is actually a soft source off-screen.

THE FUNDAMENTALS OF LIGHTING

I’m sure you’ve heard this, “If you light it right…” or “With good lighting, the scene will…” What does that mean? What is “good lighting?”

Lighting has nearly infinite permutations and variations. There is certainly no one “right” way to light a scene. As a result, there is no chance that we can just make a simple list of “proper” lighting techniques. What we can do, however, is try to identify what it is we want lighting to do for us. What jobs does it perform for us? What do we expect of “good” lighting? Starting this way, we have a better chance of evaluating when lighting is working for us and when it is falling short. Naturally, these are generalizations. There are always exceptions, as there are in all aspects of filmmaking.

THE [CONCEPTUAL] TOOLS OF LIGHTING

In the first chapter, we talked about the conceptual tools of cinematography; lighting is, of course, one of the most important of those tools. Now let's talk about the conceptual tools of lighting—the attributes of light: the things about light that we can change and manipulate to achieve our goals. They are:

THE ATTRIBUTES OF LIGHT

- Hard vs. soft light.
- Altitude (height).
- Direction (from front, side or back).
- Color.
- Focus (confined or wide).
- Texture (break up patterns).
- Movement.
- Intensity/Contrast.

HARD VS. SOFT

A key aspect of the quality of light mostly is how *hard* or *soft* it is. This is, in fact, the aspect of light that we most often alter. "Hard" light means *specular* light—parallel beams which cast a clear, distinct shadow. Soft light is the opposite; it is diffuse light that hits the subject from many different angles and thus casts an indistinct, fuzzy shadow, if any. We'll go into more detail a little later.

Figure 13.3. Texture is the major element of this strong side light through a window on the set.

WHAT ARE THE GOALS OF GOOD LIGHTING?

So what is it we want lighting to do for us? There are many jobs, and they include creating an image that has:

- A full range of tones and gradations of tone.
- Color control and balance.
- Shape and dimension in the individual subjects.
- Separation: subjects stand out against the background.
- Depth and dimension in the frame.
- Add emphasis and focus.
- Texture.
- Mood and tone: emotional content.
- Exposure.
- Balance.
- Visual metaphor.
- Invisible Technique.

Lighting can also help form the composition and most importantly, it can help you tell the story. The goal is to have your cinematography help tell the story, establish a mood and tone, and add up to a coherent visual presentation. As any working cinematographer will tell you, lighting is usually the most important aspect of the visual effect.

FULL RANGE OF TONES

In most cases, we want an image to have a full range of tones from black to white (tonal range is always discussed in terms of grayscale, without regard to color). There are exceptions to this, of course, but in general, an image that has a broad range of tones, with subtle gradations all along the way, is going to be more pleasing to the eye, more realistic, and have more impact.

The range of tones in a scene is dependent on what is actually in a scene, the colors, and the textures, but it is also a product of the lighting—*flat front lighting* (Figure 13.11) will tend to make everything dull and low contrast, the main reason we almost always avoid lighting this way. Lighting with lots of shadows and highlights will increase the contrast of a scene and result in a broader range of tones. Naturally, this may not be the final image structure you are aiming for

—there are occasions where you want a low-contrast, dull appearance to a scene, but this happens far less often.

Figure 13.4. Out of the ordinary color is frequently appropriate for sci-fi, horror, or fantasy sequences.

COLOR CONTROL AND COLOR BALANCE

Up until the eighties, it was conventional to precisely color balance all lighting sources in a scene, for example, making all the lighting sources tungsten balance, daylight balance, or even going with fluorescent balance and then correcting the color in postproduction. Now with constantly improving video cameras, better film stocks, and most of all, changing visual tastes, it is common to mix slightly, even radically, different color sources in a scene. Color control is also important in the mood and tone of a scene (Figure 13.4).

SHAPE

Flat front lighting (Figure 13.11) does not reveal the shape and form of the subject. It tends to flatten everything out, to make the scene two-dimensional. Lighting from the side or back reveals the shape of an object—its texture and subtleties of form. This is important not only for the overall depth of the shot, but it also can reveal character, emotional values, and other clues that may have story importance. It also makes the image more real, more palpable, more recognizable.

SEPARATION

By separation, we mean making the main subjects "stand out" from the background. A frequently used method for doing this is a backlight. Another way to do it is to make the area behind the main subjects significantly darker or brighter than the subject. In our quest to make an image as three-dimensional as possible, we usually try to create a foreground, midground, and background in a shot; separation is an important part of this—Figures 13.6 and 13.12.

DEPTH

Whether projected on a screen or viewed on a monitor, film and video are two-dimensional: flat (3D is really just an illusion). A big part of our job is trying to make this flat art appear as three-dimensional as possible—to give it depth and shape and perspective, to bring it alive as a real world as much as possible. Lighting plays a huge role in this. This is a big part of why "flat" lighting is so frequently the enemy. Flat lighting is light that comes from very near the camera, like the flash mounted on a consumer still camera: it is on axis with the lens. As a result, it just flatly illuminates the subject evenly. It erases the natural three-dimensional quality of the subject.

TEXTURE

As with shape, light from the axis of the lens (flat lighting) tends to obscure surface texture of materials. The reason is simple: we know texture of the subject from the shadows. Light that comes from near the camera creates no shadows. The more that light comes from the side, the more it creates shadows, which is what reveals texture. Texture can also be present in the lighting itself (Figure 13.3).

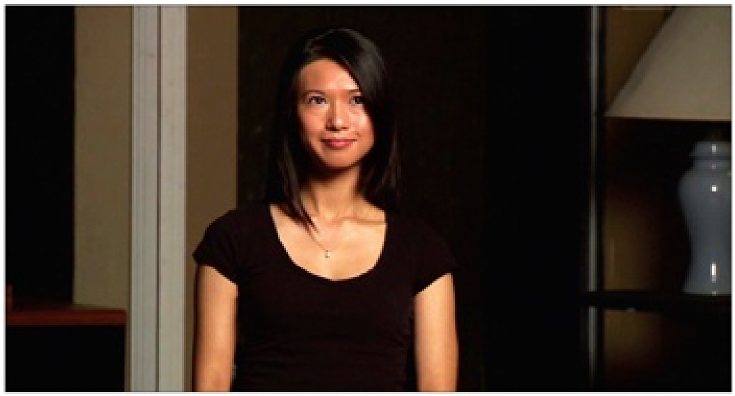


Figure 13.5. Lighting can create depth and three-dimensionality in a scene. Here, the actress is lit only with a soft key; the scene is flat, two-dimensional, and doesn't seem real. In

Figure 13.6. the addition of a backlight, a practical lamp, and lighting through the window and in the hallway makes the scene more three-dimensional and realistic.

MOOD AND TONE

Let's recall our discussion of the word "cinematic." Used in conversation, it is often used to describe something that is "movie-like." For example, someone might say a particular novel is cinematic if it has fast-moving action, lots of description, and very little exposition. That is not how we will use the term here. In this context, we will use the term *cinematic* to describe all the tools, techniques, and methods we use to add layers of meaning, emotion, tone, and mood to the content (Figure 13.8).

As every good camera and lighting person knows, we can take any particular scene and make it look scary or beautiful or ominous or whatever the story calls for, in conjunction with use of lens and camera, of course. Many tools affect the mood and tone of a scene: color, framing, use of lens, frame rate, handheld or mounted camera—indeed everything we can do with camera and lighting can be used to affect the audience’s perception of the scene.

EXPOSURE AND LIGHTING

It is important to remember in this context that exposure is about more than just "it's too light" or "it's too dark." Exposure for mood and tone is obvious, but there are other considerations as well —proper exposure and camera settings are critical to color saturation and achieving a full range of grayscale tones. There are really two ways in which you have to think about exposure. One is the overall exposure of the scene; this is controlled by the iris, the shutter speed, gain, and neutral density filters. All of this controls exposure for the entire frame. Except for some types of neutral density filters called *grads*, there is no chance to be selective about a certain part of the frame. Another aspect of exposure is balance within the frame. Film and video can only accommodate a certain brightness range. Keeping the brightness range within the limits of your particular film or video camera is mostly the job of lighting. It's not merely a technical job of conforming your lighting to the available latitude: the lighting balance also affects the mood, tone, and style of the scene.

Figure 13.7. Strong, simple primary colors can be a powerful element in any image.

SOME LIGHTING TERMINOLOGY

Key light: The dominant light on people or objects. The "main" light on a scene.

Fill light: Light that fills in the shadows not lit by the key light. Lighting is sometimes described in terms of the *key/fill ratio*; also called the *contrast ratio*.

Backlight: Light that hits a person or objects from behind and above. A *rim* or *edge light* might be added to separate a dark side of a face or object from the background or make up for a lack of fill on that side.

Kicker: A: kicker is a light from behind that grazes along an actor's cheek on the fill side (the side opposite the key light). Often a kicker defines the face well enough that a fill is not even necessary. It should not be confused with a backlight, which generally covers both sides equally.

Sidelight: A light comes from the side, relative to the actor. Usually dramatic and creates great chiaroscuro (meaning light and shadow) if there is little or no fill, but may be a bit too harsh for close-ups, where some adjustment or slight fill might be needed.

Topper: Light directly from above. (The word can also refer to a *flag* that cuts off the upper part of a light.) If a top light spills onto the actor's nose, some might say it is "too toppy."

Hard light: Light from the sun or small lighting source such as a Fresnel that creates sharp, well-defined shadows.

Soft light: Light from a large source that creates soft, fuzzy shadows or (if soft enough), no shadows at all. One example: skylight on an overcast day is from many directions and is very soft.

Ambient light: There are two uses of this term. One means the light that just happens to be in a location. The second use refers to soft, overhead light that is just sort of "there." Can also be a base light that opens up the shadows.

Practicals: Actual working prop lights—table lamps, floor lamps, sconces, and so on. It is essential that all practical lamps have a dimmer on them for fine-tuning control; small dimmers for this purpose are called *hand squeezers*. Anything on a set that works is also called *practical*, for example, a refrigerator.

Upstage: Part of the scene on the other side of the actors, opposite the side the camera is on. Downstage is the side the camera is on. Comes from theater when stages were raked (tilted) and upstage was the part farthest away from the audience.

High key: Lighting that is bright and fairly shadowless with lots of fill light; often used in fashion/beauty commercials.

Low key: Lighting that is dark and shadowy with little or no fill light. Can also be described as having a high key/fill ratio.

Bounce light: Light that is reflected off something—a wall, the ceiling, a white or neutral surface, a silk, or just about anything else; usually to make a light softer.

Available light: Whatever light already exists at the location. May be natural light (sun, sky, overcast day) or artificial (street lights, overhead fluorescents, etc.).

Motivated lighting: Where light in the scene appears to have a source such as a window, a lamp, a fireplace, and so on. In some cases the light will come from a source visible in the scene; in some cases, it will only appear to come from a source that is visible in the scene.

Figure 13.8. Lighting is your primary tool in establishing mood and tone, which add layers of meaning to the content. This shot is lit with a *Mighty Mole* bouncing off the concrete floor.

Figure 13.9. Hard light creates sharp, well-defined shadows. This is a *Mighty Mole* (open face 2K) direct. An open face light would rarely be used directly on an actor without diffusion or being bounced off a reflector—it is used here for illustration only.

Figure 13.10. Soft light creates soft shadows that fall off gradually. In this case, the soft light is created by the same *Mighty Mole* being punched through a 4x4 frame covered with 216 (a heavy diffusion) and another 4x4 frame covered in muslin—a heavy cotton cloth that has been used as diffusion since the earliest days of the film business. Notice that creating a softer source has also turned the objectionable hotspot highlights on her skin into soft, gentle highlights in the lower photo.

WORKING WITH HARD LIGHT AND SOFT LIGHT

What makes hard light hard? What makes soft light soft? How do we distinguish between them? There are many ways to light any scene; the variations are endless. The styles and techniques of lighting are nearly infinite. Oddly, there are basically only two types of light (in terms of what we are calling “quality” of light) when you really boil it down to the basics: hard light and soft light. There are, of course, all sorts of subtle gradations, and variations between completely hard and fully soft.

HARD LIGHT

Hard light is also called *specular* light. As we have seen, it is light that casts a clear, sharp shadow. It does this because the light rays are traveling relatively parallel. What creates a beam of light with the rays pretty much parallel? A very small light source. The smaller the source, the harder the light will be. This is an absolutely crucial point: how hard or soft a light appears is a function of the *size* of the radiating source (Figure 13.9).

Outside on a clear, sunny day, take a look at your shadow: it will be sharp and clean. Even though the sun is a large star, it is so far away that it appears as a small object in the sky—which makes it a fairly hard light. It is important to remember that it is not the absolute (actual) size of the source that matters—it is the size of the source *relative to the subject*. In this example, the sun is acting as a hard light because it is a small, point source *from ourpoint-of-view*. In reality, the sun is huge, of course, it is the fact that it is millions of miles away that allows it to function as a hard source on cloudless days.

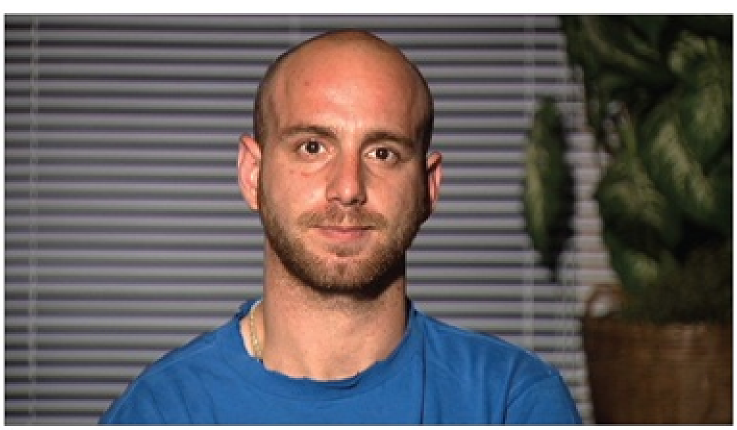


Figure 13.11. *Flat front lighting* creates no depth, no sense of three-dimensionality. It looks fake and "lit"—something we try to avoid.

Figure 13.12. Light from the sides or back (anything other than flat front lighting) creates depth, dimension, a more realistic feel. On the left side of his face, a *kicker* has been added to create more shape and a greater sense of depth and separation.

The importance of this is sometimes seen when an inexperienced crew builds a large soft source with silks or bounce and then positions it a long way away from the subject—it may still be soft, but it will not be nearly as soft as it would be if it was much closer to the subject (the actors, typically). On sets, when they are going for a really soft look, you will most often see the large soft source just barely outside the frame. Of course, this often means that it can't be there for the wide shot (typically, the master) and has to be moved in closer for the close-ups. This is common practice, and a good crew can make quick work of it; however, it means that when you build a large soft source and "box it in" with flags to control spill and prevent flaring the lens, your electricians and grips need to keep the need for mobility in mind and be ready to go when the call comes out to move in for the tighter shots.

It may seem like a small detail, but it illustrates just one of the ways to be ready for the move—make sure that there is enough cable to the light(s) so that it can be easily moved—time spend rerouting cable or adding extra cable is really inexcusable in situations like this.

SOFT LIGHT

Soft light is the opposite; it is light that casts only a fuzzy, indistinct shadow; sometimes no shadow at all. What makes light soft? A very large source. Go outside on an overcast or cloudy day and you will have little or no shadow at all.

This is because instead of a small, hard source (just the sun), the entire sky is now the light source—it's enormous. See Figures 13.9 and 13.10 for examples of hard and soft light compared.

Figure 13.13. *Upstage* is on the other side of the actors, away from the camera. Light from the upstage side gives pleasant shadows and is flattering to the face.

Figure 13.14. *Downstage* is on the same side of the actors as the camera. Lighting from the *downstage* side is unpleasant for the face, puts the shadows in the wrong place, and is more flat front lighting—something to almost always avoid.

How do we make soft light on the set? There are two ways. One is we bounce a light off a large white object. Typically we use things like *foamcore* (a lightweight artist board often used for temporary signs or mounting photographs) or soft materials such as cotton muslin or *Ultrabounce*—a cloth-like material designed specifically for this purpose—but you can use almost anything light-colored as a bounce: a white wall, an umbrella, a piece of white styrofoam building insulation (also called *bead board*). For larger applications, there are several materials that come in sizes from 4'x4' up to as big as 20'x40' and sometimes even larger. On the film *Memoirs of a Geisha*, for example, very large silks were used to cover virtually the entire set, which was several acres in size. Another way is to direct the light through *diffusion* (Figure 13.10). There are many types of diffusion available in wide rolls and sheets. It is amazing for its ability to withstand the intense heat of being put right in front of a powerful light. Diffusionmay be attached directly to the barn doors of a light or held in a frame in front of the light, or attached to a window, *etc*. For some examples of diffusion, see Figures 12.32 through 12.38 in the previous chapter, *The Tools of Lighting*.

Figure 13.15. A kicker and light source in the frame in this shot from *The Master*. If you are going for a high contrast ratio between key and fill, it is often possible to use a kicker and no fill at all, as we see in this shot. The light in the back is just a working prop (a practical) but it isn't what is really lighting the subject—that light is off-screen.

Diffusion materials are available in grades from very light, almost translucent up to very heavy diffusion. A popular diffusion is *opal*; it is so thin you can almost see through it. This doesn't make the light very soft, but sometimes we want a very subtle effect. Heavier diffusion is much thicker, and it makes the light much softer. About the heaviest, softest diffusion we normally use on the set is a cotton cloth called *muslin*. As previously mentioned, it has been used in filmmaking since the earliest days.

DIRECTION

The direction from which the key light comes at the actors is one of the most critical aspects of lighting. The most commonly used terminology is front, 3/4 front, side, 3/4 back, and backlight. The direction of the light is a major determinant not only of the shadows, but it is also an important factor in the mood and emotional tone of a shot. If most of the light comes from the side or back, the scene will tend to be “darker,” more mysterious, more dramatic. This is especially important if you are trying to make a scene appear *underlit*, such as a moody scene where you want the audience to perceive the scene as very dark.

AVOIDING FLAT FRONT LIGHTING

Flat front lighting occurs when the key light is very close to the camera. The result is an image with few if any shadows and very little depth or dimension—flat and without shape. Also, the subject is rarely *separated* from the background. This reminds us that one of the key jobs of lighting is to direct the eye and “pick out” key elements of the frame, usually the actors. There are exceptions, of course, but as a general rule, flat front lighting is shapeless, dull, and boring. See Figure 13.11—the lighting is hardly better than the average driver’s license photo. In Figure 13.12, the light has moved to the side and a backlight plus kicker is added. The more your key light comes from the sides or back, the more it is going to give the subject depth and dimension.

Figure 13.16. Overhead ambient light created with handmade soft boxes. In this case, the soft ambient is supplemented with hard light keys and other units for emphasis and shape.

Figure 13.17. A typical lighting setup for a close-up. The *key light* and *fill light* are bi-color LED panels from *CAME-TV*, the *backlight* and *kicker* are Mole-Richardson *Betweenies* and the *background light* is a *Mole Inkie*. Both the background light and the kicker have snoots on them to control the beam spread more precisely than barn doors are capable of.

LIGHT FROM THE UPSTAGE SIDE

Particularly when lighting a dialog scene, it is almost always a good idea to light the actors from the upstage side. Upstage means the side away from the camera. If a key light is on the same side of the actors as the camera, it is downstage. Whenever possible it is best to light from the upstage side. See Figures 13.38 and 13.39 for examples.

BACKLIGHT AND KICKER

Two lights that by definition come from the back are backlights and kickers. *Backlight* is sometimes referred to as a hair light or shoulder light (Figures 13.6 and 13.11). It outlines the subject, separates them from the background, and gives the subject more shape and depth.

A *kicker* is a light that comes approximately from 3/4 back and brushes along the cheek of the subject. It is an extremely useful light. Once you start looking for them, you will see kickers everywhere, even on simple interview shots. As cinematographers take advantage of the higher speed film stocks and HD/UHD cameras and their ability to “see” into the shadows, there is a tendency to use less and less fill light on subjects. The kicker can be useful to define the shadow side of the face even if there is no fill light at all. Men tend to benefit from a hard kicker, while a soft kicker frequently works better for women.

INTENSITY

How bright or intense a light is clearly affects exposure, but remember that no matter how bright or dark the overall light of a scene is (within limits), we can adjust it by exposing correctly with the iris, shutter, or neutral density filters. What is important here is the relative intensity of different lights within a scene, the relative *balance* of the various lights. These are really two completely different ways to think about the intensity and exposure of lighting in a scene: the overall lighting level and then the comparative difference between lights in a scene—which is usually referred to as the *contrast ratio* between the key and fill but also applies to objects in the frame that generate their own light—windows, lampshades, candles, and on. Controlling how much brighter they are in relation to the rest of the scene is an important use of lighting controls such as dimmers, scrims, and neutral density gels.

TEXTURE IN LIGHTING

Texture occurs in several ways. One is the inherent texture of the subject itself, but the one that concerns us here is texture of the light itself. This is done by putting things in front of the light to break it up and add some variation of light and shadow. Things you put in front of the light are called *gobos*, and a particular type of gobo is the *cuculoris* or *cookie*, which comes in two types.

Hard cookies are plywood with irregular cutouts. *Soft cookies* are wire mesh with a subtle pattern of translucent plastic. Temporary cookies can be cut from foamcore, show card, or almost anything that’s available at the time. Other tricks include putting a shadow-casting object in front of the light; traditionally these include things such as vertical *charlie bars*—vertical bars used to create shadows. This effect can also be accomplished with strips of tape on an empty frame. Another method is to put lace in a frame and place it in front of the light.

Figure 13.18. Classical hard lighting in the film noir classic *The Big Sleep*. In this method, every actor, every piece of furniture, every wall, had it's own Fresnel light.

COLOR

Color is such a large and important issue that we devoted an entire chapter to the subject earlier in the book. There are several aspects to the subject of color as we use it in filmmaking:

- The image-making side of color: how we use it to make better and more impactful images.
- The storytelling aspect of color; that is the emotional, cultural context of color. One of the best references on this topic is *If it's Purple, Someone's Gonna Die*, by Patti Bellantoni, a fascinating look at using color in filmmaking.
- Color is important at the camera—choice of film stock or video camera setup, the use of LUTs and Looks to manipulate color in the camera or at the DIT cart.
- Controlling color at the light source, which involves both using color-balancing gels, *party gels* (random colors made by the gel manufacturers), and the choice of the proper lightin gunits.

LIGHTING TECHNIQUES

The fundamental methods are discussed in detail later. They include:

- Ambient & available light.
- Classical lighting.
- Through the windows.
- Practicals and motivated lighting.

AMBIENT

The term *ambient* has two meanings. On location, it means light that is “just there”—generally a sort of soft, overall light in the room. In lighting in the studio or on a location set, it means an overall fill that is added, usually from big soft overhead sources (Figure 13.16). *Available light* is just going with whatever light is there when you arrive—street lights, daylight, etc., such as in Figure 13.44.

CLASSICAL LIGHTING

Classical lighting refers to the *hard light* style that was the norm in big movie production for decades. Some refer to it as *Film Noir* lighting. It employs hard light Fresnels individually aimed for the actors, objects on the set, the background, and so on, (Figure 13.18). The method is still used, although soft light on the actors is more frequently used.

BRINGING IT THROUGH THE WINDOWS

Many cinematographers say that they “bring it through the windows” whenever possible. It is a much more naturalistic look and it also frees the set of stands and cables, making setup changes quicker and more efficient (Figures 13.23, 13.24, and 13.25).

Figure 13.19. A practical table lamp used as a key in this scene from *The Big Combo*. Practical lamps figure prominently in the *film noir* genre. In fact, this practical lamp only *motivates* the key light, which is actually a small unit hidden behind the table lamp.

PRACTICALS AND MOTIVATED LIGHTING

Motivated lighting and *practicals* are closely related. *Practicals* are lamps and other sources that actually work. Figures 13.20 and 13.21 show a scene lit by a practical table lamp. Figures 13.31 and 13.31 show *motivated* lighting, which appears to come from the practicals (or windows, doors, etc.) but is actually coming from lighting units.

BASIC PRINCIPLES OF LIGHTING

Some basic principles:

- Avoid flat front lighting! Lights that come more from the sides and back are usually the way to accomplish this. Any time a light is right beside or behind the camera, that is a warning sign of possible flat, featureless lighting.
- Whenever possible, light people from the upstage side. This is probably the most important principle of lighting along with avoiding flat front lighting.
- Use techniques such as backlight, kickers, and background/set lights to *separate* the actors from the backgrounds, accentuate the actor's features.
- Use shadows to create chiaroscuro, depth, shape the scene and mood. Some DPs say that "…the lights you don't turn on are as important as the ones you do turn on."
- Use lighting and exposure to have a full range of tones in the scene—this must take into account both the reflectances of the scene and the intensity of the lighting.
- When appropriate, add texture to your lights with gobos, cookies, and other methods. Some DPs, such as Wally Pfister almost always add some texture to their key lights.

BACK CROSS KEYS

One of the most useful and commonly used techniques is *back cross keys*. It's simple, straightforward, and fast but also very effective. Take a look at the next ten dialog scenes you see in feature films, commercials, or television: there's a good chance that most or even all of them will be lit with this technique (Figures 13.37 and 13.38).

Have a clear vision, design and objective for every scene. Then, by lighting with your

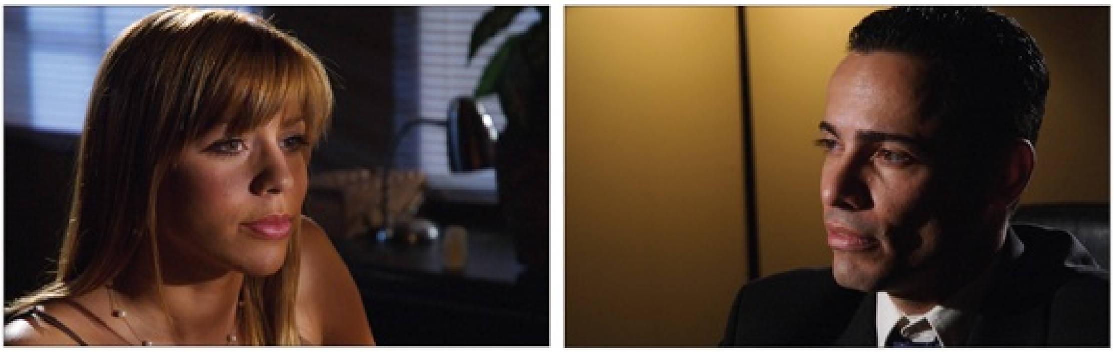
The idea is simplicity itself. For a two-person dialog scene (which constitutes a large majority of scenes in most films), one upstage light serves as one actor's key light and also the second actor's backlight. A second light does the opposite: it is the second actor's key light and the first actor's backlight. That's all there is to it, but you may want to add some fill, backlights, or whatever else the scene calls for.

instincts along with your intention and setting your own level of excellence, you will find satisfaction.
Rene Ohashi, ASC, CSC (*Forsaken, Faces In The Crowd*)

AMBIENT PLUS ACCENTS

Especially on larger sets, it is often difficult or impractical to light every corner of the set with many different hard or soft light units, as was usually done in the classic hard lighting method. It is often better to establish an ambient base—which means to simply fill the set with a soft, featureless overhead light. This gives you a basic exposure for the entire set, but it is usually somewhat bland and low in contrast. For some scenes, this might be the desired effect, such as a scene in a frozen winter landscape. In most cases, however, you will want to add some *accents* to feature actors or emphasize certain elements of the set (Figure 13.16). Establishing an ambient base can be accomplished in a number of ways:

- Overhead lights often in conjunction with an overhead silk.
- Chicken coops, space lights, or softboxes.
- Bouncing a light off the ceiling.
- Leaving the overhead fluorescents on.
- Large skylights or glass roof.



Figures 13.20. and **13.21.**Two sides ofscene lit with *back cross keys*: one light on each side is one actor's key and the other actor's backlight. Both lights are from the *upstage side*. In this case, the woman's *key* is coming through a window and some lace to add texture. His *key* is hard without any softening or texture. See the website for more on this lighting technique. Note also the *matching eyelines*—crucial in a dialog scene such as this.

LIGHTING WITH PRACTICALS

This is a method that may be used by itself or in conjunction with other methods. A practical is something that works—whether it be a table lamp or a refrigerator. Here, we are only talking about lights, whether they be table lamps, sconces, floor lamps, or whatever. Practical lamps play a part in almost any scene they are in, particularly if it is a night scene. The film noir genre in particular frequently used practical lamps as a major element in the frame as a lighting source.

One of the few absolute rules in lighting is that every practical must be on a dimmer of some sort. In most cases this will be a *hand squeezer*, a small handheld dimmer that is usually made from an ordinary wall dimmer. The reason for this is obvious—with most kinds of lights, we can control the intensity with scrims, grip nets, neutral density gels, and flooding/spotting. With practical lamps we don't have these methods of control, so a dimmer is the quickest and most precise way to control the brightness. Given that these lamps appear in the frame, it is essential to be able to control them precisely, so hand squeezers are essential. We want them to appear bright, or the lamp won't look like it's on. This means they are right on the edge—too bright and they will burn out, which means they are not only overexposed and without detail but they may also be a distraction in the composition—see Figures 13.32 through 13.34. One limitation is that ordinary dimmers won't work on fluorescents, LEDs, and neon lamps, although special dimmers are available. One thing to watch for is that the more you dim a practical, the warmer the light becomes. It is best to have a number of different size bulbs available in case you want to switch to a lower wattage bulb in order to avoid too much dimming.

LIGHTING THROUGH THE WINDOW

> Light the people, not the sets.
> John Alton (*The Big Combo, Elmer Gantry*)

In the old studio days, sets were commonly lit from the *grid* (overhead pipes). This is still done, but these days, locations are used as frequently as sets built in studios. On locations, it may be possible to rig a temporary grid of some sort through the use of various grip equipment such as *wall spreaders* or other means.

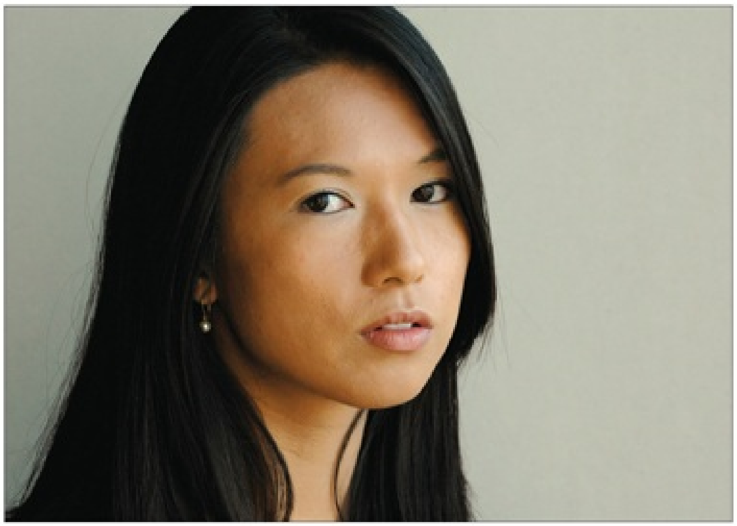


Figure 13.22. Natural window light is extremely soft as long as there are no direct rays of the sun. It is not merely the light from the sky (a huge wrapping source), it is also the lignt bouncing off the ground, nearby buildings, and so on.

Locations are often lit "from the floor," meaning that lights are placed on stands. This works, but it has disadvantages, among them that the working area can be cluttered with light stands, grip stands, and cable. For this reason, many DPs prefer to light from the outside—through window, doors, skylights, *etc.* This also has a naturalistic look almost by default; most rooms with windows naturally get a great deal of their light from the windows. Some cinematographers and gaffers go so far as to say always light from outside, although clearly there will be situations where this is not possible. This method also means that the set will be less crowded, so moving from setup to setup is quicker and easier and also gives the director much greater freedom in selecting their frame.

AVAILABLE NATURAL LIGHT

The term *available light* is used in two ways on film sets. One of them means whatever light is there in a location; usually an exterior location but it can refer to rooms that have windows, skylights, or ordinary room lighting as well. In general, the term "available light" means working with the existing lighting on the location. There is a third, less serious use of the term. Some might say that a particular DP is an "available light" cinematographer, as in "he uses every light available on the truck."

Pretty

AVAILABLE LIGHT WINDOWS

Window light can be some of the most beautiful light of all, if you use it right (Figure 13.22). Windows can also be disastrous—for example, if you place an actor against a window and the camera is placed so that the actor is in front with the view out the window behind them. In normal daylight conditions, this will produce a very high-contrast situation, and you have to choose between having the outside view properly exposed and the actor in complete silhouette or exposing for the actor and having the window view overexposed and blown out. (See "The Window Problem" on the website.)

There are workarounds, of course. One is to use a big light on the actor to bring up their exposure. This generally requires a very large unit and it can be difficult to make it look natural; also, the light has to be daylight balance. The other alternative is to bring down the exposure of the window. The easiest way to do this is to gel the window with *ND* (*neutral density gel*), which can reduce the light coming through the window by one, two, three, or even four stops (the ND designations for this are ND .3, .6, .9, and 1.2). If you want to use tungsten balance lights inside the room, you can also add 85 gel, which converts daylight (5600K) to tungsten balance (3200K). Or you can use gel that combines them: 85N3, 85N6, *etc.* But there is another alternative: change the shot. This not only makes lighting easier, but it will generally produce a better-looking shot. If the director is flexible about the staging, you'll get a better image by placing the camera so that the actor is beside the window and the background of the shot is no longer the view out the window, but rather something inside the room.

photography is easy: it's really the easiest thing in the world. But photography that rounds a picture off, top to bottom, and holds the content together is really the most beautiful. That means it can be visually very beautiful; it can also be pedestrian in certain ways because that is more appropriate to the story. You try not to put the photography in front of the story—you try and make it part of the story.

Gordon Willis (*Annie Hall, The Godfather*)

Figure 13.23. This dark, moody scene is lit primarily from the windows with four *Maxi Brutes* through *Hilight* diffusion, supplemented by the library lamps on the table. A very slight smoke effect is added as mild diffusion. In cases like this, it is important to control the smoke level so that it doesn't become noticeable in the shot.

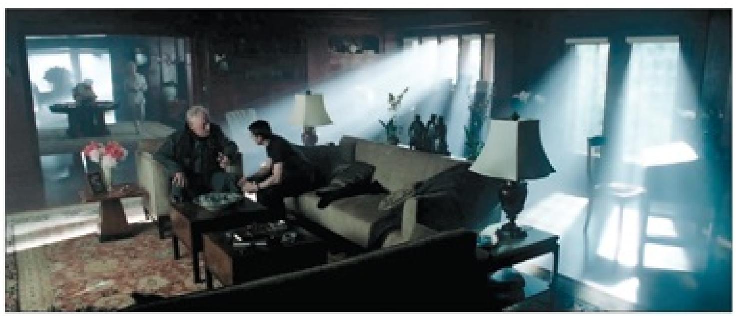


Figure 13.24. This scene from *Minority Report* is lit entirely through the windows as Janus Kaminski frequently does. Smoke makes the shafts of light visible, if you don't want to see them, just avoid smoke on the set.

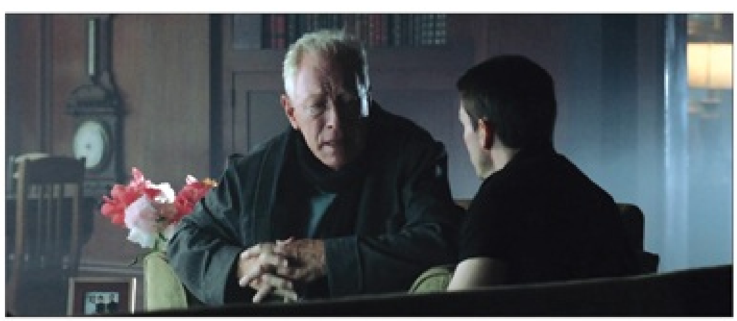


Figure 13.25. The two shot from the above scene. There is one addition to the lighting—a kicker catches the right side of Max von Sydow's face.

What is it that makes window light so beautiful? We have to distinguish between *window light, sky light*, and *sunlight*. Many people think of window light being "sunlight." Direct sun is hard and contrasty. Sky light is the light coming from the sky itself, which is a huge radiating source and thus very soft. Also coming through a window might be sun bounced off neighboring buildings, the ground, *etc*. All of this adds up to make window light extremely soft, consistent and "smooth."

Figure 13.26. For this re-creation of a noir look, his key is just a bounce off the paper in the typewriter—nothing more.

Figure 13.27. The overall setup is very simple: a *Tweenie* bounces off the typing paper, a *Betweenie* gives him a backlight/kicker, and another *Betweenie* adds a slight glow to the map. The practical lamps have very little influence on the scene; they are mostly just props. The lamps are burned out in the shot of the setup but have been dimmed to an appropriate level for the scene.

MOTIVATED LIGHT

Light in a scene may come from many sources, including lights that are actually in the frame such as practicals, windows, skylights, signs, and so on. In some cases, these sources are visible but do not provide enough output for proper exposure. In this case, the sources may only serve to motivate additional lighting that is off-screen. Some cinematographers and directors prefer that most or all lighting in a scene be motivated in this way—that the viewer should be able to intuitively understand where the light is coming from. In these frames from *Honeydripper* (Figures 13.30 and 13.31), the light is motivated by the lamps, but the illumination comes from sources not in the frame.

Figure 13.28. Her only source is the practical lamp itself: A very small source adds a *catchlight* in the eyes.

Figure 13.29. The lamp works for her even when she leans back, but only in a fairly narrow range of distance from the practical.

CARRYING A LAMP

Often we want the lamp to appear to be lighting the subject, but for some reason, it just won't do it. If we turn the lamp's brightness up enough to light the actor, then the shade will be completely blown out; or it might be that the actor just isn’t close enough to be properly lit by the lamps. In this case, we use a technique called carrying the lamp. To do this, we set a small lamp in a place where it will hit the actor from the same direction as the light from the lamp. It also needs to be the same quality of hard or soft and the same color; table lamps tend to be on the warm side, often about 2800K or warmer. Figures 13.26 and 13.27 show a modern take on a film noir look that employs a different method of carrying a lamp. Here the lighting is actually very simple: it’s a *Betweenie* (300-watt Fresnel) that is bouncing off the piece of paper in the typewriter. Another Betweenie gives the actor a backlight, and a third one puts a small splash on the map behind him.

Figure 13.30. In this establishing shot from *Honeydripper*, the oil lamps are clearly shown to be the *motivation* for the direction, color, and quality of the light, which is then used to great effect in the two-shot.

Figure 13.31. Once the sources have been established in the wide shot, the lighting of this two shot, the mediums, and close-ups makes sense and seems appropriate. This is an example of both *motivated lighting* and *carrying* a lamp.

The typing paper bounce gives him a moody look appropriate for the scene and doesn't create problematic shadows like a hidden light from below would. If we try to light the actor with the practical lamp as in Figure 13.32, the lamp is totally blown out. If we dim it down enough to see the lamp (Figure 13.33), then the actor gets lost. The solution was to have a light just out of frame on the left and below the table level. With this rig on a dimmer, it was possible to achieve the correct balance between the practical light and the actor's key (Figure 13.34). The key to this technique is to make sure the light you are using to carry the practical is hitting the actor from the same angle as would the light from the practical lamp.

DAY EXTERIORS

Working with daylight can be a lot trickier than people think. Some producers and directors believe that working with available daylight will always be faster. Sometimes, but not usually. If it's an overcast day (soft light), then nothing could be simpler. If you are dealing with direct sun, controlling it can require constant attention and adjustment. When dealing with actors in direct sun, you have several choices: diffusion of the harsh sun, filling and balancing the shadows, finding a better location or angle for the shots, or moving the shot into open shade. See video examples on the website.

Figure 13.32. If the practical is set high enough to give proper exposure to the subject, the lamp itself is completely blown out.

Figure 13.33. When the practical lamp is set to a level that gives it the proper exposure, then the subject is underexposed.

Figure 13.34. A separate source is added to "carry" the lamp. It comes from the same direction as the lamp and gives the illusion that the practical lamp is lighting the actor. The source, in this case, is a MolePar in a snoot box with a dimmer. (Photo by author).

Figure 13.35. Soft overall ambient lignting from the top is frequently referred to as "Godfather lighting" for obvious reasons. Here it works as part of the visual storytelling—the fact that you can't clearly see his eyes adds to the character's air of mystery and understated power.

FILL

You can use *bounce boards* or lights to fill in the shadows and reduce the contrast. Grip reflector boards (Figure 12.39 in *The Tools of Lighting*) have a hard side and a soft side and yokes with brakes so they can be set and will stay as positioned. The sun moves quickly, however, and it is almost always necessary to shake them up before each take. For this reason, a grip has to be stationed beside each board to re-aim it for each take. It is also important to table them if there is a break in filming. This means adjust the reflector to a horizontal position so it doesn't catch the wind and blow over. Be sure to secure them heavily with sandbags. Between scenes, they should be laid on the ground on their sides so as not to damage the surfaces. Even the soft side of a reflector board can be a bit harsh; one good strategy is to aim the hard side through medium diffusion (like *216*) or the soft side through light diffusion (such as *Opal*), which just smooths it out a bit.

SILKS AND DIFFUSION

Another choice is to make the sunlight softer and less contrasty. For tight shots, a 4x4 frame with diffusion can soften the light and can be held by a grip stand, with plenty of sandbags, of course. For larger shots, frames with silk or diffusion are made in many sizes: 6'x6', 8'x8', 12'x12', 20'x20', and even 20'x40'. These larger sizes require solid rigging and should only be done if you have an adequate grip crew who know what they are doing: a 12'x12' silk has enough area to drive a sailboat at 10 knots, meaning it can really do some damage if it gets away from you in the wind (See Figures 12.30 and 12.31).

Silking a scene can have its limitations as it can constrict the angles and camera movement in a shot. One option is to silk only the actors in the scene, possibly by "Hollywooding" (handholding) a silk. The disadvantage is that it may cause an imbalance in the exposure of foreground and background.

OPEN SHADE AND GARAGE DOOR LIGHT

The simplest and often most beautiful solution to working with harsh direct sun is simply to get out of the sun entirely. If the director is flexible about the scene, it is usually not only faster but also better lighting to move the scene to a shady spot; best of all is open shade, which is the shady side of a building, trees, and so on, but open to the sky (Figures 13.42 and 13.43). Here the subject is lit by the soft light of the radiating sky dome, reflection off the rest of the terrain, and so on. The only danger here is your background: since the exposure will be a couple of stops down, it is critical that you not frame the shot so that the hot background behind the actor will be in direct sun and thus severely overexposed. A variation on this is garage door light (Figure 13.45). This is open shade with the darker interior as a background. It can be both beautiful and dramatic. It doesn't have to be an actual garage door, of course; the key is that it is open shade with a darker background such as you would have with an actor positioned right in a large open entrance such as a garage door. Also, a good deal of the light on the actor is being bounced off the surrounding landscape and also the ground in front of them, which gives them a nice underlit fill.

Figure 13.36. A dialog scene with *flat front lighting*—no depth, no contrast, no "shape,"in other words, boring, ineffective lighting. It also doesn't look very natural.

Figure 13.37. *Back cross keys* give the scene shape, depth, contrast, and a fuller range of tones. It helps create a *foreground, midground*, and *background* to create that sense of depth—this is also helped by the practical lamp as a compositional element.

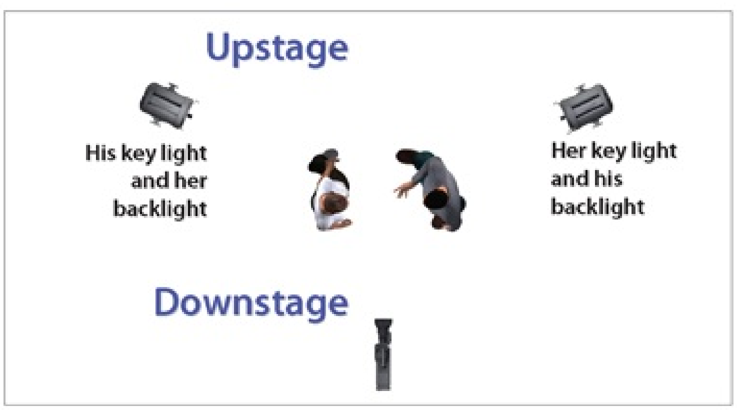


Figure 13.38. A diagram of *back cross keys*. Each light efficiently serves as both a key and a backlight. A typical setup of this method might also include a fill light, backlights, and other units. Importantly, both of these lights are on the *upstage side*—on the side farther away from the camera. Flat front lighting results from lights being too much on the downstage side, near the camera. This may not apply for a key light on someone facing toward the camera, but the lighting will still be flat if the light is very close to the camera.

Figure 13.39. The final medium shot in this scene is lit by a hard light coming from the right. However, it doesn't light the actor directly (except from mid-chest down). It is the bounce off the map on the desk that lights his face in an atmospheric, mysterious and expressive way. (Photo courtesy Noah Nicolas Matthews).

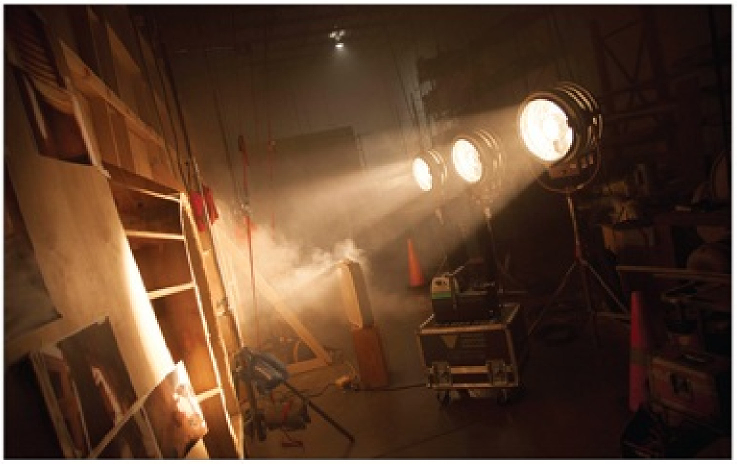


Figure 13.40. This scene by Noah Nicolas Matthews uses *Mole Beam Projectors* to create sharp, focused, specular hard light to punch through the windows of the set. Note also the smoke machine—smoke is necessary if you want to see the beams of light. (Photo courtesy Noah Nicolas Matthews).

Figure 13.41. Inside the set, we see the results of those beam projectors and the smoke. At the far end of the set is the actor in front of a small green screen. (Photo courtesy Noah Nicolas Matthews).

SUN AS BACKLIGHT

If all other options are unavailable, an alternative is to turn the shot so that the actor has their back to the sun. This does two things: first of all the actor is lit by the bounce off the surroundings. In most cases this is not quite enough, but the addition of a simple bounce board (foamcore, beadboard, or a folding silk reflector) helps. This involves working with the director to adjust the shot. Remember that shots rarely exist on their own; they are usually part of an entire scene. This means that thinking it through and planning for the sun angles must be done before starting to shoot the scene. Once you have shot the master for a scene, it is often not possible to cheat the actors around to take advantage of the sun's position, although for some close-ups it may be possible. It is also important to think ahead about the sun's movement, especially if the scene is going to take a long time to shoot or there is a lunch break during filming.

The first time you work with the sun as a principal part of your lighting scheme, you may well be surprised at how fast it moves through the sky and thus changes the lighting on your actors or the scene overall. This calls for careful planning and scheduling and referring to one of the many computer or smartphone apps that can help you predict the location and angle of the sun in advance but will also give you accurate data on the exact time of sunset or sunrise.

Figure 13.42. Direct sunlight is harsh, contrasty, and unflattering. If you do have to shoot in direct sun, try not to do so during the middle part of the day. Sunlight is softer and at a lower, more flattering angle early in the day or late in the afternoon.

Figure 13.43. Here we just have the actor back up a few feet so he is under the awning of the building. This is *open shade*; it is softer and less contrasty. Notice how it also creates a better balance between the actor and the building in the background. As a bonus, the actor isn't tempted to squint.

MAGIC HOUR

There is a special condition of lighting that deserves mention—Magic Hour is the time immediately after sunset when the light of the sky matches the existing street lights, signs, and windows of the exterior scene. It can be extraordinarily beautiful and film companies frequently plan their most special shots to be done in this time frame. The catch is that "magic hour" is nowhere near an hour; it's more like twenty to thirty minutes and can vary according to local conditions (such as mountains) and heavy cloud cover. The Terrence Malick film *Days of Heaven* is famous for having been shot almost entirely at magic hour. While the cinematography by Nestor Almendros is justifiably regarded as a masterpiece, few feature film productions can afford to limit shooting to only two narrow time slots each day—morning and evening, although they do schedule special shots for that time frame. In planning shots that depend on time of day, the Assistant Director is your key resource—he or she is in charge of the schedule and they usually understand the concerns of the cinematographer in this regard. Commercials, on the other hand, will often spend most of a day preparing for just that special shot.

Once a magic hour shot has been planned, it's all about preparation. Not only is the time frame extremely short, but the lighting conditions change minute by minute. If you are only doing available light, then you'll need to check your exposure before every shot. If, on the other hand, you are adding some foreground lights on an actor, there's another problem; as the sky darkens and exposure drops, the lights you have added will quickly become too hot—out of balance with the scene. Standard procedure by the gaffer is to have the crew standing by to adjust the intensity of the lights quickly and efficiently. This can be done by adding scrims or nets in front of the light and possibly by dimming.

Figure 13.44. A beautiful establishing shot from the movie *Rush*. Although not technically a “magic hour” shot as the sun is still up, the precise balance between the foreground lit by the fading skylight, the parking lot lamps, and the cloud-covered sun in the background is exactly the same idea. Although we can’t know for sure, it seems likely that this was planned as a magic hour shot but when the clouds moved in they decided to roll early and ended up with a perfect balance. This is a prime reason why it is prudent to set up for a magic hour shot well in advance. Also notice how a *wet-down of* the parking lot adds to the shot, especially the highlight of sun reflection that gives the shot some excitement and acts as a strong compositional element.

Figure 13.45. (right) An example of *garage door light*. The subject is just inside the door, which puts her in open shade. The sun is still hitting the ground, buildings, and the rest of the background behind the camera, which results in a soft bounce on the actress.

If the director is trying for more than a couple of takes of one shot, or even to do two or three different shots, then it’s going to be a mad scramble and a high adrenaline situation, but when you pull it off successfully, it’s high fives all around. Always be aware that a sudden change in cloud cover can ruin the best planned shots. If clouds roll in suddenly, the exposure may drop to a level that makes proper shooting impossible. Beware of frantic directors who insist on shooting anyway, sometimes by declaring that “I don’t care how it looks.” They may say so at the time, but when they are unsatisfied with the dailies, it is you they will blame. It is very unlikely that they will remember that it was them who insisted on shooting under bad conditions. Contingency plans and setting up extra early for these types of shots are what prevents disasters and what really sets real professionals apart from the amateurs. Figure 13.44 is a perfect example of this. Even with the most accurate weather predictions, it is impossible to know if there will be clouds or not around sunset, by being ready early and having an alternate plan, the DP ended up with a beautiful shot.

Figure 14.1. Lenses and the language of the lens play a key role in Hitchcock's *Rear Window*.

Figure 14.2. An *Arri Alura* 18mm to 80mm zoom lens on a Canon C-300. (Photo courtesy Niche Cameras, New Zealand).

THE PHYSICAL BASIS OF OPTICS

Except for certain minor differences, the principles of optics and the use of lenses are the same for film and video. Nearly all principles of optics and optical design are based on a few properties of physics. The two most basic are *reflection* and *refraction*. There are a few things we need to know about the basic behavior of light in order to understand the fundamentals of optics.

REFRACTION

The refraction of visible light is an important characteristic of lenses that allows them to focus a beam of light onto a single point. Refraction, or bending of the light, occurs as light passes from one medium to another when there is a difference in the *index of refraction* between the two materials. *Refractive index* is defined as the relative speed at which light moves through a material with respect to its speed in a vacuum. When light passes from a less dense medium such as air to a more dense medium, such as glass, the speed of the wave decreases. Conversely, when light passes from a more dense medium to a less dense medium, the speed of the wave increases. The angle of refracted light is dependent upon both the angle of incidence and the composition of the material into which it is entering. "Normal" is defined as a line perpendicular to the boundary between two substances.

FOCAL LENGTH AND ANGLE OF VIEW

The *focal length* of the lens is the distance between the optical center of the lens and the image sensor when the subject is in focus; it is usually stated in millimeters such as 18 mm, 50 mm, or 100 mm (Figure 14.3). For zoom lenses, both the minimum and maximum focal lengths are stated, for example, 18—80 mm (Figure 14.2).

The *angle of view* is the visible extent of the scene captured by the image sensor, stated as an angle. Wide angles of view capture greater areas, small angles smaller areas (Figure 14.6). Changing the focal length changes the angle of view. The shorter the focal length (such as 18 mm), the wider the angle of view and the greater the area seen. The longer the focal length (100 mm, for example), the smaller the angle and the larger the subject appears to be. The angle-of-view is also affected by the size of the sensor or film format. The smaller the sensor size, the greater the angle of view will be for the same focal length. The difference between two formats (sensor sizes) is called the *crop factor*. Charts and calculators are available online to help you determine what the angle of view will be for a particular combination of lens focal length and sensor size. As we will see, sensor size also affects *depth-of-field*—a larger sensor (or film format) will have less depth-of-field for the same focal length and aperture setting.

Figure 14.3. A *prime lens* has only one focal length, unlike a zoom, which is variable in focal length. This is a standard set of primes for 35mm film. Of course, they can be used on any video camera with the appropriate lens mount, but any given focal length will have a different angle of view depending on the size of the sensor. A lens is defined by its focal length and its maximum wide open aperture. (Photo courtesy of Schneider Optics)

F/STOP

It is one thing to have the lens form an image on the focal plane, but the amount of light that reaches it must be controlled. This is done with an aperture, which is nothing more than a variable size hole that is placed in the optical axis.

The *f/stop* of a lens is a measure of its ability to pass light to the image plane. The f/stop is the ratio of the focal length of a lens to the diameter of the entrance pupil. However, this is a purely mathematical calculation that does not account for the varying efficiency of different lens designs. *T-stop* (*transmittance stop*) is a measurement of actual light transmission measured on an optical bench. F/stops are used in depth-of-field and hyperfocal calculations, and T-stops are used in setting exposure. T-stops are typically 1/3 to 1/2 stop less than the F/stop.

When setting the aperture on a lens, never go backward. Most apertures have a certain amount of backlash that must be compensated for. If it is necessary to go to a larger stop (open up), open the lens all the way up and then reset the stop.

FOCUS

Focus is a much misunderstood aspect of filmmaking. What is “in focus”? Theoretically, it means that the actual object is projected onto the film or video “as it appears in real life.” The human eye tends to perceive everything as in focus, but this is a result of the eye/brain interaction. The eye is an f/2 optic and may be considered a fairly “wide-angle” lens, so much of the world actually is in focus, certainly in brightly lit situations. But, nearly imperceptible to us, the focus is constantly shifting. This is accomplished by the muscles that control the lens of the eye. They distort its shape to shift the focus. If you look at something very close in dim light, the background will be out of focus, but most likely you will not perceive it—because you are “looking” at the near object. “Looking” means the brain is focusing your attention. This is what differentiates the eye from a camera: our mental focus is a condition of our consciousness—the camera simply records everything.

Figure 14.4. A view aperture ring set at T/2.1 on a Zeiss Prime and a look down the barrel at the iris wide open.

Figure 14.5. The aperture ring set at T/22 and a look down the barrel with the iris closed down all the way.

As we will see later, a great number of the practices of focus—focal length, composing the frame, and even lighting—are attempts to re-create this mental aspect of focus and attention. We are using the camera to imitate how the eye and brain work together to tell a visual story in an imitation of how life is perceived by the mind.

First, the technical basics: the *taking lens* is the optical system that projects the image onto the film or video sensor, which is called the *image plane*. All imaging, whether photography, cinema, video, or even painting, is the act of taking a three-dimensional world and rendering it onto this two-dimensional plane.

When discussing focus, we often tend to think only in terms of the flat image plane, but it is more useful to remember that the lens is forming a three-dimensional image in space, not a flat picture plane. It is the flat picture plane that must be "focused" onto. It is the only part of the image that gets recorded.

The image plane is also called the *Principal Plane of Focus*—sort of the uptown business address for what we commonly call the focal plane. Think of it this way: we are shooting a scene that has some foreground bushes, a woman standing in the middle, and some mountains behind her. The woman is our subject. We focus the lens so that she is sharply projected onto the image plane.

In our three-dimensional model, the bushes and the mountains are projected behind the lens, but in front of her and behind her. In other words, they are being projected into the camera, but in front of and behind the *Principal Plane of Focus*. As a result, they are out of focus. By shifting the focus of the lens, or by stopping down, or using a wider angle lens, we can bring them into focus, but let's assume we are shooting wide open with a fairly long lens. By changing the focus of the lens, what we are actually doing is shifting that three-dimensional image backward and forward. If we shift it backward, the mountains are focused on the image plane; if we shift forward, the bushes are focused. Only objects that are projected sharply on the image plane are actually in *critical focus*. But there are many objects that are only slightly in front of or behind the principal subject. If we stop down a little, thus increasing depth-of-field, they appear sharp (Figures 14.9 and 14.10).

But they are not actually sharp. This is called *apparent focu*s. What is the boundary line between actual focus and apparent focus? There is none—at least not technically definable. It is a very subjective call that depends on many factors: perception, critical judgment, the resolving power of the lens, the resolving power of the film or video, the amount of diffusion, the surface qualities of the subject, lighting, and so on. Also very important is the end use of the footage. Something that appears in focus on a small television might be horribly soft on an Imax screen. There is a technical measurement of critical focus that is discussed below. It is called the circle of confusion. Note also that *depth-of-field* is different from *depth-of-focus*, as in Figure 14.8.

MENTAL FOCUS

The viewing audience will tend to focus their attention on the part of the image that is in focus. This is an important psychological function that is valuable in visual imagery and storytelling with a lens.

But cinematographers are engaged not only in shaping mental perception, they are also technicians. We need some way of quantifying focus, however arbitrary that might be. Let's think about a single ray of light—for example, an infinitely small (or at least a very tiny) point of light that is the only thing in the field of view. This sends a single ray of light toward the lens. As the ray of light leaves the object, it expands outward; no set of light rays is truly parallel, not even a laser or the light from a distant start. The lens captures these slightly expanding rays of light and reconcentrates them: this bends them back toward each other. This forms a cone behind the lens. Where these rays actually meet is where the image is in focus. The lens can then be adjusted so that this single point of light is sharply focused on the image plane.


PARADOX
IRON


PARADOX
IRON


SINCE
PARADOX
IRON
STEEL FABRICATION AND ERECT


SINCE 1894
PARADOX
IRON
STEEL FABRICATION AND ERECT

Figure 14.6. *Field of view* of a standard set of high-speed prime lenses on a 35mm format camera at a 16x9 aspect ratio. The lower the number of the focal length, the wider the field of view of the lens. The camera remains in the same position for all these examples. The frames are, from top to bottom: 18mm, 25mm, 50mm, and 85mm prime lenses.

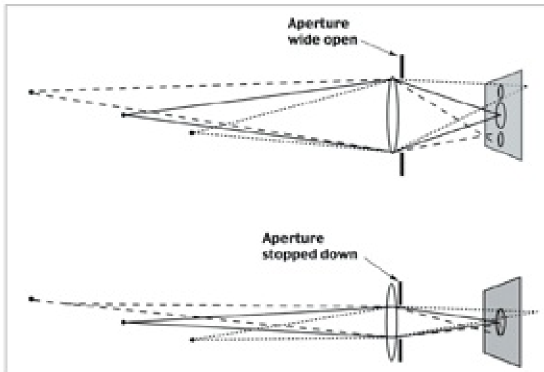


Figure 14.7. How the iris opening affects the circle of confusion and thus depth-of-field.

Now, we shift the lens so that the image of the dot of light is not exactly at the image plane. What happens? The image of the dot gets larger because we are no longer at the confluence of the rays of light as concentrated by the lens. If we do this only slightly, no one may notice. We say that this is still acceptable focus. If we shift a lot, most people would then perceive it as out of focus. Taking into account the various factors, imaging scientists have quantified how much bigger that dot can be and still be in "acceptable" focus. But who decides what is "acceptable" when it comes into to focus? Optical scientists have developed a standard we can use to quantify this aspect of lens performance.

CIRCLE OF CONFUSION

This standard is called the *circle of confusion*. Circle of confusion is defined as the largest blurred point of light that will still be perceived as a point by the human eye. It is a measure of how large the image of a point source can be before it is unacceptably out of focus.

Theoretically, the point of light projected onto the film plane should be the same size as the infinitely small point of light it is seeing, but due to the nature of optics, it can never be perfect. For film work in 16mm, the circle of confusion varies from 1/2000" (.0005") for critical applications to 1/1000" (.0001"). For 35mm it ranges from 1/700" (.00014") to 1/500" (.002"). The circle of confusion is an important part of defining the depth-of-field at a given f/stop; it is part of the calculation. The circle of confusion is smaller for 16mm because 16mm has to be blown up more to achieve the same image size on the screen or monitor. For HD/UHD video, the depend on sensor size. The circle of confusion is most important in the calculation of depth-of-field. Whenever you look at a depth-of-field chart, you will see listed the circle of confusion used in the calculations.

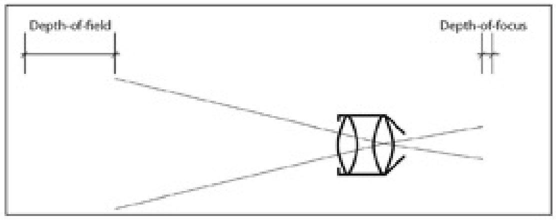


Figure 14.8. The difference between *depth-of-field* (in front of the lens, the subject) and *depth-of-focus* (behind the lens at the film plane).

DEPTH-OF-FIELD

Back to our model of a three-dimensional projected image. The portion of this image that falls on the image plane and is within the circle of confusion is called the *depth-of-field*. It has a near and far limit, but these fall off gradually. A number of factors affect depth-of-field:

- Focal length of the lens. The shorter the focal length, the greater the depth-of-field.
- The aperture of the lens. The smaller the aperture, the greater the depth-of-field.
- Image magnification (object distance). The closer the subject is to the image plane, the less the depth-of-field.
- The format: larger formats (35mm or Imax) have less depth-of-field than smaller formats (16mm or most video sensors).
- The circle of confusion selected for the situation.
- Indirectly—the resolving power of lens and film, end use, diffusion, fog, smoke, the type of subject.

Depth-of-field is not evenly distributed in front of and in back of the plane of critical focus. It is one-third in front and two-thirds behind, sometimes more in modern lenses. This is because behind the plane of focus is, of course, farther away. This may be crucial when composing shots with very limited depth-of-field. Most camera assistants carry physical or digital calculators for depth-of-field and other optical information they need quickly on the set.

HOW NOT TO GET MORE DEPTH-OF-FIELD

As a result of the basic principles of physics, wide-angle lenses will have more depth-of-field at a given f/stop. Here we must dispel one of the most persistent myths of filmmaking. Many people still believe that if you are having trouble getting the important elements in focus, the answer is to put on a wider-angle lens and you will have greater depth-of-field. This is technically true, but in actual practice, they then move the camera forward, so they have the same frame size. The actual result? You end up with the same depth-of-field you started with! This is because you have moved the camera forward and end up with same image magnification. It is image magnification that is the critical factor. You are decreasing subject distance and increasing image magnification, which decreases depth-of-field.

HYPERFOCAL DISTANCE

For every focal length and f/stop, there is a particular focus distance that is special: the *hyperfocal distance*. This is the closest focus distance at which both objects are at infinity, and closer objects are in focus. When a lens is set at the hyperfocal distance, everything from 1/2 of the hyperfocal distance to infinity will be in focus. There are two ways of defining hyperfocal distance (Figure 14.13).

Figure 14.9. In both of these frames, the focal length and distance from camera to subject are the same but the f/stop changes. In the top frame, the lens is wide open, and the depth-of-field is very small; only one card is sharp.

Figure 14.10. The lens is stopped down to f/11 and almost all the cards are in *apparent focus*—meaning that they only appear to be in focus because they are within the depth-of-field. *Critical focus*, the point at which the lens is actually focused, is still on the red king.

First: Hyperfocal distance is the focus setting of the lens when objects at infinity and objects at the nearest point to the camera are both in acceptable focus.

Second: If the lens is set at the hyperfocal distance, both objects at infinity and at 1/2 of that hyperfocal distance will be in acceptable focus. Most lens charts or apps will list the hyperfocal distance for various lenses at any given f/stop. (Remember, f/stops are used for optical calculations, and T-stops are used for setting the aperture.)

For example, for a 50mm lens at f/8 with a circle of confusion of .0001”, the hyperfocal distance is 40 feet. Thus, if you set the focus distance at 40 feet, everything from 20 feet to infinity will be in focus. Opening up two stops (going to a lower f/stop, which admits more light) doubles the hyperfocal distance: it goes from 40 feet at f/8 to 80 feet at f/4. Conversely, closing down two stops decreases the hyperfocal distance by one-half. Another characteristic of hyperfocal distance is this. When the lens is set at the hyperfocal distance, depth-of-field extends from 1/2 HD to infinity. When the lens is set at 1/2 of HD, the depth-of-field is from 1/3 of hyperfocal distance to infinity, and so on.

Figure 14.11. In this series, the f/stop remains the same but the focal length changes. With a wide lens (top) all the cards are in focus.

Figure 14.12. With a very long lens at the same f/stop, the depth-of-field only covers one card. The camera is the same distance from the subject; only the f/stop has changed.

NODAL POINTS

Another enduring myth concerning depth-of-field is that all depth-of-field calculations are from the image plane. Depth-of-field is actually calculated from the *Front Nodal Point* (*FNP*). This is accounted for in depth-of-field charts. Each manufacturer determines their own method of calculating depth-of-field, so consulting the charts they provide may be the most reliable method in critical cases.

Nodal points are the two points such that a light ray entering the front of the lens and headed straight toward the front nodal point will emerge going straight away from the rear nodal point at the same angle to the lens axis as the entering ray had. In simple double convex lenses the two principal points are somewhere inside the lens (actually 1/n the way from the surface to the center, where n is the index of refraction), but in a complex lens they can be almost anywhere, including outside the lens, or with the rear principal point in front of the front principal point. In a lens with elements that are fixed relative to each other, the principal points are fixed relative to the glass. Entrance pupil and exit pupils are not often where we think they should be—at the front and back of the lens. In fact, for some lens designs, it is possible for the front entrance pupil to actually be behind the film plane. An example: on a Zeiss 50mm lens at f/2.1 the FNP is 34.5 mm back from the front vertex of the lens and the lens is a total of 77.9 mm from the front vertex to the focal plane.

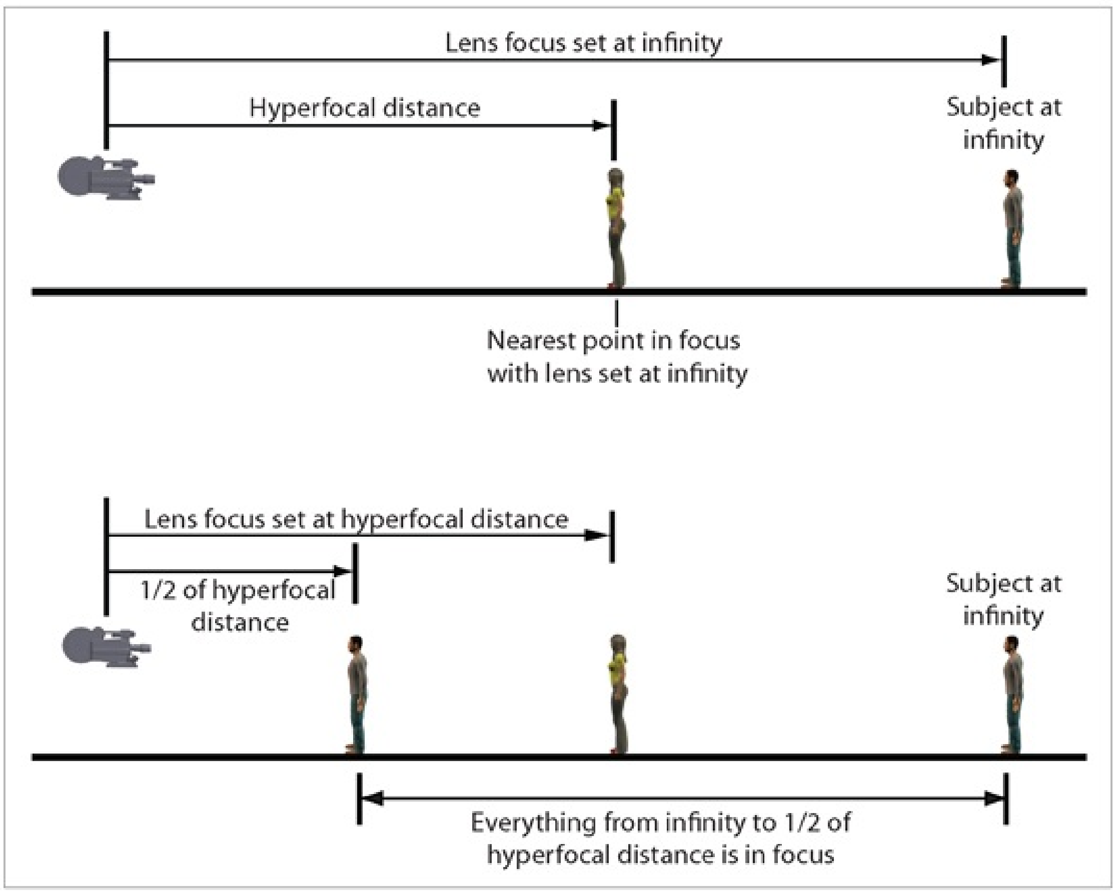


Figure 14.13. Two aspects of hyperfocal distance.

This means that for this lens at this f/stop, focus and depth-of-field are measured starting at 34.5 mm back from the middle of the front element. Since this would be impossible to determine in the field, all actual distance measurements are from the focal plane and focus charts account for this. All cameras (both film and video) have a mark at the focal plane and usually also a protruding screw to which the camera assistant can attach a measuring tape.

THE REAR NODAL POINT AND SPECIAL EFFECTS SHOTS

The *Rear Nodal Point* is also important for lining up special effects shots through half-silvered mirrors, certain types of panning shots where the camera must be panned or tilted without shifting the image, and also in front projection. If manufacturer’s data is not available, the nodal point on which the camera must rotate can be determined in the field by mounting the camera on a head that has a slide plate. Then mount a cross on a C-stand in front of the camera. On the wall behind, mount a same-size cross so that the two are congruent—that is, the front cross perfectly covers the back one. Then experiment with sliding the camera back and forth until you find a position where you can pan the camera and the rear cross stays centered behind the front cross. You have found the nodal point of the lens and centered it over the pivot point of the panning head.

Figure 14.14. A *rack focus* shot in *The Da Vinci Code*. We see the figure out of focus in the background, then the turn of her head *carries* the focus back to him—it is a perfect motivation for the rack. Very shallow depth-of-field is critical to making a rack focus work.

ZOOMS AND DEPTH-OF-FIELD

Zooms have some special characteristics when it comes to depth-of-field. As we discussed previously, depth-of-field is technically not measured from the film plane or video receptor. In fact, it is measured from the nodal point of the lens. Depth-of-field charts compensate for this in a general way by adding a fixed amount in front of the focal plane. This is why you may see different DOF charts for zooms and primes at equivalent focal lengths. The issue with variable focal length lenses is that as they are zoomed, the nodal point may actually shift. Motion control rigs that keep the nodal point over the pan center use a long worm gear that moves the camera/zoom back and forth over the center point as you zoom. There are nodal point camera heads for tripods, dollies, and cranes.

Figure 14.15. A *split diopter* gives focus both on the near objects (cards) and the far object (actor). Notice the fuzzy transition line, which is fairly well concealed here.

In practical depth-of-field applications with zoom lenses, the only thing that is really of any consequence to us is at the wide end, where the nodal point may be 10 inches or more in front of the film plane. Thus, if you are shooting a close-up at the wide end of a zoom, it’s as if you were 10 inches closer to your subject matter, which also reduces your depth-of-field. Being closer you, of course, have less depth-of-field. This is one of the reasons that zooms are seldom used in macro, table-top, and other situations where critical focus is important.

MACROPHOTOGRAPHY

For extreme close-up work (macrophotography), it is more useful to think in terms of image magnification instead of depth-of-field. Macrophotography is any imaging where the image size is near to or greater than the actual size of the object (more than a 1:1 reproduction ratio). For example, photographing a postage stamp full frame is macro work. Regular prime lenses can seldom focus closer than 9 or 10 inches; zooms generally have a minimum of around 2 to 3 feet. Extreme close-up photography has a set of problems all its own. The most critical aspect of macro work is the degree of magnification. A magnification of 1:1 means that the object will be reproduced on film actual size—that is, an object that is 1/2 inch in reality will produce an image on the negative (or video sensor) of 1/2 inch. 1:2 will be 1/2 size, 1:3 will be 1/3 size, and so on. In film, the 35mm academy frame is 16mm high and 22mm wide. Most lenses of ordinary design can focus no closer than a ratio of 1:8 or 1:10.

EXPOSURE COMPENSATION IN MACROPHOTOGRAPHY

When a small image is being “spread” over a large piece of film, it naturally produces less exposure. With reproduction ratios of greater than 1:10, exposure compensation is necessary. The formula for this is:

$$\text{Shooting f/stop} = \frac{\text{f/stop determined by meter}}{1 + \text{magnification ratio}}$$

Example: meter reading is f/8. Your reproduction ratio is 1:2 or 1/2 size. The calculation is 8/(1 + .5) = 5.3

DEPTH-OF-FIELD IN CLOSE-UP WORK

There are many misconceptions associated with macrophotography; perhaps the most basic is that “wide-angle lenses have more depth-of-field.” Depth-of-field is a function of image size, not focal length. While it is true that wide-angle lenses have more depth-of-field, the problem is that once you have put a wider lens on, you still want the same image you had before, and in order to accomplish that, you must move the camera closer to the subject. Once you have done this, the depth-of-field is the same as it was before, since focus distance is also a determinant of depth-of-field. The important aspects are:

- Depth-of-field decreases as magnification increases.
- Depth-of-field decreases as focus distance decreases.
- Depth-of-field is doubled by closing down the lens two stops.

Table 14.1. (above) Focus with diopters.

Diopter – Focus Conversion Chart (can be used with any focal length – any format)		
Diopter power	**Focus distance of lens**	**Actual distance from diopter to subject**
	Infinity	78–3/4″
	252	62–1/2″

1/2	152	54–3/4″
	102	47–1/2″
	62	37–3/4″
	42	29–3/4″
+1	Infinity	39–1/2″
	252	34–3/4″
	152	32–1/2″
	102	29–3/4″
	62	25–1/4″
	42	21–3/4″
+2	Infinity	19–3/4″
	252	18–1/2″
	152	17–3/4″
	102	16–3/4″
	62	15–1/2″
	42	14″
+3	Infinity	13–1/4″
	252	12–1/2″
	152	12–1/4″
	102	11–3/4″
	62	11–1/4″
	42	10–1/2″

CALCULATING DEPTH-OF-FIELD IN CLOSE-UP WORK

Calculation of depth-of-field in extreme close-up work methods is different from normal situations. At magnifications greater than 1:10, the depth-of-field is extremely small and it is easier to calculate the total depth-of-field rather than a near/far limit of focus.

CLOSE-UP TOOLS

Extreme close-up photography can be accomplished with a variety of tools—diopters, macro lenses, extension tubes/bellows rigs, snorkels, and specialized lenses.

DIOPTERS

Diopters are simple meniscus lenses that are placed in front of the camera lens and reduce the minimum focusing distance of the lens. The lenses are measured in diopters, which is the reciprocal of the focal length as measured in meters. A plus 1 diopter has a focal length of 1 meter; a plus 2 is 1/2 meter, and so on. Minimum focusing distance with the lens set at infinity is determined by dividing the diopter number into 100 cm. As an example, a +2 diopter would be 100/2 = 50 cm. This equals 19.68 inches.

This spec shows you the farthest working distance you can work; put a plus one-half on your normal camera lens, set it on infinity, the farthest, and objects two meters away are in focus. Nothing farther could be shot sharp. Put on a plus one and the max working distance is one meter. Put on a plus two and the object has to be 500 millimeters, or half a meter, or about 19 inches away (from the front of the diopter, not the film plane) to achieve sharpness. All those examples are with the main lens (prime or zoom) “set at infinity.”

A split diopter is one of these magnifiers split in half, like a half-moon. It covers half your field, and the stuff seen through the glass is focused closer, and the other half, which is missing (just air), will be focused where the main lens is set. Put a plus one-half split on your camera. Focus the main lens at infinity. One-half of the field, through the diopter, is sharp at 2 meters. The rest of the field is focused at infinity. If you set the lens at 15 feet, the clear half is focused at 15 feet and the diopter half might focus at 1 1/3 meters. There’s a fuzzy line at the edge of the split diopter in the middle of your picture, and this has to be hidden artfully in the composition:

- Use the lowest power diopter you can, combined with a longer focal length lens, if necessary.
- Stop down as much as possible.
- There is no need for exposure compensation with diopters.

- When using two diopters together, add the diopter factors and always place the highest power closest to the lens.

Figure 14.16. *Bokeh* is the blur produced by out-of-focus point sources in the frame. It can be used to great aesthetic purpose, as in this shot from *Nightcrawler*. Different lenses have different bokeh characteristics.

Figure 14.17. The Revolution lens system. (Photo courtesy Cine Magic).

EXTENSION TUBES OR BELLOWS

The advantage of *extension tubes* or *bellows* is that they do not alter the optics at all, so there is no degradation of the image. Extension tubes are rings that hold the lens farther away from the film plane than it normally sits, thus reducing the minimum focus distance.

A bellows unit is the same idea but is continuously variable with a rack and pinion. Either will give good results down to about 1:2. Extension tubes are incompatible with wide-angle or zoom lenses. Lenses with larger minimum apertures generally give better results than high-speed lenses. Optically, the best results at very high magnifications are obtained by reversing the lens (so that the back of the lens faces the subject) and mounting on a bellows unit. The simple rule is, to achieve 1:1 reproduction, the extension must equal the focal length of the lens. For 1:1 with a 50mm lens, for example, you would need a 50mm extension.

A variation of this is the *swing-and-tilt* mount (Figure 14.18), which gives the lens mount the same kind of controls used in a view camera. The lens cannot only be extended for macro work, but the plane of focus can also be tilted. This permits part of the image to be in focus and part of the image on the same plane to be out of focus.

MACRO LENSES

Macro lenses are actually specially designed optics, optimized for close-up work. They are good in the 1:2 to 1:1 range. Some macros have barrel markings for magnification ratio as well as focus distance; this facilitates calculating the exposure compensation.

SNORKELS AND INNOVISION

Several types of snorkel lenses are available that are like periscopes. They generally allow for extremely close focus and for getting the lens into incredibly small spaces. Some are immersible in water (Figure 14.19).

Figure 14.18. A full swing-and-tilt system. (Photo courtesy of Century Precision Optics).

Figure 14.19. A *Cinewand snorkel lens* being used for a macro shot on a food commercial. (Photo courtesy MakoFoto).

Figure 14.20. Testing focus on a checkout day or setting back focus on the set requires a good focus target such as this one from DSC Labs.

Figure 14.21. The Frazier lens in use on the set. (Photo by Dylan Reeves).

Innovision is a snorkel-type lens for extreme close-up work. It has the advantage of an extremely narrow barrel that can reach inside very small areas, even inside flowers. The f/stop is fixed and is usually a fairly large number, such as f/6.3 higher.

SPECIALIZED LENSES

Specialized applications of the snorkel are the *Revolution* system (Figure 14.17) and *Frazier* lens (Figure 14.21). These have remarkable depth-of-field that seems to defy physics and also allows for the lens itself to rotate, pan, and tilt during a shot. It is possible to have objects that are actually touching the lens in focus and still maintain usable depth in the distance.

LENS EXTENDERS AND FILTER FACTORS

Optics that increase the focal length of the lens have a corresponding effect on T-stop. To find the *filter factor*, square the extension factor. For example, a 2X optic will have a filter factor of 4, and a 3X extender will have a filter factor of 9. A factor of 4 translates to 2 stops, so a 2X extender will turn a 200mm f/4 lens into a 400mm f/8 lens. When combining extenders, the factors must be multiplied. For example, a 2X and 3X extender together would have a factor 36 (five stop increase in exposure).

LENS CARE

- Never clean a lens with dry lens tissue.
- Never put lens fluid on a lens; put it on the lens tissue.
- Brush or blow off loose grit before wiping with lens tissue.
- Never use eyeglass cleaning cloth; it may contain silicone.
- In dusty or sandy conditions, try to keep a filter on the lens. *Optical flats* are clear optical grade glass for this purpose.
- Never use rubber cement to attach a filter to a lens. Use Scotch ATG-924, otherwise known as *transfer tape* or *snot tape* (see Figure 11.34 in *Image Control & Grading*).
- Be careful when mounting a net to the rear of the lens; it can get snagged or torn and this will affect the image.
- Always close at least one latch on a lens case.
- Protect all lenses from shock.
- For transport, put lenses in the case with the iris wide open and focus at infinity.

Figure 14.22. The *reverse zoom*, ften called the *Hitchcock zoom* after its inventor, is accomplished by simultaneously dollying the camera in and zooming out the lens. Here in *Jaws*, it is used for particularly dramatic effect to convey Brody's mental state and sense of dread. It is sometimes called the *zolly*—as it is a combination of a zoom and dolly.

BACK FOCUS

When using a zoom on a video camera, it is critical to set the *back focus* at the beginning of the day and recheck it periodically. If the back focus is not set, the zoom will not stay consistently in focus as you zoom in or out. Many newer digital cameras do not require focusing.

When you set the back focus, you are adjusting the distance from the vertex of the rearmost element of the lens to the focal plane—the *flange focal depth*. Prime lenses need this adjustment as well, but it can only be done by an optical technician and it is done with thin metal shims. For a video demonstration of setting back focus, see the website that accompanies this book. The procedure is:

- Open the iris to its widest aperture. If the illumination on the test chart is too bright for the open iris, reduce the light.
- Zoom in to longest focal length.
- Focus on the chart.
- Zoom out to the widest angle.
- Loosen the back focus ring retaining knob.
- Adjust the back focus ring for the sharpest focus.
- Repeat the process until focus is consistently sharp throughout the full zoom range.
- Tighten the back focus ring retaining knob.

Some people prefer to do the opposite and start by setting back focus at the widest zoom first because back focus is most forgiving on the long end and least on the wide end. It can be helpful to keep the finger of the hand not tightening the retaining knob on the edge of the ring so that it can hold it in place as the knob is tightened, preventing drift.

Figure 15.1. (previous page) A motion control rig in a difficult location. (Courtesy Mark Roberts Motion Control).

camera movement

CAMERA MOVEMENT IN FILMMAKING

Along with sequential editing, the ability to move the camera is the most fundamental aspect that distinguishes film and video from photography, painting, and other visual arts. As we have seen, moving the camera is much more than just going from one framing to another. The movement itself, the style, the trajectory, the pacing, and the timing in relation to the action all contribute to the mood and feel of the shot. They add a subtext and an emotional content independent of the subject.

We talked about the cinematic uses of camera moves in *Visual Language*; here we can talk about the techniques and technology of moving the camera. The most critical decision about the use of the camera is where you put it, as we saw in *Language of the Lens*. Camera placement is a key decision in storytelling. More than just "where it looks good," it determines what the audience sees and from what perspective they see it. As discussed in the *Shooting Methods*, what the audience does not see can be as important as what they do see.

Since Griffith freed the camera from its stationary singular point-of-view, moving the camera has become an ever increasing part of the visual art of filmmaking. In this section, we will look at the dynamics of camera movement and also take a look at some representative ways in which this is accomplished. The dolly as a means of moving the camera dates from the early part of the 20th century. (The *crane* came into its own in the 1920s for a modern version.) Shots from moving vehicles were accomplished in the earliest of silents, especially with the silent comedians, who didn't hesitate to strap a camera to a car or train. After the introduction of the crane, little changed with the means of camera movement until the invention of the *Steadicam* by Garrett Brown. It was first used on the films *Bound for Glory* and Kubrick's *The Shining*.

MOTIVATION AND INVISIBLE TECHNIQUE

A key concept of camera movement is that it should be *motivated*—the movement should not just be for the sake of moving the camera. Motivation can come in two ways. First, the action itself may motivate a move. If the character gets up from a chair and crosses to the window, it is perfectly logical for the camera to move with her.

Both the start and the end of a dolly move or pan should be motivated. The motivation at the end may be as simple as the fact that we have arrived at the new frame, but clearly it must be a new frame—one with new information composed in a meaningful way, not just "where the camera ended up." A big part of this is that the camera should "settle" at the end of any move. It needs to "alight" at the new frame and be there for a beat before the cut point. This is especially important if this shot might cut to a static shot.

Particularly with the start and end of camera moves that are motivated by subject movement, there needs to be a sensitivity to the timing of the subject and also a delicate touch as to speed. You seldom want the dolly to just "take off" at full speed, then grind to a sudden halt. Most of the time, you want the dolly grip to "feather" in and out of the move. The camera movement itself may have a specific story purpose. For example, a move may *reveal* new information or a new view of the scene. The camera may move to meet someone or pull back to show a wider shot. Unmotivated camera moves or zooms are distracting: they pull the audience out of the moment and make them conscious that they are watching a fiction; they do, however, have their uses, particularly in very stylized filmmaking.

> When you move the camera, or you do a shot like the crane down (in *Shawshank Redemption*) with them standing on the edge of the roof, then it's got to mean something. You've got to know why you're doing it; it's got to be for a reason within the story, and to further the story.
>
> Roger Deakins (The *Shawshank Redemption,O Brother, Where Art Thou,The Big Lebowski, Skyfall*)

Figure 15.2. Grips rolling a crane onto tracks on the film *42*. The grip crew does all building, moving, and operating of cranes in addition to many other tasks. Note the use of 2x12 lumber, half and quarter *apple boxes*, and *wedges* to form a ramp. Also interesting is the use of heavy timber under the dolly tracks to reduce the need for leveling gear. Lengths of lumber are normally carried on the grip truck for uses like this and specialized pieces are ordered separately. (Photo courtesy Vertical Church Films).

There are many ways to find a motivation for a camera move, and they can be used to enhance the scene and add a layer of meaning beyond the shots themselves. They can also add a sense of energy, joy, menace, sadness, or any other emotional overlay. Camera movement is much like the pacing of music. A crane move can “soar” as the music goes upbeat, or the camera can dance with the energy of the moment, such as when Rocky reaches the top of the museum steps and the Steadicam spins around and around him. Motivating and timing camera moves are part of the goal of invisible technique. Just as with cutting and coverage in the master scene method, the goal is for the “tricks” to be unnoticed and not distract from the storytelling.

BASIC TECHNIQUE

There is an endless variety of ways to move the camera; it is useful to look at a few basic categories of types of moves to provide a general vocabulary of camera dynamics. The most fundamental of camera moves, the *pan* (left or right pivot) and *tilt* (up or down pivot), can be accomplished in almost any mode, including handheld.

The exception is when a camera is *locked off* on either a non-movable mount (as it might be for an explosion or big stunt) or where it is on a movable head, but the movements are locked down, and there is no operator. Many types of effect shots require the camera to be locked down so that not even the slightest movement of the camera is possible. Sandbags on the tripod or dolly, or even braces made of C-stands or lumber may also be used. Beyond the simple pan and tilt or zoom, most moves involve an actual change of camera position in the shot. Other than handheld, these kinds of moves involve specific technologies and also the support of other team members: the grip department. Grips are the experts when it comes to mounting the camera in any way other than right on a tripod or a dolly, and they are the people who provide the rigging, the stabilization, and the actual operation when it comes to performing the actual move.

Figure 15.3. The crew prepares a lightweight jib arm for a crane shot. Rigs like this are fairly easy to set up, break down, and transport.

A good grip crew makes it look easy, but there is considerable knowledge and finesse involved in laying smooth dolly track on a rough surface (Figure 15.2) or rigging the camera on the front of a roller coaster. Every detail of rigging is beyond the scope of this chapter, but we will touch on some of the major issues.

TYPES OF MOVES

PAN

Short for *panoramic*, the term *pan* applies to left or right horizontal movement of the camera. Pans are fairly easy to operate with a decent *camera head*—which sits atop the tripod or dolly, holds the camera, and permits left/right, up/down, and sometimes sideways tilting motions (Figures 15.4, 15.5, and 15.15). There is one operational limitation that must be dealt with. If the camera is panned too quickly, there will be a *strobing* effect, which will be very disturbing. As a general rule of thumb, with a shutter opening of 180° and a frame rate of 24 or 25 FPS, it should take at least 3 to 5 seconds for an object to move from one side of the frame to the other. Any faster and there is a danger of strobing.

TILT

The *tilt* is up or down vertical rotation of the camera without changing position. Technically, it is not correct to say "pan up," but as a practical matter almost everybody says it—it's silly to "correct" a director who says "pan up"—it won't earn you any brownie points. As we will see later in this chapter, cranes, Steadicams, stabilizer rigs, and aerial mounts are to a large extent used to break out of the confined horizontal plane and make the scenes more truly three-dimensional. Filmmaking is confined, to a large degree, by where we can put the camera. Certainly the ability of the Steadicam, drones, and similar rigs to move with action up and down stairs and slopes has opened up a new variety of moves, that help with this three-dimensional effort and keeps us "with" the characters as they move through space. Given the technology now available and the ingenuity of our grips and camera assistants, there is hardly anywhere a camera can't go.

Figure 15.4. An O'Connor *fluid head*, in this case supporting an Arri *Amira*. Camera heads fall into two

types—hydraulic fluid heads like this and *geared heads* as in Figure 15.22. (Photo courtesy O'Connor Engineering).

Figure 15.5. A *Sactler 7×7 Studio Fluid head* on a *highhat* attached to a plywood *pancake* (shortest member of the apple box family), *Ronford-Baker legs*, a *spreader* to keep the legs from collapsing, and the shipping case.

Figure 15.6. Executing a Steadicam shot requires more than just the operator. Here the first AC handles the remote focus control and a grip stays close behind the operator for safety and guidance, such as if there is a potential tripping hazard coming up—this is also standard practice for all types of handheld shots or others stabilizer rigs. (Photo courtesy of Brad Greenspan).

MOVE IN/MOVE OUT

Common terminology is *push-in* or *pull-out* for moving the camera toward the scene or away from it. For example, instructions to the dolly grip: “When he sits down, you push in.” This is different from a *punch-in* (see following). Moving into the scene or out of it are ways of combining the wide shot of a scene with a specific tighter shot. It is a way of selecting the view for the audience in a way that is more dramatic than just cutting from wide shot to closer shot. It has the effect of focusing the viewer’s attention even more effectively than just doing a wide establishing and then cutting to the scene; by moving in toward the scene, the camera is saying “of all the things on this street, this is the part that is important for you to look at.”

Of course, there are infinite uses of the simple move in/move out. We may pull back as the character moves out of the scene or as another character enters; the move is often just a pragmatic way of allowing more room for additional elements of the scene or to tie in something else to the immediate action we have been watching. Conversely, when someone leaves a scene, a subtle push-in can take up the slack in the framing.

ZOOM

A *zoom* in or out is an optical change of focal length. It changes the framing without moving the camera. Visible zooms are not popular in feature film making—certainly not since the end of the 1970s. The reason is simple: a zoom calls attention to itself and makes the audience aware they are watching a movie —something we usually want to avoid in *invisible technique*. When a zoom is used, it is important that the zoom be motivated. Also, it is best to hide a zoom. Hiding a zoom is an art—the zoom may be combined with a slight lateral camera move, a dolly move, a slight pan, or with a move by the actors so that it is unnoticeable.

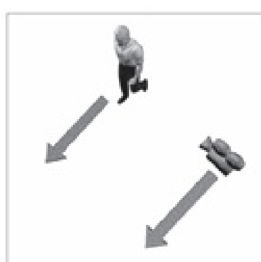


Figure 15.7. An ordinary *track with* move. Camera move matches the direction of the subject.

Figure 15.8. Countermove.

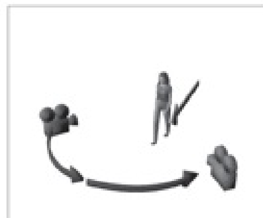


Figure 15.9. Dolly across the line of movement. This one has to be used with caution. If the entire shot is not used, the screen direction will be flipped without explanation. See the chapter *Continuity & Coverage* for further discussion of this issue.

DIFFERENCE BETWEEN A ZOOM AND A DOLLY SHOT

Say you want to go from a wide or medium to a close-up during the shot. On the face of it, there would seem to be no real difference between moving the dolly in or zooming in. In actual effect, they are quite different, for several reasons.

First, a zoom changes the perspective from a wide angle with deep focus and inclusion of the background to a long-lens shot with compressed background and very little of the background. It also changes the depth-of-field, so the background or foreground might go from sharp focus to soft. These might be the effects you want, but often they are not. Second, the dolly move is dynamic in a way that a zoom cannot be. With a zoom your basic point-of-view stays the same because the camera does not move; with a dolly the camera moves in relation to the subject. Even if the subject stays center frame, the background moves behind the subject. This adds a sense of motion, and also the shot ends with an entirely different background than it opened with. This is not to say that a zoom is never desirable, just that it is important to understand the difference and what each type of move can do for your scene as a visual effect. Many people will also “hide” the zoom by making some other type of move at the same time so that the zoom is not noticeable.

A very dramatic effect can be produced with a combination of zoom and a dolly. In this technique you zoom out as you dolly in. This keeps the image size relatively the same, but there is a dramatic change of perspective and background. This was used very effectively in *Jaws*, when Roy Scheider as the sheriff is sitting on the beach and first hears someone calls “shark” (Figure 14.22 in *Optics & Focus)*. It was also used effectively in *Goodfellas* in the scene where Ray Liotta is having lunch with Robert De Niro in the diner. At the moment Liotta realizes he is being set up for killing by his old friend, the combination move effectively underscores the feeling of disorientation.

PUNCH-IN

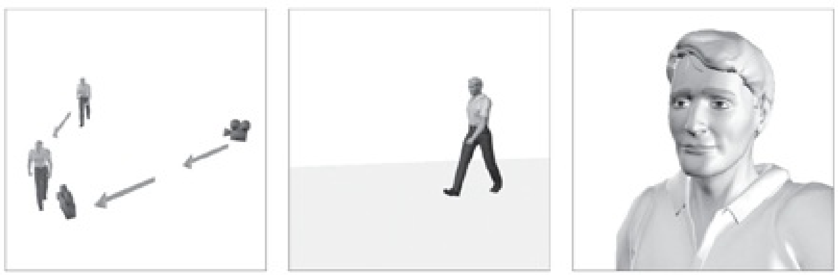
Different from a *push-in*, which involves actually moving the camera, a *punch-in* means that the camera stays where it is, but a longer focal length prime is put on or the lens is zoomed in for a tighter shot. The most common use of a punch-in is for coverage on a dialog scene, usually when going from an over-the-shoulder to a clean single. Since moving the camera forward from an over-the-shoulder may involve repositioning the off-camera actor and other logistics, it is often easier to just go to a longer lens. There is some slight change in perspective, but for this type of close-up, it is often not noticeable as long as the head size remains constant.

MOVING SHOTS

Moving shots happen in all kinds of ways. As cameras have become smaller and lighter and new inventive camera supports have developed, there are few if any limits on how the camera can move.

TRACKING

The simplest and most clearly motivated of camera moves is to *track* along with a character or vehicle in the same direction (Figure 15.7). For the most part, the movement is alongside and parallel. It is certainly possible to stay ahead of and look back at the subject or to follow along behind, but these kinds of shots are not nearly as dynamic as tracking alongside, which gives greater emphasis to the moving background and the sweep of the motion.



Figures 15.10, **15.11**, and **15.12.** A *going to meet them* camera move. This is a very dynamic shot as the subject distance changes. This can be used to start with a wide tracking shot and end up with a tight close-up or vice versa.

COUNTERMOVE

If the camera always moves only with the subject, the camera is “tied to” the subject and completely dependent on it. If the camera sometimes moves independently of the subject, it can add a counterpoint and an additional element to the scene. Certainly it can be dynamic and energetic; it adds a counterpoint of movement that deepens the scene (Figure 15.8). Whenever the camera moves in the opposite direction, the background appears to move at twice the rate it would move if the camera was tracking along with the subject. A variation is to move across the line of travel, as in Figure 15.9. A variation of the *countermove* is where the dolly moves in the opposite direction and the subjects cross the axis of motion as in Figure 15.13.

REVEAL WITH MOVEMENT

A simple dolly or crane move can be used for an effective *reveal*. A subject fills the frame, and then with a move, something else is revealed. This type of shot is most effective where the second frame reveals new content that amplifies the meaning of the first shot or ironically comments on it.

CIRCLE TRACK MOVES

When ordering a dolly and track, it is quite common to also order at least a couple of pieces of *circle track*. Circular track generally comes in two types: 45° and 90°. These designate whether it takes four pieces or eight pieces to make a complete circle, which defines the radius of the track. Some companies specify by the radius of the circle. A very specific use of circle track is to dolly completely or halfway around the subject; this type of move is easily overused and can be very self-conscious if not motivated by something in the scene.

One important note on setting up a circle track scene: as it is quite common to use circle track to move very slowly around the subject in a tight shot, focus pulling can get quite complex. The best way to simplify a circle move is to set up the shot so that the subject is positioned at dead center of the radius of the track.

Figure 15.13. An example of a complex and dynamic move: a shot of this type tracks, pans, and subject distance and direction change all at the same time.

CRANE MOVES

The most useful aspect of a crane is its ability to achieve large vertical moves within the shot. While a crane may be used only to get the camera up high, a typical variety of crane shot is to start with a highangle view of the overall scene as an establishing shot and then move down and in to isolate a piece of the geography: most often our main characters, who then proceed with the action or dialog. This is most often used to open the scene by combining the establishing shot with the closer-in master of the specific action.

Figure 15.14. A heavy lift drone carries a Red Dragon in a *three axis stabilizer mount* for remote control pans and tilts. (Photo courtesy of Alpine-Aerials).

The opposite move, starting tight on the scene and then pulling back to reveal the wide shots, is an effective way to end a scene as well and is often used as the dramatic last shot of an entire film—a slow disclosure. Depending on the content of the scene and the entire film, it can have a powerful emotional content. The ability of the crane to “swoop” dramatically and flowingly can be used for exhilarating and energetic effect; more than any other type of camera move, it can really “dance” with the characters or the action.

Another aspect of the crane that is important to keep in mind is that most cranes are capable of going below the level of their mounting surface. This use can always be enhanced by building a platform for the crane. This has the effect of raising the top end of the move as well as allowing you to get below “floor” level at the bottom end.

ROLLING SHOT

The term *rolling shot* is used wherever the camera is mounted on a vehicle, either on the picture vehicle or a camera car that travels along with the *picture* vehicle. The "picture" vehicle is the one being photographed. See Figures 15.25 and 15.26.

CAMERA SUPPORTS FOR MOVEMENT

What moves we can make is dependent on what type of equipment is supporting the camera. In the early days of film, they had only the tripod. Today, we have a huge variety of potential camera supports.

DRONES

Drones have become an important tool in filmmaking (Figure 15.14). They are the result of two trends: much more powerful and controllable mini-helicopters and far lighter cameras that can produce professional quality video (HD or higher). The advantages are obvious—aerial shots without the expense of a helicopter and pilot, small sizes that can fly into surprisingly tight spaces, and reasonable control without years of training.

Figure 15.15. A true *nodal point head*. See the chapter on *Optics & Focus* for why a nodal point head is required for some types of shots. This one is a *Lambda* head by Cartoni—it is also a typical *underslung head*. (Photo courtesy of Cartoni, S.p.A).

Figure 15.16. A *leveling head* is essential for any camera mount. Without one, there is no way of making sure the camera is perfectly level, which is critically important to check for every camera setup. This one has a flat *Mitchell base* on top for mounting the camera head.

Figure 15.17. A *Movi* stabilizer rig in use by DP John Brawley. (Photo courtesy John Brawley).

Figure 15.18. An *Alexa Amira* in *handheld mode* with a curved shoulder pad mounted to the tripod screw hole as is typical for handheld work.

HANDHELD

Handheld is any time the operator takes the camera in hand, usually held on the shoulder, but it can be held low to the ground, placed on the knees, or any other combination. For years, *handheld* was the primary means of making the camera mobile in cases where a dolly was not available or not practical. With so many other ways to keep the camera mobile, it is often used for artistic purposes as it has a sense of immediacy and energy that cannot be duplicated by other means.

STABILIZER RIGS

As many cameras have become smaller and lighter, handheld stabilizer rigs have become very popular. Prominent among these is the *Movi*, *CAME-TV 7800*, the *Ronin*, and similar units (Figures 15.14, 15.17, and 15.19). They allow a great deal of freedom of movement for both the camera and the operator but provide a considerable degree of stabilization for the camera. Despite the popularity of "shaky cam" as a style, it can get to be too much and thus distracting.

CAMERA HEADS

The camera cannot be mounted directly on a dolly. If it was, there would be no way to pan or tilt the camera. On dollies, cranes, and car mounts, there is also an intermediate step: the *leveling head* (Figure 15.16). This is the base the camera head sits on, which allows for leveling of the camera. In the case of a tripod, leveling is accomplished by lengthening or shortening one of the legs to get the camera level but for all other types of supports some method of leveling in needed—the obvious exceptions being Steadicams and similar types of supports. Most dollies have a built-in leveling capability, but they often are needed when mounting a camera on something like a car mount *hostess tray* (Figure 15.26). Camera heads make smooth, stable, and repeatable moves possible. Camera heads have two main types of mounts: the flat *Mitchell base* (Figure 15.16) and the *ball head* (Figure 15.31), which allows for leveling the head quickly. Camera heads fall into two general categories: *fluid heads* and *geared heads*.

Figure 15.19. An operator in China lines up a shot with a combination of a *Ronin* stabilizer rig and a Steadicam style arm. (Photo courtesy Jowei Verhoeven).

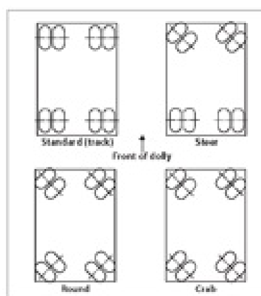


Figure 15.20. Dolly wheel positions for various types of moves.

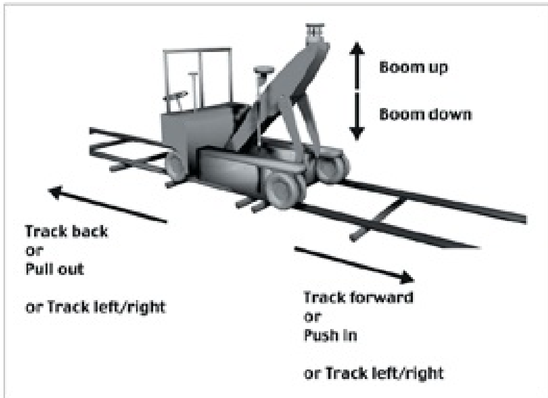


Figure 15.21. Dolly and boom terminology.

Figure 15.22. A *geared head*. Long a staple in classic studio production, it is essential not only for the ability to execute perfectly smooth and repeatable moves but also for the ability to hold very heavy cameras. On top is a tilt plate. (Photo courtesy Arri Group).

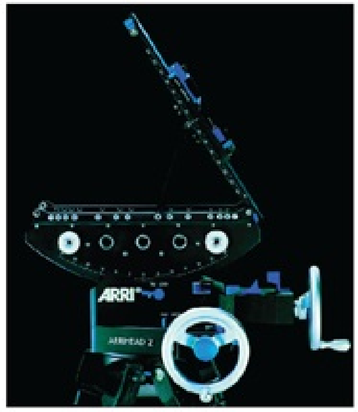


Figure 15.23. A *Cartoni underslung head* mounted to the jib with an offset arm allows for a full range of motion in the tilt axis. In this scene, DP Jowei Verhoeven needed both a shot of an actor laying on the ground and a POV shot of the sky. This rig allowed him to get both without reconfiguring the setup. (Photo courtesy Jowei Verhoeven).

Fluid Head

These use oil and internal dampers and springs to make extremely smooth left/right and up/down moves possible (Figure 15.4). The amount of resistance is adjustable. Most camera operators want the head to have a good amount of resistance working against them as this makes it easier to control the speed and timing of a move.

Geared Head

These heads are operated with *wheels* that the operator can move smoothly and precisely repeat moves (Figure 15.22). The geared head has a long and venerable history in studio production. The geared head is useful not only for the ability to execute smooth and repeatable moves but also because it can handle very heavy cameras. Geared heads also isolate the operator's body movement from camera movement.

Remote Head

Geared heads can also be fitted with motors to be operated remotely or by a computer for *motion control (mo-co)*. Remotely controlled heads are used for a variety of purposes and have made possible the use of cranes, which extend much farther and higher than would be possible if the arm had to be designed to carry the weight of an operator and camera assistant. As with geared heads, *wheels* are now also used to control remote heads on cranes or helicopters, so it is very useful to learn how to operate them—it takes a good deal of practice to become proficient with them.

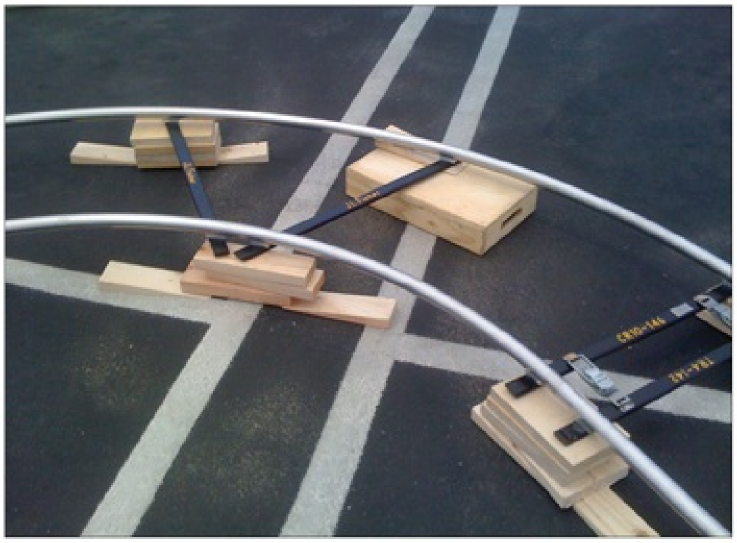


Figure 15.24. Dolly track leveling with a *half apple box, wedges*, and *cribbing* (blocks of wood).

Figure 15.25. A *hood mount* supports three cameras for a *rolling sho*t. Three cameras means that the twoshot and close-ups on each actor can be filmed at the same time for greater efficiency in covering the scene. (Photo courtesy of CaryCrane).

Figure 15.26. These *side mounts* (also called *hostess trays)* are set up to cover the front seat action from the driver's side window and from the left rear of the front seat. (Photo courtesy of CaryCrane).

Figure 15.27. Christopher Ivins operates his Steadicam rig. The First AC stays close by in order to judge focus, which she pulls with a remote control and a small motor on the lens focus ring. (Photo courtesy Christopher Ivins).

UNDERSLUNG HEADS

Underslung rigs are fluid heads, but the camera is not mounted on top; it is suspended on a cradle below the pivot point. Underslung heads can rotate vertically far past where an ordinary fluid head can go and thus are good for shots that need to go straight up or down or even further, as in Figure 15.23.

DUTCH HEAD

Dutch angle is when the camera is tilted off horizontal. The variations are *dutch left* and *dutch right*. As with many obscure terms in film, there is much speculation as to the origin. In fact, it goes back to 17th-century England, when a Dutch royal, William of Orange, was placed on the throne of Britain. There was much resentment, and anything that was considered "not quite right" was called "dutch." Specially built dutch heads are also available that convert back and forth between dutch and normal operation very quickly.

THE TRIPOD

Often called "sticks," the tripod is the oldest and most basic type of camera mount but still sees constant use on all types of film and video sets (Figure 15.5). Being smaller, lighter, and more portable than just about any other type of mount, its versatility makes up for its shortcomings. It can be quickly repositioned and can be made to fit into very tight, odd places. Its main advantage is that it can be transported just about anywhere.

HIGH-HAT

The *highhat* (Figures 15.5 and 15.31) is strictly a mounting surface for the camera head. It is used when the camera needs to go very low, almost to the surface. It is also used when the camera needs to be mounted in a remote place, such as on top of a ladder. The highhat is usually bolted to a piece of plywood (a *pancake)* that can be screwed, clamped, or strapped to all sorts of places.

Figure 15.28. A *porkchop* on a Fisher dolly. The dolly is mounted on a skateboard sled that rides on the tracks.

ROCKER PLATE

The drawback of a highhat is that the camera head (fluid or geared) still has to go on top of it. As a result, the lens height is still at least 18 inches or more above the surface. If this just isn't low enough, the first choice is usually to prop it on a sandbag. The pliable nature of the sandbag allows the camera to be positioned for level and tilt. Any moves, however, are pretty much handheld. If more control is desired, a *rocker plate* can be used. This is a simple device that allows the camera to be tilted up and down. Smooth side-to-side pans are not possible.

TILT PLATE

Sometimes, a shot calls for a greater range of up-and-down tilt than a typical camera head can provide. In this case, a *tilt plate* can be mounted on top of the camera head (Figure 15.22). It is usually geared and can be tilted to the desired angle. The gearing (if there is any) is generally not smooth enough to be used in a shot. Some geared heads have a built-in tilt plate.

THE CRAB DOLLY

The *crab dolly* is by far the most often used method of mounting and moving the camera. A crab dolly in the hands of a good dolly grip is capable of a surprising range and fluidity of movement. Figure 15.28 is a typical dolly widely used in production today.

DOLLY TERMINOLOGY

Special terminology is used to describe dolly motion so that it can be communicated precisely. This is especially important when you need to tell the grip what you need for the shot (Figure 15.21).

DOLLY IN/OUT

Move the dolly toward or away from the subject. When a dolly is on the floor (i.e., not on track) and you want to move forward, there are two choices. “Move in” can either mean move forward on the axis of the lens or on the axis in which the crabbed wheels are aiming. These are “in on the lens” or “in on the wheels.”

Figure 15.29. Cranes mounted on automobiles have become a very popular method for doing running shots, as in this rig for *The Dark Knight*. The grips have built a ramp so the vehicle can smoothly negotiate the steps.

Figure 15.30. The *Cable Cam* in use for a scene on a bridge

DOLLY LEFT/RIGHT

Move the dolly left or right. If the dolly is on tracks, it is left or right in relation to the axis of the track. If the dolly is on the floor, then it is left or right in relation to the subject.

BOOM UP/DOWN

Nearly all dollies have a *boom*: a hydraulic arm capable of moving vertically in a smooth enough motion to be used in a shot without shakes or jarring. Some boom terms include *top floor* and *bottom floor* (bargain basement).

CRAB LEFT/RIGHT

Most dollies have wheels that can crab (Figure 15.20), that is, both front and rear wheels can be turned in the same direction, allowing the dolly to move laterally at any angle. For most normal operations, the rear wheels are in crab mode and are the “smart wheels.” The front wheels are locked in and function as the dumb wheels. For a true crab move, all four wheels are switched to crab mode. There is another variation that can be done only with certain dollies. This is *roundy-round*, where the wheels can be set so that the dolly revolves in a full 360° circle on its own center. To do this, the front and rear wheels are crabbed in opposite directions.

DANCE FLOOR

Stable, shake-free dolly moves can only be accomplished on smooth floors. If there is no room for track to be laid or if the director is looking for dolly moves that can't be accommodated by straight or curved track, a *dance floor* can be built that allows the camera to move anywhere. A dance floor is built with good quality 3/4 inch plywood (usually birch) topped with a layer of smooth *masonite*. It is important that the joints be offset and then carefully taped with paper tape. This forms an excellent surface for smooth moves. The dolly can crab and roll anywhere, and combination moves can be quite complex. The only drawback is that you often have to avoid showing the floor. Smooth floors or dance floor becomes especially critical if anything other than a wide lens is up on the camera because, with a longer lens, every bump in the floor will jiggle the camera.

Figure 15.31. A *highhat*. In this case, it is a bowl shape for fluid heads that can be leveled without adjusting the tripod, highhat, or other mount. (Photo courtesy 3D Video Systems).

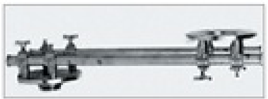


Figure 15.32. An offset arm (extension plate) for a dolly, this one can also be set up for an underslung camera if needed. (Photo courtesy of J.L. Fisher, Inc).

Figure 15.33. A dropdown plate, sometimes called a *Z-bar*. It is used to get the camera very low but still maneuverable. (Photo courtesy of J.L. Fisher, Inc).

EXTENSION PLATE

When the camera is mounted on the dolly, it may be necessary to extend it to the left, right, or forward of where the dolly can go (Figure 15.32)—for example, if you need to place the dolly at the center of a bed. This can be done with an extension plate that mounts on the dolly; then the camera head is mounted at the end.

Low Mode

Sometimes the camera needs to be lower than the boom can go. In this case, there are two possibilities. Some dollies can have their camera mounting arm reconfigured so that it is only a few inches above the floor (Figure 15.37). If this is not available or is not enough, a *Z-bar* can be used to get the camera all the way to the floor (Figure 15.33). The Z-bar is basically an extension arm that extends out and then down as close to the floor as possible.

Front Porch

Some dollies have a small extension that fits on the front of the dolly—the *front porch*; this is also known as a *cowcatcher*. This can be used to hold the battery or as a place for the operator or the camera assistant to stand during a move.

Side Boards

Sideboards fit on either side of the dolly as a place for the operator or camera assistant to stand. They are removable for transportation and for when the dolly has to fit through tight spaces. These are especially important for complex moves that require the operator to shift their body position.

Risers

Six, 9, 12, or 18-inch *risers* can place the camera higher than the boom travels. The longest extensions can get the camera very high but at the price of complete stability.

Steering Bar or Push Bar

This allows the dolly grip to push/pull the dolly and also to steer the dolly in standard mode (where only the rear wheels pivot) or in crab mode, where both sets of wheels pivot.

CRANES

Cranes are capable of much greater vertical and horizontal movements than a dolly. There are two types: jib arms have no seat for the cameraperson and are usually operated by someone standing on the floor or perhaps an apple box. True cranes have seats for the operator and a camera assistant. Large cranes can generally get the camera to 27’ or more or more above the base. A typical crane is shown in Figure 15.34. Telescoping cranes, pioneered by *Technocrane* are also capable of making the boom arm longer or shorter as in Figures 15.41 and 15.42.

Both cranes and jib arms have one fundamental characteristic that may become a problem. Because they are all mounted on a pivot point, the arm always has some degree of arc as it moves up, down, or laterally. With dolly arms, this degree of arc is usually negligible for all except exacting macro or very tight work that calls for critical focus or a very precise frame size. For nearly all cranes, there is a pivot point, and behind this point are *counterweights*. This is different from a dolly, where the boom arm is fixed and usually operated by hydraulics.

Figure 15.34. Crane and remote head mounted on a pickup. (Photo courtesy of LoveHighSpeed).

The counterweights extending behind the pivot point have two important consequences. First, it is important to take this *backswing* into account when planning or setting up a crane move. If there isn't sufficient room, at best your moves will be limited and at worst something will be broken. The second one is a safety issue, and it is one that cannot be emphasized enough. Any crane can be dangerous.

When you are on a crane, the key grip or crane grip is in charge. Nobody gets on or off the crane without permission of the crane grip. The reason for this is that your weight and the camera are precisely counterbalanced by the weights on the back end. If you were to suddenly get off the crane without warning, the camera end would go flying up in the air and very likely cause damage or injury. With anyone getting on or off, or with any changes in equipment, the crane grip and the back-end grip communicate loudly and clearly so that every step is coordinated.

Other safety issues when working on a crane: always wear your safety belt. Always and be extremely careful around any electrical wires. After helicopters and camera cars, cranes around high-voltage wires are the leading cause of serious injury and death in the motion picture industry. Take it seriously. The best bet is to tell your crane grip what you want and then just let him be in charge.

CAR SHOTS

Car shots have always been a big part of film production. In the old studio days, they were usually done on sets with rear projection of moving streets visible through the rear or side windows. Special partial cars called *bucks* had the entire front of the car removed for ease of shooting.

Rear or front projection of exterior scenes is rarely used these days, partly because the technology of shooting on live locations has been perfected as well as film or digital replacement of the background. Car shots are accomplished with *car mounts* or a *low-boy trailer* (Figure 12.12 in *The Tools of Lighting)*. The trailer is low enough that shot of the actors doesn't seem to be unnaturally high off the ground.

Figure 15.35. A suicide rig built and operated by Mark Weingartner. Kids, don't try this at home. (Photo courtesy Mark Weingartner).

CAMERA POSITIONS FOR CAR SHOTS

The standard positions for car shots are on the hood and either passenger or driver-side windows. Those at the side widows are accomplished with a *hostess tray* (Figure 15.26). The ones on the front are done with a *hood mount* (Figure 15.25). These two components are the standard parts of a car rig kit, but be sure to specify both if you need them. On low-budget productions where car rigs are not possible, there are some standard tricks. For shots of the driver, the operator can sit in the passenger seat. For scenes with two people in the front, the operator can sit in the back seat and do 3/4 back shots of each, two shots of both, and so on. In such cases, exterior mounted lights for the car are usually not available, so it is common to let the outside overexpose 1 to 2 stops and leave the interior slightly underexposed. It also helps greatly to pick streets with greenery or dark walls on the side of the street to hold down the overexposure of the exterior.

VEHICLE TO VEHICLE SHOOTING

Camera cars are specialized trucks with very smooth suspension and numerous mounting positions for multiple cameras. Camera cars are used in two basic modes. For close-ups of the actors, the picture car is usually towed by the camera car or mounted on a low-boy trailer that is towed. Towing has two advantages. First, the position of the picture car doesn't change radically and unpredictably in relation to the cameras, which can be a problem for the camera operators and the focus pullers. Second, it is much safer because the actor doesn't have to perform and try to drive at the same time.

Figure 15.36. Steadicam operator Santiago Yniguez has the arm mounted on a two-wheel rig operated by a grip.

A simpler technology for towing shots is the *wheel-mount tow*. This is a small two-wheel trailer that supports only the front wheels of the car. Because the picture car is still at ground level, there are few problems with perspective. This can be an advantage if, for example, the car has to stop and someone approaches the window. This could all be done in one shot, where it would be difficult if the car is mounted on a full trailer. One safety consideration for front wheel tows:

the tires are usually held onto the tow carriage with straps. Camera positions for vehicle to vehicle usually repeat the standard positions for hood mounts. A crane may also be mounted on the camera car, which can be used for very dynamic moves such as starting with the camera shooting through the windshield, then pulling back and up to show the whole car traveling alongside.

AERIAL SHOTS

Aerial shots were also attempted very early in film history. Vibration has always been a problem with aerial shots as with the pressure of the windstream. Both make it difficult to get a good stable shot and control the camera acceptably. The Tyler mounts for helicopters isolate the camera from vibration and steady it so it can be operated smoothly. Today, most aerial shots are accomplished with remote head mounts, with the camera mounted to the exterior of the aircraft and the operator inside using remote controls, but in tight budget or impromptu situations it is still sometimes necessary for the camera operator to lean outside and balance on the pontoon—hopefully with the proper safety rig. In such cases, don’t forget to secure the camera as well as any filters, matte box, or other items that might come loose in the slipstream.

Figure 15.37. An Alexa mounted on a dolly in low-mode. This allows the camera to go lower than mounting directly on the dolly head. (Photo courtesy Sean Sweeney).

OTHER TYPES OF CAMERA MOUNTS

There are some other methods of rigging cameras for use in specialized situations. As with the other camera support systems we have covered, the proper equipment needs to be reserved for rental and in many cases, trained operators need to be booked, which means that what the director and DP want to do with camera movement has to be well thought out in preproduction.

STTADIOAM

The *Steadicam* revolutionized camera movement. It can smoothly move the camera in places where a dolly would be impractical or difficult, such as stairs, rough ground, slopes, and sand. A skilled operator can pull off amazing shots that can almost be an additional character in the scene. In standard mode, the film or video camera is mounted on top of the central post, and the operator's video monitor and batteries ride on the sled at the bottom of the rig. The only limitation is that since the post extends down from the camera, that is the lower limit of travel for the camera. To go any lower than this, the entire rig must be switched to low-mode, which generally takes several minutes.

RICKSHAW, WHEELCHAIR, AND GARFIELD

Camera mounts can be put on just about anything that moves. The poor man's dolly, often used by film students, is a wheelchair. With its large-radius wheels and the operator handholding, it can provide some remarkably smooth dolly shots. The Garfield is a mount that goes on a wheelchair to allow for mounting of a Steadicam.

Figure 15.38. *Sliders* have become very popular for their ability to make small camera moves with a minimum of equipment and setup. (Photo courtesy Cinevate).

Figure 15.39. A *crash cam* and its steel housing. In this case, the camera is an *Eyemo*, a WWII combat camera, fitted with Nikon lenses—it's expendable.

CABLE-CAM

Invented by Garrett Brown, who also conceived the *Steadicam*, the *Cable-Cam* can perform some truly amazing shots in places that a helicopter might not be usable, such as over a stadium crowd. The Cable-Cam can carry an operator or use a remote head. The unit comes with its own crew and generally requires at least a day of setup as it involves setting long runs of support cables and operating motors in several positions.

CRASH CAMS

For explosions, car wrecks, train crashes, and other dangerous stunts, cameras must sometimes be placed where there is great danger of them being destroyed. In this case, *crash cams* are used (Figure 15.39). In film, these are usually

Eyemos (a WWII combat camera) that have been fitted with crystal motors and mounts for Nikon or Canon lenses, which are a fraction of the cost of motion picture lenses. In video, DSLRs are sometimes used as they are considered to be expendable.

SPLASH BOXES

In cases where the camera doesn't have to be actually submerged but will be very near the water or even slightly under the surface, a splash box can be used. These combine a clear optical port for the lens with a waterproof box or plastic bag that protects the camera without encasing it in a full underwater casing, which can be clumsy and time-consuming to use. A splash box is something that can be used quickly for a single shot.

UNDERWATER HOUSINGS

For actual underwater work, a fully waterproof housing is necessary. These are specially constructed rigs which have exterior controls for the on/off switch and focus. In most cases, they are specially built for particular types of cameras. Underwater housings generally have to be made for the particular type of camera being used.

MOTION CONTROL

The idea of motion control is simple: instead of a human operator, a computer controls the camera movement through servo motors attached to the dolly, crane, or camera mount (sometimes all three). It is mostly used to ensure perfect repeatability in every take (Figure 15.1). This is important in VFX work where sometimes multiple passes are needed for different elements of the scene. Motion control should not be confused with remote control camera mounts. Remote control heads also use servos to move the camera according to input made by an operator who is not at the camera, such as inside the helicopter (when the camera is outside) or when the camera is on a long crane that will support the weight of the camera but not an operator; the difference is between the operator controlling the camera live or the camera moves being programmed into a computer that then controls the movement. There are also “repeat” heads which are operated by a human the first time and then are able to exactly re-create those movements again and again, until the operator inputs a revised or different move.

Figure 15.40. Camera on a ladder—one of the quickest ways to get a camera up high. It is usually done with a highhat clamped and strapped to the top rung. This rig is a triple ladder, which gives easy access for the camera assistant to pull focus on the right side of camera. (Photo courtesy Jowei Verhoeven).

Figure 15.41. An extending *Technocrane* mounted on a camera car. All cranes move up/down and left/right but some add an additional axis of motion: in and out. The arm can be extended or retracted smoothly during the move. Some heads can also be revolved so that the camera spins horizontally. The Technocrane was the first to offer this movement, but other companies have made similar devices. (Photo courtesy CaryCrane).

Figure 15.42. The *Technocrane* arm fully retracted. (Photo courtesy CaryCrane).

Figure 16.1. A typical set in operation: dolly and camera are at lower left center, *video village* is under the blue tent (note the black backing to prevent glare on the monitors), DP and director's monitor is at the center with 4x4 *floppies* side and back. At the left, a 12x16 *solid* provides *negative fill* for the set. (Photo courtesy Heavy Horse Productions).

set operations

New directors sometimes feel that they must be the sole creative force on a motion picture set, but that's impossible. They are the gatekeeper of creative ideas: they don't have to have all the ideas, they just have to know which ones will work. A good director hires great people tells them what is needed, and then determines which of their additional ideas will enhance the narrative.

Directors must be aware that certain shots take extra time and resources to execute, and must let the DP know in advance that they want a fancy shot like this to happen. There's a huge difference in time and cost when the director lets the DP know they want a six-minute moving camera take well in advance vs. on the day of the shoot.

Art Adams

MAKING IT HAPPEN

The working relationship between the director and cinematographer is the key to getting a film made. Along with the production designer, they are the people on the set responsible for creating the look and feel of the project. Let's look at the responsibilities of everyone involved, first of all in a typical feature film. These procedures are general to most types of production including, commercials and music videos, and on small productions such as industrials and documentaries; some of these are omitted, but the essentials are the same.

In relation to the camera work, the director has a number of duties. It is the director who makes the decision as to what shots will be needed to complete a particular scene. He or she must specify where the camera will be placed and what the field of view needs to be. Some directors prefer to specify a specific lens, but most just indicate to the DP how much they want to see, and then the camera person calls for the lens (or focal length on a zoom) to be used.

The director must also specify what camera movement, zooms, or other effects will be needed. Most directors do all of this in consultation with the DP and ask for ideas and input. Problems often arise when a new director feels he must make every decision by him/herself. One thing is beyond question—the lighting of the scene is the cinematographer's responsibility, the director should indicate the look, tone, and feel they want for a scene but should never call for a specific lighting plan or certain lights to be used.

One of the most common situations is when directors ask for long, complex dolly or Steadicam moves. It can be very effective and dramatic to shoot an entire scene in one shot, with the camera moving constantly with the characters even as they go from room to room or make other types of moves. However, these types of shots are generally difficult to set up, difficult to light (since you are so often forced to hide the lights), and usually very demanding for the focus puller. They also require many rehearsals and many takes to get all the elements to work together: the timing of actors' moves, the timing of camera moves, changes in focus, and in some cases changes in T-stop. Lighting is much more complex because it is like lighting for multiple cameras with very different positions: it is very difficult to make the lighting work well for both cameras and hide all the equipment.

Long, complex shots are exciting to conceptualize and great fun when they are completed successfully. Also, it sounds so quick and convenient to just "go ahead and get the whole thing in one shot." The problem is that almost inevitably, the shot gets cut up into pieces anyway, with inserts, close-up, or other coverage. This means that time and effort spent to accomplish it were largely wasted.

Unless you absolutely know that the continuous take will be used, it is often better to break it up into logical pieces. At the very least, bet a couple of cutaways in case the long take is boring, technically flawed, or otherwise unusable. This is not in any way to say that you shouldn't try for long, continuous takes – just that you need to be aware of the dangers and difficulties. Certainly, films like *Birdman* use them to extraordinary effect.

Ideally, the director should arrive on the set with a complete shot list. This is a list of every shot and every piece of coverage needed for the scenes on that day's shooting. Some directors are extremely well prepared with this, and others let it slide after the first few days, which is a mistake. It is true that shot lists are often deviated from, but they still provide a starting point so that everyone in all departments is headed in the same direction.

Figure 16.2. A typical working set. In the foreground is an *electrician (lighting technician*) with various colors of electrical tape for marking distribution cables. (Photo courtesy Owen Stephens at Fill-Light).

THE DIRECTOR OF PHOTOGRAPHY

Every director has a different style of working: some will be very specific about a certain look they want and exact framing, while others want to focus on working closely with the actors, and staging the scenes and leave it to the DP to decide on exact framing, camera moves and the lighting style, filtration, and so on.

> Stay calm, listen, observe and lead by example.
> Jonathan Taylor, ASC

Ultimately the director is the boss; he or she may work in whatever fashion they wish. A professional DP should have the flexibility to work with a director in whatever manner they choose. Ultimately it is up to the DP to deliver for the director the kind of look and visual texture they are looking for and ensure that the director and editor have all the footage they need and that it is all editorially usable. The DP's responsibilities are numerous. They include:

- The look of the scenes, in consultation with the director.
- Directing the lighting of the project.
- Communicating to the gaffer and key grip how the scene is to be lit: specific lights to be used, gels, cuts with flags, silks, overheads, diffusion, and so on. Directing and supervising the lighting process.
- Coordinating with the production designer, wardrobe, makeup, and effects crew concerning the overall look of the film.
- Filtration on the camera.
- Lenses: including whether to use a zoom or a prime lens (though this may sometimes be the director's call).
- Ensuring that there are no flicker problems (see the chapter on *The Tools of Lighting*).
- Being constantly aware of and consulting on issues of continuity: crossing the line, screen direction, and so on.
- Being a backstop on insuring that the director hasn't forgotten specific shots needed for good coverage of the scene.
- Supervising their team: camera operator, the camera assistants, the electricians, the grips, and any second camera or second unit camera crews; also the data wrangler and DIT.
- Watching out for mistakes in physical continuity: clothing, props, scenery, and so on. This is primarily the job of continuity and the

department heads, but the eye looking through the lens is often the best way to spot problems.
- Specifying the specific motion picture film raw stock(s) or type of video camera to be used and any special processing or the workflow for video footage.
- Determining the exposure and informing the First AC what T-stop to set on the lens.
- Ensuring that all technical requirements are in order: correct film speed, shutter angle, and so on.

Typically, when starting to light and set up a new scene, the assistant director will ask for an estimate of how long it will take to be ready to shoot. This is not an idle question, and it is very important to give an accurate estimate. The AD is not just asking this to determine if the company is on schedule: there is another important consideration. She has to know when to start putting the actors through *the works*. This means sending them through makeup and wardrobe; this may also be referred to as when to *"put them in the chairs."*

Figure 16.3. DP Art Adams takes an *incident reading* for a night exterior scene. Deciding what f/stop to set the lens at is one of the DP's most important responsibilities. (Photo courtesy Adam Wilt).

Many actors do not appreciate being called to the set a long time before the crew is ready to shoot, and in addition, if they have to wait, their makeup might need to be redone, and so on. It may also affect the timing of rigging special effects.

THE CINEMATOGRAPHER'S TOOLS

Light meters were discussed in *Exposure*. Generally, DPs carry two meters with them: the *incident meter* and the *spot meter (reflectance*). The Sekonic meter (Figure 16.3) combines both functions, but there are many types of light meters in use on sets. A color meter is also useful but usually not carried on the belt (or around the neck or in a pocket) all the time. Adam Wilt's *Cine Meter II* (Figures 9.35 and 9.36 in *Exposure*) actually performs all three functions with the addition of the *Luxi dome* for incident readings.

Figure 16.4. A *gaffer's glass* (neutral density viewing filter) with a China ball reflected in it. (Photo courtesy E. Gustavo Petersen).

GAFFER GLASS

A viewing glass, called a *gaffer's glass* (Figure 16.4), is an important tool. It allows you to look directly into a light without being blinded. This is important when *focusing* a light: a standard procedure when setting lights is to stand (or sit) where it needs to be aimed, then looking into the light with the viewing glass. This allows you to see precisely where it is aimed so you can direct the electrician in trimming it up/down, left/right, and spot or flood. Focusing the lights might be done by either the DP or the gaffer. The viewing glass can also be used to look at the sun to see if clouds are coming in. This can also be done by looking at the reflection in a pair of sunglasses.

LASER POINTER

Once you stand on the studio floor pointing and waving your arms trying to communicate to someone on a ladder or on a *catwalk* exactly where you want something rigged, you will appreciate the ease and precision of a laser pointer.

DIRECTOR'S VIEWFINDER

A *director's viewfinder* allows you to see how a certain lens will portray the scene without looking through the camera. There are two types of director's finders. The first is a self-contained optical unit that can be "zoomed" to different focal lengths to approximate what a lens will see. Far more precise is a viewfinder/camera mount that allows you to mount the actual lenses you will be using; however, the camera lenses won't be available on a *location scout* or *tech scout*. First-time directors often seem to think that constantly wearing a director's viewfinder around their neck is the ultimate symbol of "I'm the director." It isn't.

DIGITAL STILL CAMERA

A digital still camera (most of them also do video) is useful for location scouts and also for use on the set. DPs frequently shoot a still then manipulate it in software to get a "look" that they show the director so they can make decisions about the scene.

THE SHOT LIST

The director's *shot list* serves a number of functions. It lets the DP and the assistant director better plan the day, including possibly sending off some electricians and grips to *pre-rig* another location. It also helps the DP in determining what additional equipment should be prepped, and how much time is reasonably allowable to light and set the shot within the constraints of what needs to be done that day. Even if the shot list doesn't get followed step by step, it will often at the very least provide a clue as to what style of shooting the director wants to employ: is it a few simple shots for each scene or detailed and elaborate coverage or perhaps a few "bravura" shots that emphasize style and movement?

Figure 16.5. Attaching a filter to a lens when there is no matte box or the filter won't fit the matte box can be accomplished by making a *daisy* out of *camera tape* (l-inch cloth tape).

Figure 16.6. The filter attached to the tape. This is a last resort for when you don't have a matte box that will hold the filter. Be very careful—filters are expensive!

In addition, it is very helpful in serving as a reminder for the director, the DP, the assistant director, and the continuity person so that no shots or special coverage are missed. One of the gravest production errors a director can make is to wrap a set or location without getting everything needed. Reshoots are expensive, and there is always the possibility that the location or the actors will not be available to correct this mistake. Although all these people assist in this, it is the director's fundamental responsibility to "get the shots." This is far more important than being stylish, doing fancy moves, and so on. None of these matter if scenes are not completed and usable. In video, the absolute most basic rule is to never leave a location until you have checked the footage for problems, performance, and continuity.

Even if not in the shot list, some directors will charge the script supervisor with keeping a list of "must haves." This is especially useful for cutaways or inserts that might easily be forgotten. It is also helpful for "owed" shots. "We owe a POV shot from the window," is a way of saying that there is a shot that is part of this scene that we are not shooting now, but we have to pick it up while at this location.

Prep is an important part of every production, no matter how large or small. On small to medium feature films, a very general rule of thumb is at least one day of prep for every week of planned filming, but on larger productions and especially ones that are heavy on stunts, effects, and VFX, the DP's prep may extend to many months.

During this time, the DP will be consulting with the director on the look, the method of shooting, how many cameras are to be used and the general "feel" of the film that they are going for. Of course, *location scouting* is a huge part of prep—both selecting locations and then revisiting them to think about what needs to be done to most effectively work at that location. Prep includes:

- Reading the script.
- Talking to the director.
- Sharing images, screening films.
- Talking to the production designer.
- Location scouts and tech scouts.
- Meeting with the Gaffer, Key Grip, and First AC.

PUTTING THE ORDER TOGETHER

- Camera.
- Lighting.
- Electrical (up to the gaffer and best boy).
- Gels/Diffusions (DP selects favorites, gaffer adds a "standard package"—*CTO*, *CTB*, common diffusions, etc.)
- Practical bulbs.
- Special gags (lighting rigs).
- Grip equipment (mostly up to the key grip).
- Special gear requested by the DP.

READING THE SCRIPT

As you read the script, there are a number of things you are doing. First of all, you need to really understand the story. Not the plot, but what is the real inner meaning of the story—this will be an important clue to how it wants to be portrayed visually. Second, you'll need to understand the logistics of the project: is it mostly studio or locations? Are the locations pretty standard or are they far away, difficult, or involve a lot of travel and transportation? Weather conditions? Underwater or near water? Aerial shots? Do they need to be fixed-wing aircraft, helicopter, or drone shots? Driving shots? Are there lots of stunts? Extensive VFX (visual effects) work? All of these will help you get started thinking about what equipment will be needed, what cameras or film stock is needed, how much crew is to be booked, how much *second unit*, and so on—some of these issues will not be decided yet, but you need to start forming ideas about these issues and giving input on what may be the best way to approach these from the standpoint of cinematography and logistics.

Figure 16.7. A typical day exterior setup. The *sound mixer* is at the left, *boom operator* is at the corner of the set. In the foreground is a docking station for the *Steadicam*—a rolling stand with a hook for when the operator needs to set the camera down.

TALKING TO THE DIRECTOR

Another important part of prep is "getting on the same page" with the director. It will usually involve lots of discussions about the script, the overall plan and, of course, the “look.” Most directors will have some visual ideas about how they want the film to look; some will be vague and unformed, some will be very specific. An excellent way to talking about it without the need to get specific is to discuss analogies and metaphors.

Probably the most commonly used technique is to compare other films and talk about what it is you think works or doesn’t work about them. Watching entire films or clips can be key to this process. Hopefully, the director won’t show you a film and say “I want it to look exactly like this.” Similar to this is to look at photographs. Some directors and DPs keep *look books* which consist of pictures torn from magazines, or images downloaded from the net.

Referring to great paintings or painters is also extremely useful. The production designer will sometimes be part of these conferences as well. This is particularly important if sets are being built. The DP will need to explain the lighting and grip needs for the set. An excellent example of this is a space movie. Sets for spacecraft are almost always very tight and cramped and this is going to make traditional lighting techniques difficult or impossible. Often the lighting opportunities and sometimes the actual lighting need to be built in as part of the set: glowing panels, monitors, wall lights, overheads; all of these may be actual lighting sources or just serve as motivation for added units that are hidden around the set.

> It would be wrong to take a painter and ask him to paint in a certain style from the past. It would be wrong to ask a cinematographer to photograph a film in the same style as another picture because you can never do that. The same elements, the same history, does not exist in the same way as it did previously. But you can reference past work in order to be more clear with yourself about where you want to go and what you want to do.
>
> Vittorio Storaro
> (*The Conformist*, *Apocalypse Now*)

LOCATION SCOUTS AND TECH SCOUTS

Hopefully, the DP will have some input on selecting locations, but that doesn’t always happen—sometimes they have already been chosen. However, it is up to the DP to say so when they spot potential problems with a location, especially ones which mean that the location may not yield the kind of look the director is going for, either for weather, time-of-day, or logistical reasons.

On the actual location scout, it is important to think beyond just "how it will look." It is also critical to think in terms of transportation, climate factors, and even things like loading and accessing equipment—these factors are the primary responsibility of the gaffer, key grip, sound mixer, transpo coordinator, and, of course, the location manager, all of whom must be on the scout. If at all possible, try to scout the location at roughly the same time of day and conditions you will be shooting—week day vs. week end, for example. Once locations have been chosen, there will be *tech scouts*.

> I think that a lot of the best films are collaborations by people with a shared vision. Someone has an idea which is turned into a script. A director and cameraman get together and interpret that script. Production designers, location managers, costume designers, makeup artists and other people play roles. We all need each other. Everyone contributes.
>
> Phil Meheux (*Casino Royale*,*Edge of Darkness*)

COORDINATING WITH OTHER DEPARTMENTS

Besides their own crew, the DP must also coordinate with other crew members. The first is the production designer. If sets are being built or extensively dressed, it is essential that the DP look at them while they are still in plans or sketches, not after they are built. The DP will discuss with the designer what lighting opportunies will be part of the set. These include windows, skylights, doors, and other types of places to hide lights or bring light into the set.

Also to be discussed are the practicals—that is, working lights that are part of the set, and whether they are hanging lamps, wall sconces, or table lamps. A good *set dresser* will usually have a couple of spare table lamps or hanging lights on the truck. These can be invaluable either as a lighting source themselves or as a "motivator" of light. It may be up to the electricians to wire them up, however.

The situation may call for "wild walls," which are walls of the set that can be removed to make room for the camera, dolly track, and other equipment. Finally, it is important to consider not only the set, but how it will be positioned on the stage. There might be a window or glass wall that would be a great lighting opportunity, but if it is only a few feet away from the wall of the stage, it may be difficult or impossible to use it. On the set, the DP is in constant communication with the assistant director concerning the schedule: how much time is left before the actors go into overtime, and so on.

Before the shooting begins the AD makes the schedule indicating what scenes will be shot on what days and a *one liner*, which is a one line description of each scene. The schedule also indicates whether scenes are day or night, interior or exterior, whether the day scenes are to be shot during the day or night and vice versa. This is essential for the DP in planning what equipment and supplies will be needed.

The *call sheet* for the day lists what scenes will be shot, what actors are involved, if there are stunts, *etc.* At the beginning of each day, a production assistant or second AD will hand out sides. These are copies of the script pages to be shot that day that have been reduced to a quarter of a page, so that they can be easily slipped into a pocket. The sides are the "bible" for the day (along with the *call sheet*). Of all the principles of filmmaking perhaps the most important of all is that everyone must know what is going on and is working, as they say, "on the same page." Communication is the key—nothing can derail a production quicker than poor communication. This is why everyone should have a copy of the script pages for the day.

During shooting, the DP is under a great deal of pressure and is thinking about a dozen things at the same time; complete focus and concentration are essential. One of the unwritten rules of filmmaking is that only certain people talk to the DP: the director, of course, the First AD, the First AC, the gaffer, and the grip. A working set is no place for idle chitchat, or as a great AD used to say, "Tell your stories walking."

> Preproduction is the most important part of filmmaking; you must have it all in the brain so when you start shooting, the simple shot is a done deal. As a cinematographer, you're like a boxer on the balls of your feet. You have to be balanced and ready to go in any direction so as to cover a scene in a way which will enable it to fit into the film.
>
> John Seale (*Mad Max: FuryRoad*, *Witness*)

THE TEAM AND THE ORDER

Both during and after the scout, the DP will talk to the team: *gaffer (Chief Lighting Technician), Key Grip*, and *First AC*—these people are called the *keys* —the leaders of their departments. In general, the DP will explain what it is they want to do and maybe mention some of the major equipment, then the keys will fill in the details. The DP will give the gaffer a list of the major lights (as an example: two 18Ks, 4 Maxi Brutes, and a 12K HMI PAR) and then the gaffer will add in all the equipment that is needed to accomplish that: stands, headers, adapters, as well as the distro and generator power required.

The gaffer may also add in a "standard list" of items even if the DP didn't mention them: some tungsten, maybe some LEDs, and other equipment needed for the smaller stuff, fill, background lights, and so on. Also important are the work lights to illuminate the craft service table, the makeup area, *home base* (where the trucks and campers are parked), and so on—these are important too and might need small *putt-putt generators* if they are not accessible to the main set power. Often the production trailer, makeup, and wardrobe trailers will have their own built-in generators but they might need some *single extensions* to distribute the power to where it's needed. The *Assistant Chief Lighting Technician* (*second electric*) is in charge of all issues of electrical distribution and generators.

The gaffer will also take note of any lighting color needs and perhaps show the DP some gel samples for approval; this might be done for diffusion also, unless the DP has a particular list of diffusions they like to use—most cinematographers have favorites they rely on.

The same procedure generally applies to grip—the DP will talk about any special cranes, camera mounts, or lighting mounts needed and the key grip will put together the full list of grip equipment needed for that scale of production and special needs for particular types of locations. As with lighting gear, it will be up to the key grip to fight any budget battles with the production manager, bringing the DP in only if absolutely necessary.

THE PAGE TURN

There may be several production meetings along the way but the main one will be the *Page Turn* (which might just be called the *production meeting*). This one is crucial. The director will be present but the meeting will be run by the

Assistant Director (*First AD*). He or she will go through the script page by page and talk about the location, props, lighting gags that are in the script, stunts, mechanical effects, and so on. As each thing is mentioned, the relevant key will say whether or not they have that covered or if they need more equipment, more crew, or other special needs that have not yet been approved. It's a little bit like a NASA control room when they go around to each supervisor and get a "Go—No Go" from everyone. This procedure is especially important for effects where more than one department is involved, such as a stunt that has a lighting gag as part of it, for example.

Figure 16.8. The *camera operator* in handheld mode on a short ladder. *Steadicam* or *handheld* can be difficult on a windy day. Trying to use a solid *flag* as a wind block just creates an unmanageable and potentially dangerous sail. Here the grips are using a 4x4 *double net*; it blocks most of the wind but is more stable and easily controlled.

TESTS

Any larger production is likely to involve camera tests which are the DP's responsibility, assisted by the camera assistants and possibly the gaffer. These might include testing the camera itself, testing different "looks" or LUTs to determine what will be used in the camera or at the DIT cart, but also wardrobe, makeup, and location tests as well.

CAMERA CREW

Typically on a feature or commercial, the camera crew will consist of the camera operator, the *First AC* (assistant camera), the *Second AC*, and the *Loader*. If multiple cameras are used, more assistants and operators will be more necessary; on very small productions or industrials, the crew might be as small as a First and a Second or even just a First for very small jobs. The team may also include an *Operator* (Figure 16.8) if the DP is not operating. A *Camera Utility (Camera Trainee* in the UK) might also be part of the camera crew. On digital jobs, the tasks performed by the Second AC, DIT, data manager, and loader are fluid and not always well defined. They are assigned on a job-by-job basis.

Producers may question the need for a loader, but remind them that if the camera crew is not sufficiently staffed, the production will be slowed down because the Second has to frequently leave the set to load magazines or download digital material. The *DIT* (*Digital Imaging Technician*) is also part of the camera team but operates somewhat independently. The DIT may have a *Digital Utility* or *Data Manager* working for them as well. See *The Filmmaker's Guide to Digital Imaging* (also from Focal Press) for more on the a digital camera crew.

OPERATOR

The operator is the person who actually handles the camera: pans and tilts, zooms, coordinating with the dolly grip on moves. As she operates, she must always frame the shot as the director has called for, make the moves smooth, and also be looking for any problem that might ruin the shot. Typical problems include the microphone dipping into the frame, lens flares, a piece of equipment visible in the shot, reflections in windows or mirrors of the crew or equipment, missed focus, a bump in the dolly track, and so on. Almost everyone has a monitor (via *video tap* when shooting film) these days, but the director will probably be so focused on the actor's performance that small problems will not be seen. The person actually looking through the lens has prime responsibility for this.

Figure 16.9. A crew at work with a crane for low-angle shots. This is an actual New York City subway station. The same station was re-created as a set for the greenscreen shots and stunts that could not be performed at a working station—Figure 18.8 in *Technical Issues*. (Photo courtesy Michael Gallart).

It is essential that the operator immediately reports any problems. For example, if the sound boom gets into the shot, the operator should immediately call out "boom" loudly enough for both the boom operator and the director to hear. Some directors want this and some don't; it is something that needs to be discussed in prep. It is up to the director to decide whether to cut the shot or continue filming, knowing that most of the shot is still usable or there will be coverage. This practice will vary from set to set; some directors, especially on larger-budget projects, may want it reported only after the shot. On smaller projects, there will be no operator and the DP will operate the camera. Although many DPs prefer to operate, it does take time and concentration away from the other duties. Under the *English system* (also used in many other countries) the distinction is even more dramatic. In this method of working the DP is primarily responsible for lighting the scene (they are occasionally listed in the credits as "lighting cameraman"). It is the operator who receives orders from the director about camera moves, dolly moves, focal length, and so on.

FIRST AC DUTIES

The *First AC* is also known as the *focus puller*. The First is the crew member who directly works with the camera. Duties include:

- Loading digital recording media or film magazines on the camera on film shoots.

- Ensuring that the camera operates properly.
- Checking for hairs in the gate before any scene is wrapped (film only).
- Guarding against flares, light leaks, and any other problems.
- Setting the T-stop at the DP's direction. Also, frame rate and shutter angle.
- Measuring the focus distances in conjunction with the *Second AC*; sometimes focus is set by eye.
- Pulling focus during the take.
- In some cases operating the zoom control. This is sometimes done by the operator using a zoom control on the handle.
- Moving the camera to the next setup, with the help of the other ACs and sometimes the grips.
- Guarding the camera against damage or malfunction.
- Making sure the proper film stock is loaded, or in digital that ISO and other settings are as they should be.
- Calling out the footage so that the Second AC can note it on the camera report (film only).

Focus may be determined by measuring or by eye. Measuring is generally done in two ways. Cameras have a mark on the side that identifies the position of the film plane. Positioned above that is a stud that the AC can hook a cloth measuring tape onto. Most ACs also carry a carpenter's metal measuring tape; this is useful for quick checks before close in shots. *Laser rangefinders* are also widely used. The third method is eye focus. This can be done with either the operator and the ACs or by the First AC himself. Someone—either the actor, a standin or the Second AC—goes to each of the key positions. The operator looks through the viewfinder and focuses. Always do this with the aperture wide open (to minimize depth-of-field); with a zoom lens, zoom in all the way, also to minimize depth-of-field and also to be able to see fine detail better.

For critical focus, it may be necessary for the Second to take the top off a small flashlight. The exposed bulb provides an accurate and fast focus point that can be used even in low-light situations. For complex dolly shots, the Second may make tape marks alongside the dolly track, thus knowing that at a specific point he is x number of feet and inches away from the subject. Good ACs are uncanny in their ability to judge distance and

Stay true to yourself. When everything is crazy around you and you feel like you're being forced into making all the compromises, do what is right for make adjustments on the fly.

Good ACs will always go through a mental ritual before every shot: is the T-stop properly set? Is the focus prepared? Is the camera set at the right settings? Are there any flares in the lens? It is best to do it in the same order every time for consistency. In previous times this checklist was remembered as *FAST*: focus, aperture, speed, and tachometer. Cameras no longer have tachometers, but they do have frame rate controls that must be checked regularly. There are also codecs, recording format, and “Looks” to keep track of. They might be different for frame rate changes as some cameras can’t record maximum resolution at higher frame rates.

> you and make the compromises you can live with. In the end, what people see on the screen is what they remember you by.
>
> Billy Dickson (*Fast Company,Believe*)

The Second should also keep track of how much footage is used on each take and then check to make sure there is enough digital media or film stock left to get all the way through another take of the same shot. It can be very frustrating for the director and the actors to roll out in the middle of the take.

When shooting film, as soon as the director announces she is through with the scene, the First AC immediately checks the gate. This is to ensure that a hair or other piece of junk has not crept into the film gate and thus ruined the shot. Anything like this would not be visible through the eyepiece, and if something is in there, everyone must know immediately so that it can be reshot. There are three ways of doing it. One is to look into the lens from the front. This can be difficult with zooms because there is so much glass between your eye and the gate. The second way is to open the camera and gently lift the film up and examine the gate. The most reliable method is to pull the lens and look at the gate.

Figure 16.10. The grip crew handles anything to do with the dolly. The *key grip* may operate the dolly, or there may be a designated *dolly grip*. Rather than setting the dolly directly on the tracks, many grips use a *sled* that runs on skateboard wheels; it's fast to set up and because it has a larger contact area with the dolly track, it smooths out the bumps. Here, a grip *Hollywoods* (handholds) a *courtesy flag* for the camera operator and AC.

SECOND AC

When the DP or First AC calls for a lens change, filter, or any other piece of equipment, it is the Second who will bring it from the camera cart (Figure 16.20) or the truck. The Second AC is also sometimes referred to as the *clapper* or the *clapper/loader*. This is because one of her main duties is to operate the *slate* or *clapper*, as it is sometimes called. The slate serves several functions. First, it allows the editor or video transfer person to coordinate the visual image of the stick coming down with the audio of the clap, thus achieving *sound sync*. The slate also identifies the scene number, the take number, and the roll number. It will also identify a scene as day-interior, night-exterior, and so on. It should also indicate whether a shot is sync sound or MOS. It should list the frame rate and any special filters being used. The slate will also indicate any effects such as different frame rates. We'll talk about slating in more detail later. Another important duty of the Second AC is setting focus marks (Figures 16.11 and 16.12) for the actors, and assisting the First in measuring focus. In addition, the Second keeps the camera notes (often taped to the back of the slate) and camera logs.

The Second AC may also be in charge of setting up monitors for the DP and director, cabling them, and making sure they are operating properly. If there is a DIT on the job, they might handle this task, although it's best to have a *digital utility* or *camera utility* do this as obviously the camera assistants and DIT have many other urgent duties to attend to. The Second will also be in charge of making sure the carts (Figure 16.20) are as close as possible. It is especially important to keep the lenses close as not having the correct lens up can hold up everything. Also note taking, cleaning, inventory, *etc.*

In summary: The First does everything that needs to be done at the camera and configures the camera as necessary and is responsible for its being able to function however it is mounted or used. The Second handles everything that needs to be done away from the camera.

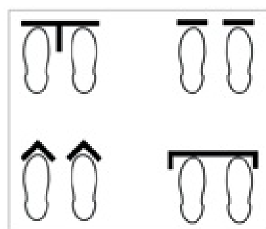


Figure 16.11. Types of *toe marks*.

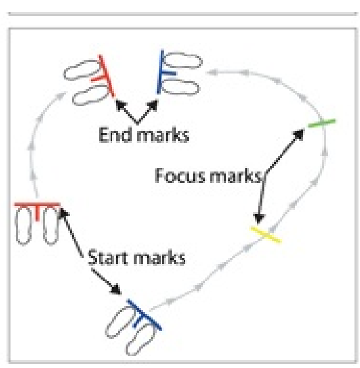


Figure 16.12. Different colored marks are used for each actor, so there is no confusion. This is why the second AC always carries several colors of paper tape that are used for making marks.

Figure 16.13. When shooting out in the sun, the grips will provide a *courtesy flag* to protect the camera and operator. On the left is the *sound recordist*.

LOADER

The *Loader's* duties vary depending on the requirements of the job. They might serve as the Loader (both on film and video shoots) or just assist the First and Second AC in whatever way is needed (and there are plenty of them) such as ferrying equipment to and from the camera cart or the truck, running out cables, moving equipment, *etc.*

DIT

The *DIT* (*Digital Imaging Technician*) is the data workflow manager and often also a “second pair of eyes” for the DP. The DIT will generally have a DIT cart or station near the set with high-quality monitors and good viewing conditions (no stray light—often a light-proof tent for exteriors) and a waveform monitor and vectorscope. The DIT may also make camera adjustments and setup in accordance with the DP’s instructions. In some cases, the DIT can remotely control exposure and other camera settings—this is especially useful on multi-camera shoots where it is important to keep the same look on all cameras. DITs work on the set near the camera, just off the set, or off the set entirely, sometimes in a truck.

DIT WORKFLOW

More than any other job in filmmaking, the duties and responsibilities of the DIT can vary widely depending on the production, the DP, the requirements of postproduction, *etc*. The same goes for the workflow. All of this is why a preproduction meeting with the DP, DIT, editor, *postproduction supervisor*, and others involved in post is so important—issues of who does what, file naming conventions, transcoding dailies, LUTs, and labeling of drives absolutely must be worked out before shooting begins. The actual duties of the DIT will vary from the simplest file management up to consulting with the DP on the look, preparing LUTs, *etc.*

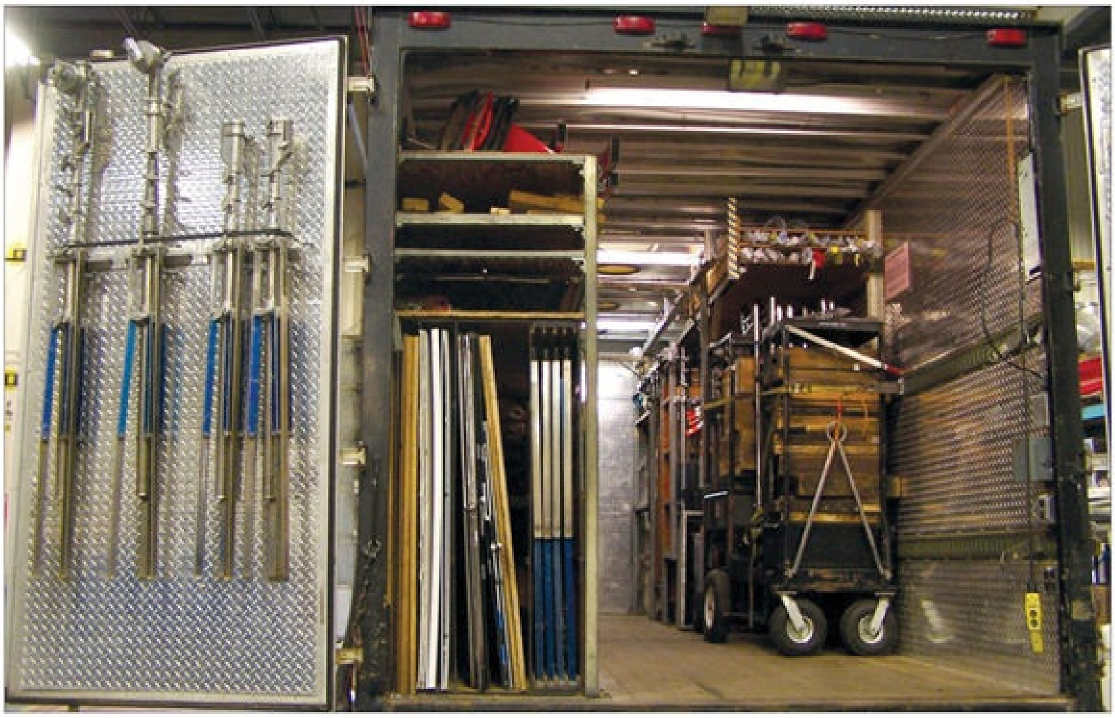


Figure 16.14. The additional space on the right side of the lighting or grip truck may sometimes be used as a place to transport the audio cart or, if it's a small show and there is no camera truck, the camera cart or perhaps the DIT cart. (Photo courtesy HighOutput, Inc.).

SIMPLE DATA WORKFLOW

Let's start with the simplest case.

1. Media is delivered from the camera.
2. DIT, Loader, or Data Manager downloads the media and backs it up to at least two separate hard drives or RAIDs—preferably three.
3. DIT *scrubs* through the shots to make sure everything recorded and downloaded properly. *Scrubbing* is viewing the footage at higher than normal speed for a quick look.
4. Media is delivered back to the set, ready for camera use.
5. Keep a detailed media log of all operations.

ADVANCED WORKFLOW

Now a slightly more advanced workflow:

1. Media delivered from the set.
2. Downloads and backs up.

3. Scrubs through the shots to make sure everything recorded and downloaded properly.
4. If requested, prepares LUTs for viewing and for the camera or applies previously developed LUTs for reviewing on the set and for dailies.
5. May do more advanced color correction for dailies.
4. Media sent back to the set ready for formatting.
5. Files are transcoded for dailies.
6. Keepa detailed media log of all operations.

For much more on DIT workflow, LUTS, Looks, and media management see *The Filmmaker's Guide to Digital Imaging* by the same author. It also covers digital files, transcoding, creating digital dailies, and camera-specific workflows in greater depth and detail than we have room for here.

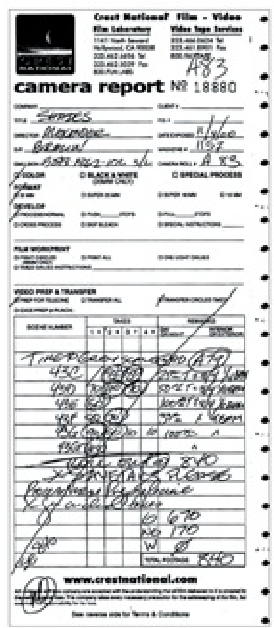

Crest National Film - Video
camera report № 18880
www.crestnational.com

Figure 16.15. A typical *camera report* for a film shoot. Blank camera report forms are provided by the lab that will be processing the footage. They are multi-page forms. At the end of the day, one copy is taped to the cans of exposed footage; one copy goes to the editor, and the camera assistant keeps one.

DIGITAL LOADER/MEDIA MANAGER

In digital, the *Loader* serves the same function as on film jobs, just with different tools. A digital Loader will bring media to the camera; when it is filled, the Loader will take the media to the DIT cart. The loader may or may not also format the media, label it, and keep a log (just as film loaders do). Whether or not the media is formatted in the camera or before being loaded in depends on the type of camera (some cameras need to format their own media) and what procedures the First AC prefers. *Loader* is the official term in the US cinematographer's guild, but other terms sometimes get used, such as *Data Loader*, *Data Wrangler*, *Digital Asset Manager*, *Data Asset Manager*, *Digital Media Manager*, and *Digital Media Tech*.

Some people object to the term 'Data Wrangler,' as there are times when higher-ups don't realize the full aspect of the position, thinking it to be just a simple matter of "drag and drop." DIT Matt Efsic comments, "If I am only doing the secure downloads and backups with bit parity checks and download logs, checking the files against the camera reports, and parsing out stills for the DP; I feel that covers the Data Loader, Data Wrangler, or Digital Media Tech label. I am not altering the files in any way, but am putting them in a secure, organized structure for post and working with the paperwork (not unlike a film loader). If I am making any changes to the footage, such as changing color temp, adjusting ISO (at the request of the DP), applying a *LUT* or a *one-light grade*, or rendering out dailies and possibly *transcodes*, I would prefer the title *Digital Imaging Technician*, as I am now working with the image."

So when does a Digital Loader get hired? DIT Dane Brehm summarizes —"On features it's pretty regular for a DIT to have a Loader depending on the complexity of the shoot. That Loader may or may not be handling data and be more of a 3rd AC with the ability and know-how to handle data. On larger pictures north of $25M shooting 3, 4, and 5 or more cameras with the accompaniment of large volumes of data, the skill set of a second DIT may be more appropriate. Therefore, my Media Manager will be a DIT in classification but handle the media management exclusively. This is because Loaders don't typically have network, coding, and scripting skills that are required on some shows. It's more of an experience and knowledge solution that's particular to the higher end acquisition formats. On some productions, I sometimes get push back from the *Unit Production Manager* to not have a second DIT on payroll, so I must hire them as a Camera Utility (not Digital Utility) as the pay scale is that of a First Assistant. Then I'm not asking other DITs to take such a pay cut for their valuable skill set which often is in demand on other jobs."

UTILITY

Digital Utility assists the DIT with extra monitoring, cables, media inventory, rental house needs, and paperwork in regards to DIT duties. *Camera Utility* can do everything a Camera Assistant/DIT/Data Manager does minus coloring the image on set. Utilities, either digital or camera are mostly only found on larger jobs.

Figure 16.16. *Video village* on a two-camera HD shoot. The monitors are mounted on the camera assistant’s *Magliner Junior*, which makes moving them quick and easy.

CAMERA CREW REPORTS, EQUIPMENT & TOOLS

As with many jobs, it ain't over till the paperwork's done. For the camera crew, the key piece of paperwork is the *camera report*. A film style report is shown in Figure 16.15 and a digital camera report in Figures 16.19 and 16.23, the latter being more "European style" as it has a column for *Slate Number* instead of *Scene Number*—we'll talk about the difference a bit later.

CAMERA REPORTS

In addition to slating, the Second will also maintain the camera reports. On traditional film shoots, the camera report will include some general information:

- Name of production company.
- Title of the project.
- In some cases, the production number.
- Name of director. Name of DP.
- In some cases the purchase order number.
- Sometimes, as a courtesy, the film lab will pre-print this information on a batch of camera reports.

> Virtually every UK AC I know takes shorthand notes on a pad, then writes up the sheets neatly at the end of the day. As a trainee, it was always reinforced how important it was to have neat reports!
>
> Stu McOmie, UK Camera Assistant

Then, the information gets more specific to this roll of film:

- Camera number or letter (A camera, B camera, etc.).
- The magazine number (very important if you are later trying to identify which of the mags is scratching or jamming).
- Roll number of the film stock loaded.
- Date exposed.
- Raw stock type used.
- Scene number.
- Take number.
- Footage used for each take, usually referred to as the "dial."

- Whether a shot was with sound or "MOS."
- *Circle takes*: the take number of the shots the director wants to be "printed" are circled.
- Remarks.
- Inventory: the total amount good footage (G), no good (NG), and waste (W).
- The total amount shot when the mag is downloaded. For example, "Out at 970."

Figure 16.17. A camera assistant's *front box*. Here it's on the assistant's cart but while shooting, it attaches to a bracket on the front of the camera head and sits just below the lens, providing quick and easy access to the most frequently used items. It also has a slot at the bottom for storing the slate. Held to the front of the box by Velcro are *filter tags*—reminders attached to the matte box showing what filters are in front of the lens. (Photo by Alexander Kohn, courtesy Sebastian Ganschow).

Film camera reports are multi-sheet, usually an original with two copies. Information written on the top sheet is transferred to the second two. The top sheet is folded and securely taped to the film can when the roll is finished. The second sheet is usually yellow. It is given to the production manager, producer, or First AD, who then passes it on to the editor. The third sheet is retained by the production office or producer for reference in case there are any problems. In some cases, there may be additional sheets for other departments such as the production coordinator.

Standard procedure is for the loader to fill in as much of the information as possible and then tape the camera report to the mag before it is delivered to the set. When the mag is loaded onto the camera, the Second will usually then tape the report to the back of the slate for convenience; some assistants use a separate clipboard for writing on camera reports. This is helpful as they are multi-copy forms, and you want to be sure that all the layers of the form are legible. After each take the Second will then ask the First for the "dial," which is the cumulative footage shot as displayed on the counter. This is always rounded off to the nearest ten and only the first two numbers are given: for example, "97" rather than "970." The Second then has to do some arithmetic to use the total cumulative number to determine the footage run on the last take. This is important in being able to predict when the magazine is about to "roll out."

Figure 16.18. Typical gear in a camera assistant's bag. (Courtesy Jake McClean).

Having the camera roll out in the middle of a take can be very disturbing to the actors and the director—it is essential to warn the director when there is a possibility of rolling out on a shot. This is especially true if it is a shot that may be difficult or impossible to repeat. The Second AC is also responsible for providing the First with whatever he or she needs, most importantly the lens that is called for, fresh magazines/media, lens shades, charged batteries, and different tripods or other mounting equipment. Once the camera is set up, the First AC or one of the other camera crew members should never be more than "two arms lengths away" from the camera.

CAMERA ASSISTANT TOOLS AND SUPPLIES

Having the right tools and *expendables* on hand is critical for the camera crew. *Expendables* (such as camera tape, canned air, etc.) are provided by the production company or reimbursed—don't provide them free. A typical camera assistant's kit includes:

- Carpenter's metal measuring tape.
- Soft measuring tape.
- Multitool.
- Laser rangefinder.
- Sync slate.
- Insert slate.
- Phillips and flathead screwdrivers.
- Metric and imperial hex/Allen wrenches.
- Pliers.
- Flashlight (torch).
- Work gloves.
- Velcro.
- Cable ties.
- Laser pointer.
- T-markers or mini-sandbag for actor's marks.
- Small clamps.
- BNC adapters.
- *Space blanket* for camera cover.
- Assorted spare cables.
- First aid kit.
- Film negative or digital camera reports.
- Spare 35mm/16mm 1000ft/400ft cans, bags, and cores (obviously only for film shoots).
- Film changing bag for film shoots.

Expendables are ordered by the First AC and supplied by the production company. They include:

- Canned air.

- Lens cleaning fluid (such as Pancro Lens Cleaner) and tissues.
- Sharpies & pens.
- Erasable slate markers.
- Eyepiece covers.
- Assortment of different colors of 1” camera tape.
- Assortment of different colors of 1” paper tape for actor’s marks and focus marks. Also 2” paper tape.
- 2” white gaffer tape.
- 2” black gaffer tape.
- Chalk.
- Batteries for all equipment you will be dealing with. (Not the rechargeable batteries from the rental house.)
- Light rope/trickline and bungee cords.
- Plastic bags.
- WD-40.


FotoKem
Digital Camera Report
Date / /
Production Co.
Title
Director
Shutter Speed
Shutter Angle

Scene	Take	Clip/File	Comment

Figure 16.19. A digital camera report (Courtesy FotoKem).

AC PREP

Prep starts with talking to the DP and discussing the order. The DP will probably specify what cameras, how many cameras and the lenses (zooms, primes, specialty lenses), what camera head they prefer (or may be the choice of the Operator). How much film stock or recording media is needed. It's up to the AC to order all cables, accessories, supplies, and all other equipment.

How many batteries? Don't underestimate—not all batteries will hold a full charge and battery capacity may be impaired by factors such as low temperatures. You won't always have time to allow them the proper recharge time. Err on the side of caution—most batteries take a surprisingly long time to charge. Standard practice is for the AC or Second to take them home at night to charge.

Another big item for AC camera checkout—all those cables! You need to test every one and make sure the connectors fit properly and, of course, that they are the right type of connections for the cameras, monitors, and other equipment you will be using on the shoot. Always have at least one backup for every cable you're using. Cables are a frequent source of problems. Be prepared!

CAMERA PREP CHECKLIST

Camera prep on the checkout day cannot be haphazard. It's important to be methodical and make sure every base is covered—a checklist is invaluable in making sure nothing is missed.

- Assemble every piece—check against order list!
- Be sure everything fits and operates.
- Test camera with a professional test chart.
- Possibly test different "looks" as specified by the DP or DIT.
- Test camera at all frame rates.
- Shoot a framing chart.
- Shoot color chart to test color rendering.
- Resolution/noise/color space tests if requested.
- Different ISO, color spaces, RAW, Log mode, *etc.*
- Test that marked focus matches actual distance for lenses.
- Have a lens test chart or borrow one from the rental house.
- Test all media (digital) or mags on film shoots.
- Test and charge all batteries.
- Check tripods, spreaders and heads.
- Sometimes a high-hat hasn't been ordered, add if needed—same for handles, focus handles.
- Check cases, clean if necessary.
- Label cases with camera tape.
- Put everything back in cases, arrange to your liking.
- Check that you have all expendables.
- Go through your personal kit, make sure you have all tools and supplies (often the rental house has them for sale).
- Second AC may take home batteries to charge overnight.

Some other tasks that will be part of a proper camera checkout day:

- Learn how new rigs work and pre-configure them.
- Organize equipment within cases in a way you prefer.
- Troubleshoot and fix hardware problems with rented gear. The rental house staff will be glad to assist you and repair or replace anything that isn't working properly.

Figure 16.20. A typical AC's *camera cart*. Room for lens cases, batteries, tripods, and other gear that needs to be kept immediately on hand. A high-hat or other camera support is typical, such as this one holding the Red camera. Hooks for tripods on the side of the cart are also widely used. A mount for the monitor is not standard—it depends on the specifics of the production. (Photo courtesy Austin Kite).

Figure 16.21. The *tool belt* is where the AC carries many of the tools and supplies needed on the set. (Photo courtesy Cris Knight).

There will be very few opportunities to get together as a camera department on such a relaxed schedule. When you're on set, there is little or no time to work these things out. Being prepared is a big responsibility for all crew members!

THE TEAM

The DP has three groups of technicians who are directly responsible for: the camera crew, the electricians, and the grips. The DP also coordinates with the art department and, of course, the AD.

LIGHTING TECHNICIANS (ELECTRICIANS OR SPARKS)

The lighting crew carries out the DP's instructions on lighting. The crew consists of the *gaffer* (the head of the crew), the *second electric*, and *electricians* (*sparks* in the UK). US unions now use the terms *Chief Lighting Technician, Assistant Chief Lighting Technician,* and *Lighting Technicians*. The *second electric* used to be called the *best boy*—no longer preferable for obvious reasons.

In addition to the full-time *set crew*, there may be *day players*—additional crew on an as needed basis. For preparing sets and locations before the set crew arrives, a rigging gaffer and electricians may also be booked. We'll talk about *second unit* and *splinter units* a bit later—these might be very small or sometimes nearly as large as the main crew, especially for very large stunts or special effects shots. For more on the lighting crew, see *Motion Picture and Video Lighting*, by the same author.

GRIPS

The grip crew is headed by the *key grip*. His assistant is the *best boy grip* or *second grip*. Then there is the *third grip* and whatever additional grips are needed. Grips are sometimes referred to as *hammers* as one of their duties is to build platforms, rigs, and bracing that are not part of the sets. The key grip may push the dolly, or there may also be a *dolly grip* whose sole responsibility is to push the dolly (Figure 16.22). In the US, the grip crew has a very wide range of duties:

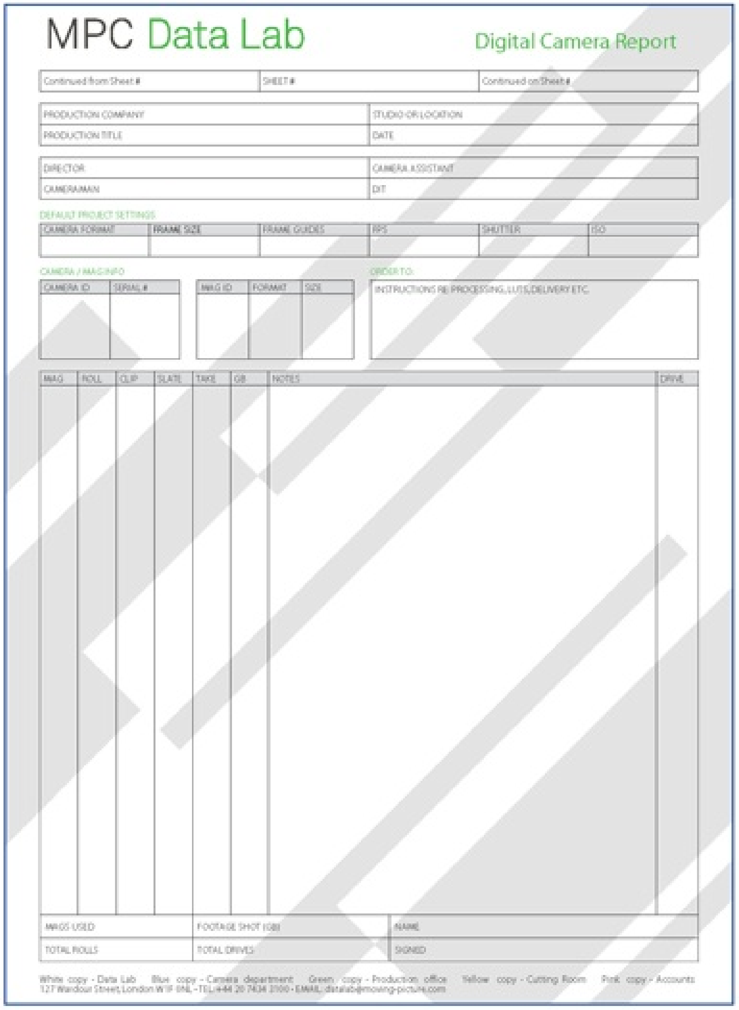
- The grips handle all C-stands, high rollers, and so on, and whatever goes on them: nets, flags, frames, *etc*. This includes any form of lighting control or shadow making that is not attached to the light itself—nets, flags, and silks.
- They also handle all types of mounting hardware, specialized clamps of all types that might be used to attach lights, or almost anything else anywhere the DP or gaffer needs them.
- They handle all *bagging* (securing lights and other equipment with *sandbags*). They may also have to *tie-off* a stand or secure it in another way in windy or unstable conditions.
- They deal with all issues of leveling, whether it be lights, ladders, or

the camera. Their tools for this are apple boxes, cribbing, step blocks, and wedges.

- They handle all dollies, lay all dolly track, and level it. Also, any cranes are theirs to set up and operate. This is especially critical when a crane is the type that the DP and First AC ride on. Once they are seated, the crane grip then balances the crane by adding weights in the back so that the whole rig can be easily moved in any direction. Once this has been done, it is absolutely critical that no one step off the crane until the grips readjust the balance.
- The grips are also in charge of rigging the camera if it's in an unusual spot, such as attached to the front of a roller coaster, up in a tree, and so on.
- The grips build any scaffolding, platforms, or other rigs necessary for camera rigs or other purposes. They may assist the stunt men in building platforms for the airbags or mounts for stunt equipment.
- The grip crew and the key grip, in particular, are in charge of safety on the set, outside of anything electrical, which is, of course, handled by the electricians, and stunts, which are directed by the stunt coordinator.

This is the prevalent system in the United States; in other countries (and other areas where the so-called "English system" is used) it is handled differently—the electricians (*sparks*) handle all lighting-related issues such as nets and flags, and so on, and the grips are primarily responsible for dollies and cranes.

Figure 16.22. Grips use the *lifting bars* to hoist a dolly onto tracks—an AC assists them by steadying the cradles it will fit into. Although the Fisher dolly is capable of riding on track, the multi-wheel *sled* makes for a smoother ride by spreading out the bearing surface. (Courtesy Vertical Church Films).



MPC Data Lab

Digital Camera Report

Continued from Sheet #	SHEET #	Continued on Sheet #

PRODUCTION COMPANY	STUDIO OR LOCATION
PRODUCTION TITLE	DATE

DIRECTOR	CAMERA ASSISTANT
CAMERAMAN	DIT

DEFAULT PROJECT SETTINGS

CAMERA FORMAT	FRAME SIZE	FRAME GUIDES	FPS	SHUTTER	ISO

CAMERA / MAG INFO

CAMERA ID	SERIAL #

MAG ID	FORMAT	SIZE

ORDER TO:

INSTRUCTIONS RE PROCESSING, LUTS, DELIVERY ETC.

MAG	ROLL	CLIP	SLATE	TAKE	GB	NOTES	DRIVE

MAGS USED	FOOTAGE SHOT (GB)	NAME
TOTAL ROLLS	TOTAL DRIVES	SIGNED

White copy - Data Lab Blue copy - Camera department Green copy - Production office Yellow copy - Cutting Room Pink copy - Accounts
127 Wardour Street, London W1F 0NL - TEL +44 20 7434 3100 - EMAIL: datalab@moving-picture.com

Figure 16.23. A downloadable digital camera report form from MPC Data Lab.

OTHER UNITS

Three other types of teams will also be under the DP's control: *second unit, additional cameras*, and *rigging crews*. *Second unit* is an important function. Usually, it is used for shots that do not include the principal actors. Typical second unit work includes establishing shots, crowd shots, stunts or special effects, and insert shots.

ADDITIONAL CAMERAS

In the case where additional cameras are used in principal photography, they are designated B camera, C camera, and so on. On a big stunt that cannot be repeated such as blowing up a building, it is not uncommon for a dozen or more cameras to be used. Some are used as a backup to the main camera in case of malfunction, some are just to get different angles, some run at different speeds, and so on. Particularly on crashes and explosions, some may also be crash cams and will either be in a reinforced housing or be "expendable." GoPros are a widely used option for this application.

Figure 16.24. The Second AC pulls a measuring tape to set the focus distance. (Photo courtesy Vertical Church Films).

SECOND UNIT

Second unit may be supervised by a second unit director, but often the team consists only of a second unit DP, one or two camera assistants, and possibly a grip. It is the duty of the second unit DP to deliver the shots the director asks for in accordance with the instructions and guidance of the director of photography. It will often be up to the DP to specify what lenses and settings are used. It is the DP's name that is listed in the credits as the person responsible for the photography of the film; the audience and the executives will not know that a bad shot or a mistake is due to the second unit. A variation on second unit is called *splinter unit* for specific kinds of shots that aren't stunts or normally second unit. VFX units may also handle shots intended for visual effects, such as background *plates* for greenscreen/bluescreen.

STUNT CAMERAS

Some cameras are "crash cams," small expendable cameras that can be placed in dangerous positions. On digital shoots, DSLRs and *GoPros* are often used as crash cams due to their low cost. Is it a problem that a DSLR isn't going to have the same visual quality as a highend camera? Not usually, primarily because the kinds of shots a crash cam is intended to get generally play on screen only briefly—often just a few frames. This also means that a number of different cameras with different inherent "looks" will need to be edited together—this is one of the primary reasons for *ACES* system we talked about in *Color*.

LOCKED OFF CAMERAS

In some cases, cameras are *locked off*, often because it is simply too dangerous to have an operator in that position. In these cases the camera is mounted securely, the frame is set, and the focus and T-stop are set. They are then either operated by wireless control, remote switch, or an AC switches on the camera and moves to a safe position. Crash boxes may be used if there is danger to the camera. *Polycarbonate* (bulletproof "glass") or pieces of plywood with a small hole for the lens might also be used. Of course, small lock-off cameras such as *GoPros* are now everywhere on some shots.

RIGGING CREWS

Many sets need preparation ahead of time. Rigging crews perform tasks such as running large amounts of cable for electrical distribution, setting up scaffolding, rigging large lights, and other jobs that it wouldn't make sense for the shoot crew to do while the rest of the crew (makeup, hair, set dressers, etc.) waits. These crews are run by a *rigging gaffer* and *rigging key grip*, and the size of the crew varies widely depending on the needs of the production.

> The advice I got the first day I worked in the film business: always be five minutes early to work, never five minutes late. But more importantly, live on the edge when it comes to your photography—take risks. Put your ideas on film

and fall down a few times; it will make you a great filmmaker.

Salvatore Totino (*The DaVinci Code*, *Everest*)

SET PROCEDURES

The way a movie is shot is the result of decades of trial-and-error that arrived at some universal principles that have become the standard procedures for shooting a scene. These methods are surprisingly similar around the world with some exceptions.

BLOCK, LIGHT, REHEARSE, SHOOT

The most fundamental rule of filmmaking on the set is *Block, Light, Rehearse, Shoot*. It's simple. It's the smart and efficient way to get through a scene.

BLOCK

First the director *blocks* the shot—not only showing the actors their movements, but also indicating the camera positions or moves they want. The Second AC will also set marks for the actors at this stage.

LIGHT

Once that is done, the AD announces "DP has the set" and both actors and director step aside while the cinematographer works with the gaffer and key grip to light the shot with lighting *standins* replacing the actors.

REHEARSE

When the DP is ready, the AD calls for "first team" and the director and actors do the serious rehearsals for the scene.

SHOOT

Once this is done, it's time to actually shoot the scene. At this point, the director is in charge and the entire crew stands by for any last minute changes or alterations in the plan.

THE PROCESS

Generally the lighting for the scene will be *roughed in* before this process commences based on a general understanding of the scene as described by the director. This may range from everything fully rigged and hot for a night exterior to only having the power run for a small interior. One of the most important things the DP needs to know at that point is what will *not* be in the shot—where it is safe to place lights, cables, *etc.* After blocking, the DP is ready to begin lighting seriously, the steps of production are reasonably formalized. They are as follows:

- The director describes to the DP and AD what shot is. At this stage, it is important to have an rough idea of all of the coverage needed for the scene, so there are no surprises later.
- The director blocks the scene and there is a *blocking rehearsal*.
- *Marks* are set for the actors. The First AC might choose to take some focus measurements at this time, if possible.
- If needed, focus measurements are taken by the First AC, assisted by the Second AC. Preferably with standins.
- The AD asks the DP for a time estimate on the next setup.
- The AD announces that the "DP has the set."
- The DP huddles with the gaffer and key grip and tells them what is needed.
- The electrics and grips carry out the DP's orders. Lighting standins are essential at this point. You can't light air!
- The DP supervises the placement of the camera.
- When all is set, the DP informs the AD that "camera is ready."
- The AD *calls first team in* and actors are brought to the set.
- The director takes over and stages final rehearsal with the actors in makeup and wardrobe.
- If necessary, the DP may have to make a few minor adjustments (especially if the blocking or actions have changed), called *tweaking*. Of course, the less, the better, but ultimately it is the DP's responsibility to get it right, even if there is some grumbling from the AD.
- The DP meters the scene and determines the lens aperture. When ready, he informs the AD.
- The director may have a final word for the actors or camera operator, then announce that he or she is ready for a take.

- The AD calls for *last looks* and the makeup, hair, and wardrobe people to make sure the actors are ready in every detail.
- If there are smoke, rain, fire, or effects, they are set in motion.

When everything is set, the AD calls "lock it up" and this is repeated by *production assistants* to make sure that everyone around knows to stop working and be quiet for a take.

- The AD calls *roll sound*.
- The sound recordist calls *speed* (after allowing for *pre-roll*).
- The AD calls *roll camera*.
- The First AC switches on and calls "camera speed." (If there are multiple cameras it is "A speed," "B speed," etc.)
- The First AC or operator says "mark it," and the Second AC slates, calling out the scene and take number.
- When the camera is framed up and in focus, the operator calls out "set."
- When applicable the AD may call "background action," meaning the extras and atmosphere begin their activity.
- The director calls "action" and the scene begins.
- When the scene is over, the director calls "cut."
- If there are any, the operator mentions problems she saw in the shot and any reasons why another take may be necessary or any adjustments that may make the physical action of the shot work more smoothly.
- If there is a problem that makes the take unusable, the operator may say something or in some cases stop the shot (it's up to the director's preferences). The operator may call out "boom" if the mic is in the shot. Do it between dialog.
- If the director wants another take, the AD tells the actors and the operator tells the dolly grip *"back to one,"* meaning everyone resets to position one.
- If there is a need for adjustments, they are made and the process starts over.

Figure 16.25. *Second Electric* (*Assistant Chief Lighting Technician*) Josh Day plugs in three-channel *flicker boxes* for a lighting effect. The *Second Electric* (which used to be called the *Best Boy*) handles all electrical distribution on the set.

Figure 16.26. At the end of *checkout day*, the cameras are in their cases which are labeled with colored camera tape to indicate cameras "A," "B" and "C" (Courtesy Sean Sweeney).

Most directors prefer that they be the only ones to call cut. Some ask that if something is terribly wrong and the shot is becoming a waste of film, the DP or the operator may call cut and switch off the camera. The operator must be sure they know the director's preference on this point. The operator will call out problems as they occur (best to do it in between dialog so as not to ruin the sound track), such as a microphone boom in the

Listen to your gut instinct and believe in it. And remember that the craft-service person on this job might be the producer on the next.

Roberto Schaefer,

ASC, AIC
(*Monster's Ball*,
StrangerThan
Fiction)

shot, a bump in the dolly track, and so on. It is then up to the director to cut or to continue. If you as the operator are in a mode where you call out problems as they occur, you certainly want to do it between dialog, so that if the director does decide to live with it, the dialog editor can edit around your comments. Most directors prefer that no one talk to the principal actors except themselves. For purely technical adjustments about marks or timing, most directors don't mind if you just quickly mention it to the actor directly—but only if it will not disturb their concentration.

Figure 16.27. Shooting in tight quarters requires courtesy and calmness to prevent tempers flaring, which is why observing proper set etiquette at all times is so important. (Courtesy Vertical Church Films).

ROOM TONE

Easily the most annoying thirty seconds in filmmaking, rolling audio *room tone* is an absolute necessity. It is used to fill in blanks or bad spots in the audio track. Room tone must be recorded in the same environment as the original audio. It is *very* easy to forget to record room tone. If the audio mixer is recording it, the camera crew only needs to be quiet while it's rolling; if audio is being recorded onto the camera sound tracks, then it should be slated.

You can either write "tone" in the take number slot or write it on the back of the slate as "room tone—Int. Dave's Living Room." Writing it on the front of the slate is probably better as it shows the scene number. This is important as “Dave’s Living Room” might be shot for different scenes, some day, some night, some with traffic outside, some (hopefully) without traffic noise. The audio editor needs to know this information in order to relate this particular room tone with the right production audio. If room tone is being recorded to camera, it’s useful to frame the mics in the shot after slating as a quick visual reference for the editor.

SET ETIQUETTE

You'll find that a great deal of what we call "set etiquette" is really just common sense, good manners, and understanding how the professional working environment operates:

- Show respect for your fellow crew members and their jobs at all times. Be respectful of actors, and background people.
- Absolute silence during a take!
- Make sure your cell phone is off—duh!
- Do not give the director or DP "advice" on how to shoot the scene. The director will not be the least bit impressed if you try to show off your film school knowledge by speculating on how Hitchcock would have done it.
- Don't talk to the director or DP unless they speak to you.
- Don't offer your opinion on *anything* about the scene, unless it is something you are responsible for.
- Nobody talks to the DP except the director, operator, First AC, and DIT (and they know how to pick the right time). If a crew knows each other well and it's a lighter moment on the set, the occasional joke is not out of place.
- Nobody uses a light meter on set except the DP and gaffer.
- Don't crowd around the camera.
- Don't crowd around the monitor. The only people who should be looking at the main monitor are the director, the DP, and maybe the producer or an actor.
- Don't try to do somebody else's job. There is a very real reason for this. See the commentary below.
- Don't get in the way of other people doing their job.
- Do not touch the camera unless you are the DP, the operator or the First or Second AC, loader and sometimes the DIT. Never—like seriously, never.
- Don't pick up or touch the recording media.
- Do not ask to look through the camera. On some sets, even the director will ask if it's OK to look. A big deal? So are eye infections.
- Do not touch anything on a *hot set*—one that has been dressed and prepped and is ready for shooting, or one where shooting has taken

place, and the crew is going to be coming back to that set.

- Don’t leave cups, water bottles, or food laying around. Never put them down on a working or “hot” set.
- Put your initials on the cap of your water bottle.
- Call “flashing” when shooting a photo. This is so the electricians don’t think that your camera flash means that a bulb burned out in one of their lights.
- When a stunt is being run, never applaud until the stunt performer or stunt coordinator signals that the performer is safe and not injured—usually a thumbs up. If you applaud and then it turns out the stunt performer has been injured, you’re going to look (and feel) like a real jerk.
- Don’t be in an actor’s sight line, especially Christian Bale.
- Don’t walk around or be distracting during a take.
- Some actors prefer that you not make eye contact with them at all—respect the fact that they are extremely focused and concentrating on their job.
- Never try to chat with an actor uninvited.
- Never any off-color jokes or sexist remarks or anything crude; it’s a professional environment—act accordingly.
- If you’re shooting on the street, several dozen people a day will ask you “What are you shooting?” Standard response is “It’s a mayonnaise commercial.” Nobody’s interested in mayonnaise.

Why is it such a big deal to not do somebody else’s job? You may have heard stories about “There was a rope hanging down into the shot and everybody had to wait for a union guy to come fix it.” It is not, as people sometimes like to think “a union thing.” Sure, that does apply but it’s not the real reason. Who does what is thoroughly defined by long-standing practice for some very good reasons.

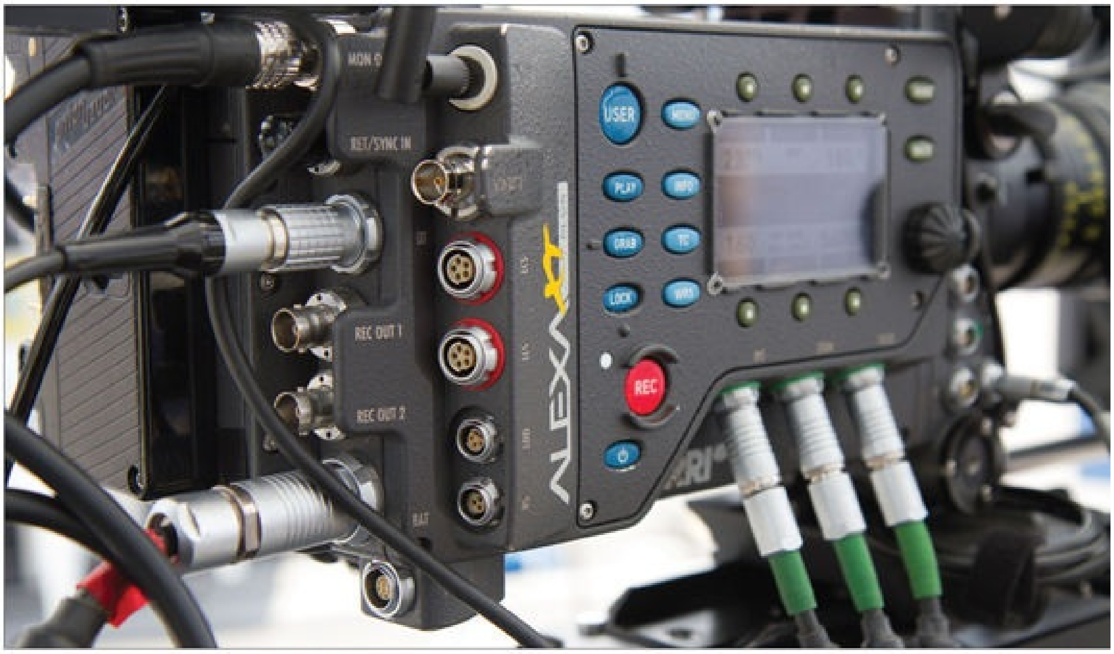


Figure 16.28. Keeping track of all the cables and making sure they are correctly plugged in is a big part of the camera assistant's job.

Figure 16.29. An excellent example ofwhy everyone needs to know who is responsible for what—the *Digital Loader* slides a media card into the camera. Not all productions can afford a *Loader* but on larger jobs they are essential—not only to avoid over-taxing the camera crew but also to make sure that the person handling the media is not distracted by other jobs. There is no more dangerous situation on a set than holding two media cards in your hand wondering "Which one is ready to go in the camera and be erased and which one has that very expensive stunt we just shot?"

First of them is safety. Let's take the rope example. Let's say it's the grip department that is responsible for that rope in this case. Suppose a camera assistant decides he's going to be a hero and yank on the rope to get it out of the way. What if it's tangled around some heavy object which then comes down on the main actor's head? Bad news.

In this case, the grips would have known what it was, would have known how to deal with it and also would have had the training to know that you ask the actors and crew to move off the set before dealing with anything over their heads. More importantly, the insurance company is not going to be very interested in your colorful and amusing story about how the wrong crew member pulled the rope!

Second, is the “we had to wait” part. Except in unusual circumstances, there will be a grip right near the set who can deal with it. If there is a delay, it’s usually going to be for a good reason, such as someone is bringing a ladder so it can be done safely.

Here’s another example: some C-stands are in the shot. The inexperienced, first-time director barks at a PA to “move those things.” The PA panics and moves them. It is unlikely that there won’t be a grip nearby to handle it, but let’s assume that there isn’t. Those C-stands were put there by the grips for a reason. Now, the grip comes back to the set and needs a C-stand quickly—where are they? He can’t find them and then he looks bad and worse, it causes a delay in getting the shot! To sum it up—every type of task is assigned to one crew and one crew only—because it creates an efficient and safe work environment. It’s just good common sense.

Art Adams puts it this way: “Be aware of your surroundings and never get in the way. One way to spot a crew person in the real world, for example, is that they never stand in doorways, because that’s one great way to prevent work from being done. Most crew, if they have nothing going on at the moment, will stand near the set, somewhere behind the camera, out of the way but close enough to hear what’s going on. They will always face the set, even if they are having a quiet conversation about sports or whatever, and they will break that conversation off as soon as they see if they are needed. This is not considered rude at all. As a rookie crew person, you should always have something to do.”

Figure 16.30. A properly done *MOS slate* (no audio recorded)—fingers between the clap sticks make it clear to the editor that there will be no sync mark. MOS is also circled at bottom right of the slate. Some assistants indicate MOS by keeping the slate closed, but this has the danger of being seen as a just a mistake; also it won’t work on timecode slates as they usually don’t run when the clappers are closed.

SET SAFETY

Safety on the set is no joke. Movie sets are, quite frankly, potentially dangerous places. People do get killed and seriously injured. Some general safety rules:

- Don’t run on the set—ever.
- Never stand on the top of a ladder or even the second rung down. Seriously, never. Never walk under a ladder.
- Production should always make sure fire extinguishers and first aid kits are available and easy to find.
- Be sure the name, phone # and location of the nearest hospital are on the *call sheet*.
- Don’t operate any piece of equipment unless you are the person who should be doing it.
- Wear your gloves.
- Don’t operate any piece of equipment you are not completely familiar with.
- Wear safe shoes—no sandals or open toes.
- Don’t do anything with electricity unless you are one of the electricians.
- The key grip is also the chief safety officer of the set.
- Stunt coordinator has responsibility for safety on stunts.
- Never leave anything on a ladder.

LIGHTING, ELECTRICAL, AND GRIP

- Nobody touches anything electrical except electricians!
- Excuse talent from the set before working overhead. Don’t let anyone stand under you when on a ladder or in the grid.
- Sandbags on all stands, both lighting and grip.
- Double, triple, or more bags on anything big or likely to catch the wind.
- Safety *tie-offs* on any stand or equipment that goes up very high, especially if it’s windy.
- Safety cables on all lights and anything overhead.
- Call out “going hot” before energizing any electrical run.
- Point a light away or block it from others before striking.

- Say “striking” before switching on any light.
- Know your knots!
- All electrical equipment should be properly grounded and checked by second electric.
- Wear gloves when operating lights, especially if they have been on recently.
- Communicate warnings when carrying anything heavy. Loudly say “points!” or “free dental work!”
- Wear eye protection at all times when called for.

Figure 16.31. *Tail slates* should only be used when absolutely necessary. Proper procedure is to put the slate in upside down at the end of the shot (before the camera cuts) and then turn it over and clap it. This is so the editor can read the numbers.

CRANE SAFETY

- Only qualified, experienced grips operate a crane, especially one that carries people!
- Never get on or off a crane until told it’s safe by the crane grip. Never.
- Wear your safety belt at all times on a crane.
- Never operate a crane anywhere near high-voltage electrical lines—this is a frequent cause of death on movie sets.

SLATING TECHNIQUE

At the time the AD calls “*roll camera*” and the AC announces “speed” (that the camera is up to *sync speed*), the Second holds the slate where it is in focus and readable and announces the scene and take number so that it will be recorded on the audio track (more on this later). She then says “marker” (so that the editor knows that the next sound they will hear is the clapper) and slaps the clapper stick down sharply so that the clap is clearly audible on the audio. She then quickly gets out of the way. In case adjustments are necessary, such as changing focus from the slate to the scene, the operator will call out “set” and the director can then call for “*action*.” Proper slating technique is essential; bad slating can cause the editor real problems, frequently problems that end up costing the producer more money—and you can guess how they feel about that.

Older slates could be written on with chalk. Most slates today are white plastic, and an erasable marker is used (Figure 16.30), or they are digital and the timecode and other information are displayed electronically (Figure 16.32). For erasable slates, the ACs frequently tape a makeup powder puff to the end of the erasable marker; that way they will be conveniently together in one piece for both marking and erasing. This is referred to as the *mouse*. You can also buy erasers that fit on the end of a slate marker, which is much more compact and efficient.

Figure 16.32. A timecode slate. (Photo courtesy E. Gustavo Petersen).

VERBAL SLATING

Whenever sound is being recorded you must also say the important information out loud as you slate—this is called verbal slating. An example would be “Scene 27, Take 3, marker,” and then you clap the slate. If it’s a new roll of film or new media in a digital camera, you should also say the roll number. After the initial slate, you don’t have to repeat it. If there are multiple cameras, add “A slate,” “B slate” as appropriate. Frequently, the

Try to update the take number immediately after slating. Become a master at removing the cap of your pen quietly during a take. This helps a lot in the event of a quick cut and restart.

Never take the slate away from the camera. If you hang it on your belt and walk away from the camera and it rolls you’re going to be embarrassed when the First AC yells for the slate and sound mixer records the verbal information, instead of the camera assistant.

> you have to run it over. If you step away from the camera, leave it behind so the first Ac can grab it if necessary.
>
> Art Adams

TAIL SLATE

In some cases, it is not possible to slate before the shot. In such instances, a *tail slate* can be used (Figure 16.31). A tail slate (called an *endboard* in the UK) comes at the end of the shot and must be done before the camera is switched off or it can't be used for synchronization. For tail slates, the slate is held upside down. Best practice is to hold it in upside down to show it is a tail slate and then turn it right side up so the editor can read the information on the slate. The clapper is still used, and a head ID should be shot as well, if feasible.

Tail slates should be avoided if at all possible. It is time consuming and expensive for the DIT, colorist, or editor to roll all the way to the end of the take, sync up, and then roll back to the beginning to lay the scene in. It is also very easy to forget at the end of the take and switch off the camera before the slate comes in. It is also important to note the tail slate on the camera report.

MOS SLATING

In the case of shooting without sync sound (*MOS*), everything is the same except that the clapper is not used. It may be necessary to open the clapper slightly on a timecode slate for the numbers to be visible, and running, but it is important not to clap it. If you do, the editor may spend time looking for an audio track that does not exist. Hold your fingers between the clap sticks so that it is very clear that no audio is being recorded as in Figure 16.30. Some ACs just keep the clappers closed to indicate MOS. Of course, it should written on the slate as well.

SLATING MULTIPLE CAMERAS

Running multiple cameras on a shot has become more common. Action scenes and stunts may have five or more cameras. In slating with multiple cameras, there may be a separate slate for each camera, clearly marked as A, B, or C slate (Figure 16.33). The slating AC then calls out "A marker" or "B marker" and claps the slate for that camera. An alternative is to use a *common marker*. This is possible where all cameras are aimed at approximately the same part of the scene or where one camera can quickly pan over to catch the slate, then pan back to the opening frame. If this is the case, then the director must wait for all operators to say “set” before calling action.

TIMECODE SLATES

Timecode slates include the usual information but also have a digital readout of the timecode that will match the timecode on the audio recorder; they are also called smart slates. Timecode slates make syncing up much quicker and cheaper and particular shots are more readily identified. The reason it is faster and cheaper in telecine is that the colorist rolls the film up to the frame that has the clapper sync on it, then reads the timecode numbers that are displayed and types them in. The computer-controlled audio playback deck then automatically rolls up to the correct point to lay in sync. Having the deck find it automatically is significantly faster than manually searching. If there is not sufficient *pre-roll* for the timecode on the audio tape or if the slate is unreadable, then this automation fails, and sync must be set up manually. The clapper is still used on timecode slates. When the clap stick is up, the timecode will be displayed as it is running. When the clapper is brought down, the timecode freezes, thus indicating the exact timecode at the time of slating.

Figure 16.33. Slating multiple cameras including a VFX shot.

JAMMING THE SLATE

Jamming the slate is for digital slates that display the timecode (Figure 16.32). The timecode on the slate must agree with the timecode on the audio recorder.

The timecode on the audio equipment is used as the master. The digital slate is plugged into the recorder with a special cable and the timecode signal is "jammed" into the slate. Some slates will display the words "Feed Me" when it is time to re-jam.

SLATING TECHNIQUES

- Always write legibly, large, and clearly on the slate.
- Make sure the slate is in the shot! A slate that is out of frame doesn't do anybody any good. Take notice of where the lens is pointed and hold the slate in that line.
- Try to hold it far at a distance so it nearly fills the frame, so it is readable! An unreadable slate is worthless. On a very tight shot, it's OK to roll the slate through the frame before clapping. The scene and take numbers are what's critical.
- If you have to be very far away, such as a crane shot, sometimes comically giant clapper sticks are used and there is no chance of slating the scene and take numbers.
- Hold the slate as steady as you can—a blurred slate can't be read by the editor (Figure 16.37). Don't start pulling the slate out while clapping—this will mean the exact moment of sync is blurred. Hold the slate steady for a brief moment after clapping the sticks. The main point is that the bottom doesn't move. If both parts of the slate are moving it's very difficult to tell when the hit happens, as the editor is looking for the precise frame where the slate closes and both parts are free of motion blur.
- It is good technique to tilt the slate slightly down to avoid reflections that will make it difficult to read.
- If the room is dark or you aren't able to get the slate into the lighting being used on the scene, then the practice is to illuminate the slate with a flashlight. If it doesn't cover the whole area, it's ok to move it back and forth, so it's readable.
- Once you slate, get out of the way! Taking too long to get out of the way is annoying to the director, the actors, and the operator. Have a place picked out to go to—an "escape route." Remember that you will need to get there quickly and then stand there making no noise to the end of the take.
- Don't wander off with the slate. If the First needs you do something,

make sure the slate stays right with the camera so whoever is going to slate doesn't have to look for it. There is a slot at the bottom of the front box for the slate and that's the best place to keep it (Figure 16.17).

- On the first slate of a scene, you call out "Scene 27, take 1" (or whatever the scene number is). For the rest of the scene, you only need to call "take 2" or "take 3," and so on. You call out "roll number xx" only when roll/media is changed. In the English system call out the slate number, but don't say "slate," as in "376 take 3." We'll cover this system later.
- Always coordinate the correct slate numbers with scripty. The script coordinator is the authority on what the slate numbers should be.
- If the audio mixer has pre-slated the audio with the small mic on the mixer, then you may not need to call out the slate numbers, but be sure to check this out first by talking to the mixer and clearing it with the First AC.
- Right before you clap the sticks, say "marker." This will help the editor identify what sound is the actual sync mark and not just some random noise on the set.
- If, for some reason, the first clap isn't valid (maybe the camera wasn't rolling), the First AC may call for "second sticks." The clapper then says "*second sticks*" and claps it again. The reason to say this is that there are now possibly two claps on the sound track and the editor may have trouble figuring out which one is the real sync marker.
- Don't put the slate in front of the camera until the First AD calls "roll sound" or "rolling." It varies—make an effort to learn how your DP, Operator, and First AC likes to do it. Putting a slate in blocks the operator's view and can be very annoying if they are not ready and still checking something in the frame. Sometimes the Operator will call for "slate in" but you should have already been there.
- When calling out the numbers, speak loudly enough that it can be understood on the sound track but don't shout. The boom operator may swing the microphone in to record you and the sync clap of the sticks, but that isn't always possible. Turning your head toward the mic helps.
- Make sure that the slate is already in the frame when the camera begins rolling. Digital cameras use the first image as a *thumbnail* and this will make the editor's job of finding circle takes much easier. Things that make the editor happy are good for your reputation in the long run!

- Snap the sticks together smartly but not too loudly if you are close to the actors. If the shot requires you to hold the slate close to the actor’s face, clap the sticks gently! A loud noise is disturbing to the actor at the moment they are most concentrated. Say “soft sticks” so the editor will know.
- Update the slate numbers right away. The director may call cut sooner than expected and need to “go again” right away. It also prevents forgetting to update the numbers.
- While camera is rolling (“picture is up”) you can update your camera reports and erase the take number to be ready for the next take—as long as you can do it quietly and not distract the actors.
- Sometimes circumstances don’t permit slating at the beginning of a shot; when it’s done at the end of the take, it’s called a *tail slate* (Figure 16.31). When doing a tail slate, clap it upside down, then quickly turn it right side up so the editor doesn’t have to stand on her head to read it! Be sure to call out “tail slate” when you do it. Only do tail slates when necessary as they make more work for the editor.
- For MOS shots (no audio) be sure to hold your fingers between the clap sticks (Figure 16.30). Some prefer to hold the sticks closed all the time to signify an MOS shot, but fingers between the sticks is unmistakable. The slate should also say “MOS.”
- For multi-camera shoots, you may need to slate each camera separately, but the sync clap has to be common for all of them, although sometimes separate claps are made for each camera—that’s up to the editor and audio mixer to call. Cameras should slate in order: A camera, then B camera, *etc.*
- Multiple camera work is done differently in film and digital. When shooting film you would roll a few seconds of the slate on each camera (*bumping* a slate), then at the beginning of the take you would call “*A & B common mark*.”
- Most Second ACs attach their blank camera report forms to the back of the slate with a piece of tape. Some take shorthand notes and write up the reports separately.

Figure 16.34. A timecode app for smartphones; in this case MovieSlate.

Figure 16.35. An *insert slate* is used for situations where a normal slate would be difficult to fit in. You can turn a normal slate into an insert slate by writing the scene and take in the take box with a slash between them, such as 36A/1.

WHAT TO WRITE ON THE SLATE

Production name, *director*, *DP*, *camera name*, and *date* are self-explanatory. *Roll number* in film is changed whenever a new mag (film magazine) is put up; same for digital media. *Day* or *Night* should be indicated as well as whether the shot is *Sync* with audio recorded or

When shooting digital, the slate should always be in frame when the camera rolls as the first frame of the take ends up being the thumbnail in the editing software. That makes it easy for the editor to find a take. Always think about how to make things easy for the next person down the line who will be working with footage that you help create.

Art Adams

Of course, we use scene and roll/card number we just don't waste time repeating a long litany of all the info every take of the same roll/card scene every clap. It is a long winded waste of time. If everything is the same, just say the take # and go! As far as camera notes yes, lens height, lens, filter, time of day, stop—all of it.

Gerard Brigante, SO

MOS with no audio

being recorded—this is important so the editors don't waste time looking for audio that doesn't exist. *Scene Number* and *Take Number* require a bit more explanation and are treated differently in various parts of the world, so we'll talk about them in more detail. Most camera assistants skip the letter "I" when slating and it is too easily mistaken for the number 1. Often, the letters "O," "Y," and "Z" are not used as they are too easily mistaken for numbers. The script supervisor has the last word on slate numbering as it must be coordinated with what is going in the *script notes*. The most important rule of writing on the slate? Never spell the DP or director's names wrong!

WHEN TO CHANGE THE LETTER

In the "American style" of slating, the scene designation is a combination of a number and a letter. The number is the scene number as it appears in the script. So, when starting a brand new scene, you simply write just the scene number and it stands on its own, such as 27, for example. Whenever a new shot is set up—usually when the camera changes position or changes lenses—you add a letter: 27A, for instance. The bottom line is this: if it's a new camera *setup*, you have to change the letter. What is a new setup for slating purposes? It's when the shot changes. Most often this is when the camera moves, but it might also be a change of lens for a *punch-in* (closer shot from the same camera position) or something like changing the frame rate or going to handheld even though it's the exact same shot otherwise. For the editor, these are most definitely different shots and need to be cataloged in a way that the assistant editor can easily find them and know what they are. What happens if you go all the way through the alphabet? You double-up on the letters (27AA, etc.). All of these changes must be noted on the *script notes* and also in the *camera report*.

Figure 16.36. A European or English style slate uses *Slate Number* instead of *Scene Number*. The *Continuity Supervisor* keeps track of what Slate Number equates to each Scene Number in the script. It is also roll number 122 on camera A. (Photo courtesy Ben Ramsden).

TAKE

Each time the same shot is repeated and the camera cuts, it is considered a *Take*. When it is a new setup (changing the letter after the scene number) or new scene (changing the scene number), you start over again with Take 1. Don't re-slate another take if the camera doesn't cut because, technically, it is still on the same take. The exception will be if you're told to re-slate it while keeping the camera rolling. If the director wants to do many repetitions of the show without cutting, this is usually slated as "series" (or "ser") indicating that there is more than one take. Even "blown" takes that are cut early because of problems should be properly numbered. Don't re-slate the same take for any reason. It's much easier to just change to the next number.

> [In the UK], we never call scene numbers unless specifically requested to do so by the scripty. Most of the time if a pickup warrants a new slate # (i.e. a setup change) then it's going to be an 'added shot' rather than a pickup.
>
> Stu McOmie, UK Camera Assistant

THE EUROPEAN SYSTEM OF SLATING

In the European system (sometimes called English style) of slating (Figure 16.36), the slate number serves the same function as the letter which denotes each new shot in the scene in the "American" system. The slate number alone doesn't relate to the script without some other documentation. Or sometimes a scene number is written on the slate such as—Scene 27, Slate 18, Take 1, 2, 3. Australian cinematographer John Brawley says this about how it's done Down Under—"In Australia we tend to use 'consecutive' slating or sometimes called 'European' slating as opposed to 'American' slating. We increment the shot number and usually in episodic TV it starts again from one with a new block. Also on the slate is the scene number and take number of course. The loader for each camera calls the slate, or common slates where possible. The call is only the shot number and the take number, not scene number.

Figure 16.37. A common slating mistake—pulling the slate out while also clapping the sticks. This results in blurred frames that make it difficult or impossible for the editor to read the numbers or see the frame where the sticks come together. See the slating video on the website for more examples of slating mistakes, as well as video of proper slating procedure.

Pickups are often new slate numbers or an extra take number with *PU* added to the take count depending the on the script supervisor's preference. You can generally work out how many setups you're getting through for a day.

"Second unit, splinter unit or VFX units get an extra letter code at the head of the slate number. This system's main advantage is that it allows for the crew to gamble on trying to guess the final shot number of a show. We do American slating with scene numbers and letter codes for each setup when Americans are in town. Mostly editorial and script supervisors seem to prefer consecutive numbers but none can ever say why."

PICKUPS, SERIES, AND RESHOOTS

There are a few other designations that will show up on slates. As with the primary markings, they will vary from region to region and from production to production. Of course, the most important thing is to keep the procedures and numbering system consistent throughout an entire production.

PICKUPS

There are two kinds of *pickups*. One of them is when you shoot only a specific part of a scene, such as if they only need the actor to do the last line again. When slating a pickup shot write “P/U” or “PU” next to the take number. This lets the editor know that this particular take was a pickup and not to panic if the rest of the scene is “missing” from the footage. The other kind of pickup occurs after principal photography is finished. This is when a skeleton crew goes out and does a few additional shots that the editor may need on what are called *pickup days*.

Figure 16.38. An assistant holds a Datacolor *SpyderCheckr* color reference and MOS slate at the head of the roll. (Photo courtesy E. Gustavo Petersen).

SERIES

Sometimes the director will call for “shoot it as a series.” This means that there will be several takes in a row without cutting. In this case, ACs will write “ser” or “series” after the take number on the slate and also say it when slating —“Scene 28D, series.” Don’t worry about reslating during a series, just be sure it’s in the camera notes, just as the script supervisor will note it in the script notes.

RESHOOTS

A *reshoot* is when the crew has to go back to a scene that was previously finished. It can be on the same day, or several months down the road. The problem reshoots pose to slating is that you are technically shooting the same scene as before—so do you continue slating at the last remaining take? That would make sense, but is impractical if you revisit a scene several weeks or months later when you might not know what the last take of each shot was. The more elegant solution is to put an “R” in front of whatever shots are being redone. So say you are reshooting Scene 27A, it now becomes Scene R27A.

SECOND UNIT

If additional shots are needed that don’t involve the principal actors, a *second unit* is often employed. They might do simple scenes such as establishing shots, sunsets, cars driving on the road, or more complex scenes such as car chases, explosions, or major stunts, in which case the second unit crew might be nearly as large as the main unit crew. Some productions may also have a *splinter unit*. Usually an “X” is written in front of the roll number on the slate and in the script notes and camera reports.

Figure 16.39. A well-organized location shoot—the trucks are at the right side of the photo, the generator is at far right, as far as possible from the set to reduce noise problems. At center is a protective cover for the camera carts; grip equipment carts are lower right. Lower left is the most important part of any working set—the *craft services* table (snacks and coffee)!

VFX

For visual effects shots, be sure to add a label for "VFX" or "Plate VFX" on the slate. A *plate* is a clean shot with no actors or action—it is to be used as the background for computer effects or a greenscreen/bluescreen foreground to be added later. Some other types of shots are also done specifically for visual effects and should also be slated appropriately—see Figure 16.33 for an example of this being done on a *Terminator* film. Since these shots will be handled by a separate facility, it's a good idea for the VFX or postproduction supervisor, the script supervisor, and the First AC to agree on a naming format for these shots.

BUMPING A SLATE

If you are working on a film shoot as the clapper on a set and the First AC says to you "bump a slate" what does that mean? "Bumping" means shooting a short burst of the slate to just record the date, Roll #, and Scene # before shooting. It doesn't involve syncing as it's not with the scene and so no clapper is used. On film, it will show up in the dailies just before the rest of the takes for that scene, so it serves to identify the following footage. This only works when shooting film as digital makes a new file every time the camera rolls.

INSERT SLATES

Sometimes the camera needs to be very close to the subject, such as a tight insert of a pen on a desk. In these cases, normal size slate just won't fit into the shot. In these cases, we use an insert slate, which is a very small slate with no clappers (Figure 16.25). If you do need a sync mark with an insert slate, the most commonly used solution is to hold the slate still then gently tap it on something in the frame—the tapping sound serves as the sync mark. You can use a regular slate for this by writing the scene and take number in the "take" slot; such as "36A/5."

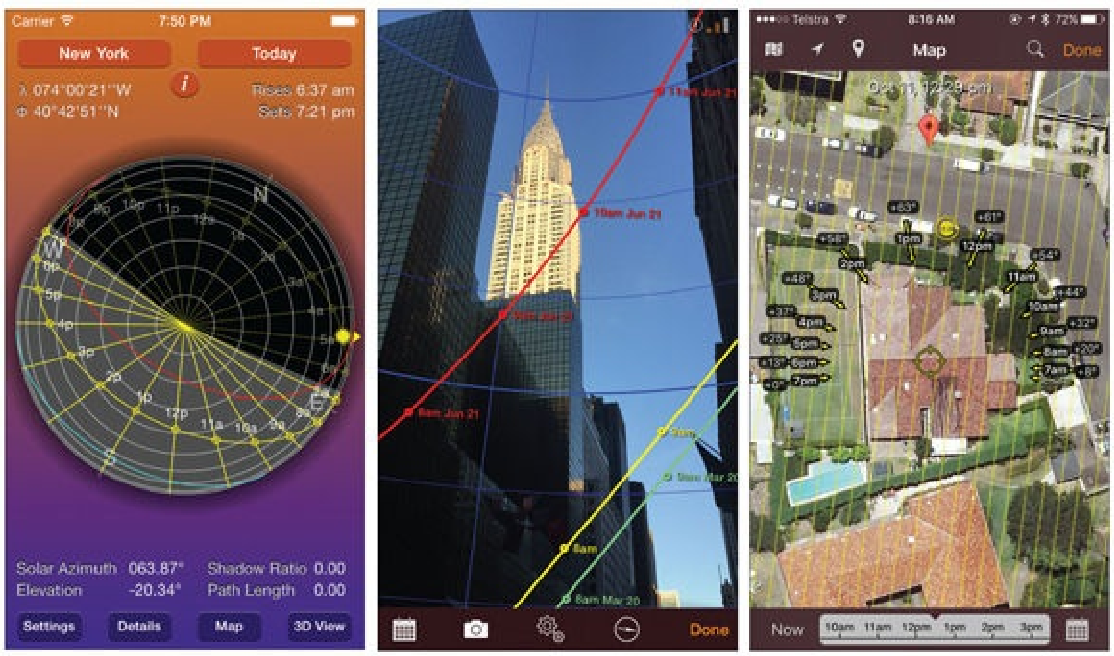


Figure 16.40. *Sun Seeker* software in *Flat* mode (left), *Augmented Reality* (middle). and *Map* mode (right).

FINDING THE SUN

For all day exterior shooting, it is important to know where the sun is going to be at any given time. It influences when you might want to schedule certain shots, when the sun might go behind a mountain, *etc*. On some productions, it might even be useful to know where the shadows will fall when you're going to be on location a month from now, or when the sun will be coming through the windows of a building you are scouting. Often, it is important to determine these things at the time of scouting the location and scheduling the shoot day, so you'll need to know them in time to work with the AD as they are doing the scheduling.

This is particularly true for sunset/sunrise and *magic hour* shots, where timing is crucial. With sunrise shots, you need to know where the sun is going to come up before you can see it. Here the problem is that many operators look at the glow on the horizon and figure that's where the sun will pop up—they are forgetting that the sun is traveling at an angle.

This makes accurate sun path prediction critical. Several smartphone or pad apps are available that make this much easier. One of the best is *Sun Seeker* by Graham Dawson. It has three modes (Figure 16.40), *Flat* mode (left) shows a compass view with the sun's position throughout the day, including an indicator of where it is now. *Augmented Reality* mode (center) uses your smartphone's GPS and camera to allow you to point the phone in any direction and see the sun's path overlaid on top of the camera image. It will also tell you, of course, exactly where the sun will be, by drawing the sun's path hour by hour and laying it over the phone or tablet camera's live image. It can also be invaluable if you're scouting the location at night or on a cloudy day.

Map mode (right) shows an overhead photograph of your location with indicators showing the angle of the sun at different times of the day. A slider at the bottom allows you to move ahead in time to select the day, month, and time you'll be shooting.

Figure 17.1. The importance of proper labeling and an organized work station cannot be overemphasized. (Photo courtesy Sean Sweeney).

data management

DATA MANAGEMENT

In principle, data management sounds simple: you download the camera media, put it on a hard drive, and back it up. In reality, it is a process fraught with danger and chances to mess up badly. Handling the recorded media is an enormous responsibility; a single click can erase an entire day's shooting!

The film industry has spent decades developing methodical and careful processes regarding the handling of exposed film stock: *loaders* (the member of the camera crew who loads the film mags with raw stock and then downloads the exposed footage) are trained in standard methods and procedures; they keep extensive standardized paperwork and prepare the film in a prescribed way for delivery to the film lab, which in turn keeps a thorough paper trail of every roll of film. On a video shoot, the person doing this may be called the loader, the data manager, media manager, or data wrangler. With digital video, in some ways, the job is made more difficult by the fact that we are dealing entirely with computer files. Since they are invisible, keeping track of them and what is on what digital media calls for careful labeling and systematic organization.

BASIC PRINCIPLES

Certain core principles apply when handling digital media:

- Cover your rear.
- Have a standard procedure and be methodical.
- Maintain all logs.

Let's talk about these in detail.

COVER YOUR REAR

When everything is going OK, people rarely even notice what the loader is doing; it seems routine and automatic. When something does go wrong, the entire production can turn into a blame machine. You don't want to be the person who ends up bearing responsibility for a major disaster. The most important protection against this is, of course, to not screw up, but it is also important to be able to demonstrate that it wasn't you. Film camera assistants have a long standing tradition of immediately and unreservedly owning up to mistakes they make: DPs, ADs, and directors respect them for this. However, if it really wasn't you that messed up, you need to have the procedures and paperwork to show it.

Some people interpret this rule as just being "avoid blame." That's not the point at all. The real issue is make sure nothing goes wrong so that there is no blame to go around. Protect the production from mistakes and you'll be hired again and recommended to others. If you do screw up but immediately own up to it, the DP and production will still know that you are someone who can be trusted as part of the production process: mistakes happen—the point is to fix them and prevent them from happening again.

STANDARD PROCEDURES

As camera assistants have learned over the decades, the number one way to ensure against mistakes is to have a methodical and organized way of doing things and *then do it the same way every time*. Observe any good crew of camera assistants working: there is almost a ritualistic aura to the way they work. They are also very focused and attentive to every detail at all times. Their repetitive actions are practiced and reliable. Their procedures are standardized industry-wide.

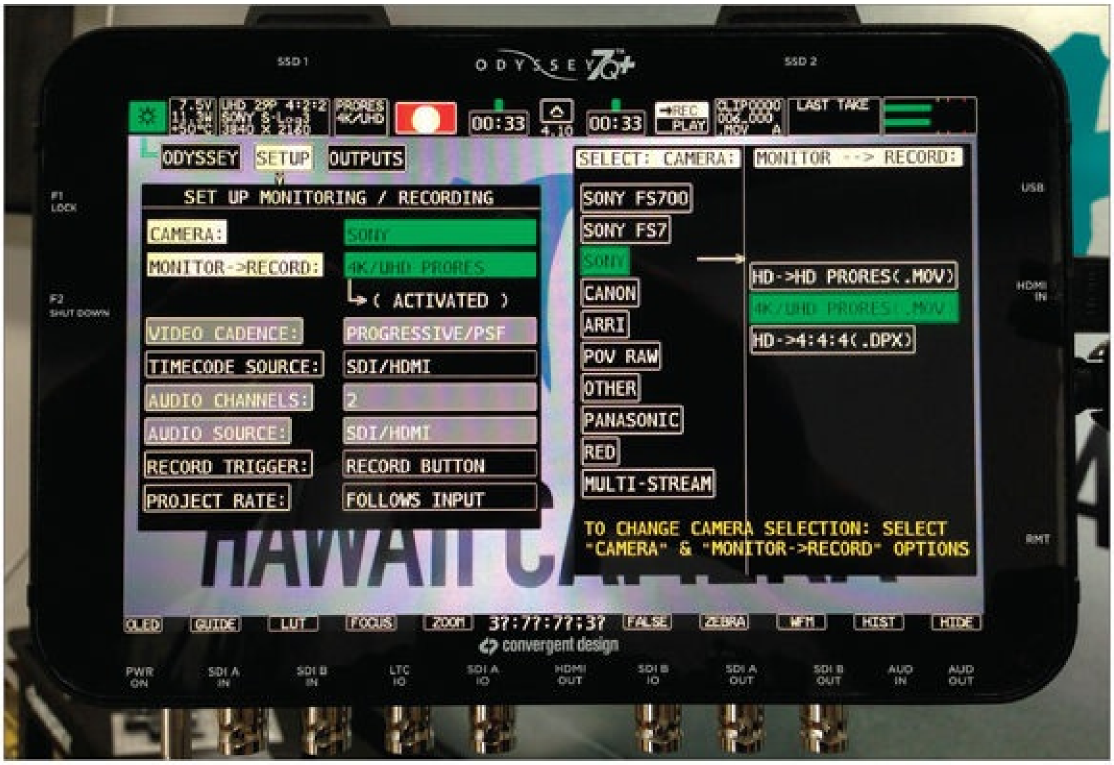


Figure 17.2. The menu selections on an *Odyssey 7Q+* by Convergent Design, a combination monitor and HD recorder. Detachable SSDs can record up to several hours of Apple ProRes HD as well as 4K and RAW+DPX. (Photo courtesy of Josh at Hawaii Camera Crew).

MAINTAIN YOUR LOGS

Film camera assistants have quite a few forms that need to be filled out and kept up to date: camera reports, film stock inventories, camera logs, and so on. In the digital world, we are lucky that a good deal of this work is done by the camera and the various software applications we use immediately after the camera. Most downloading apps (such as *ShotPut Pro*, *Silverstack*, *Double Data* and others) also create logs that can track the files. Many loaders also maintain separate logs either handwritten or more commonly as spreadsheets (Figure 17.5).

PROCEDURE—BEST PRACTICES

By far the biggest danger is accidently erasing data which has no backup—this fear hangs over any operation where media is handled. Practices vary between different data managers and may be adapted or changed for various productions if the producer or insurance company requires certain procedures but they all have one basic goal: ensuring the safety of recorded data by clearly marking what media is empty and what media has recorded data on it.

One fundamental principle is that there should be one and one only person on the set who is allowed to format the media. This addresses the most basic of all dangers in digital workflow—being absolutely and unfailingly sure that the data has been downloaded and backed up and so it is safe to format. You certainly don't want to have conversations on set like "Is this ready to format? I thought Danny already did that." There is no room for uncertainty. Designating one person to be responsible for formatting helps keep this under control. It is not the entire solution of course; a rigid adherence to a standardized procedure is necessary also, just as camera assistants have always done.

Figure 17.3. At first glance, this may look like a DIT cart but in fact, it is a *Loader station* for downloading and logging exposed footage. (Photo by Keith Mottram).

LOCKED AND LOADED

One typical method is for the second AC to remove the media (whether SSD or card) from the camera and immediately engaging the *record lock* tab (if there is one). It is delivered to the DIT or data manager locked. After downloading, it is returned to the AC with the record lock still engaged. This way *only* the AC (the designated formatter, in this case) is authorized to disengage the lock, put the media back in the camera and format the card. This is one method only and different DITs and camera crews will have their own way of doing this.

Naturally there are variations on this procedure, such as when the camera crew doesn't want to take the time to format media. This varies by the type of camera you are using. For example, it is very quick and simple to format a drive with the Alexa; on the other hand, formatting media for the Phantom takes quite a bit of time. What is important about this process is not so much who does it as it is that it be an established procedure understood by everyone on the crew and that it be religiously observed at all times. Remember the basic religion of being a camera assistant: establish procedures and do it the same way every time—be methodical!

One method is this: if cards are formatted in the camera there should be some indication that they are ready. For example, most camera assistants on commercials will write the roll number on a piece of red tape, and when the card comes out of the camera the piece of tape is placed on the card across the contacts, so it can't be inserted into the camera. If the tape is removed, this indicates that it has been backed up and can be reformatted. It falls on the data manager to remove that tape.

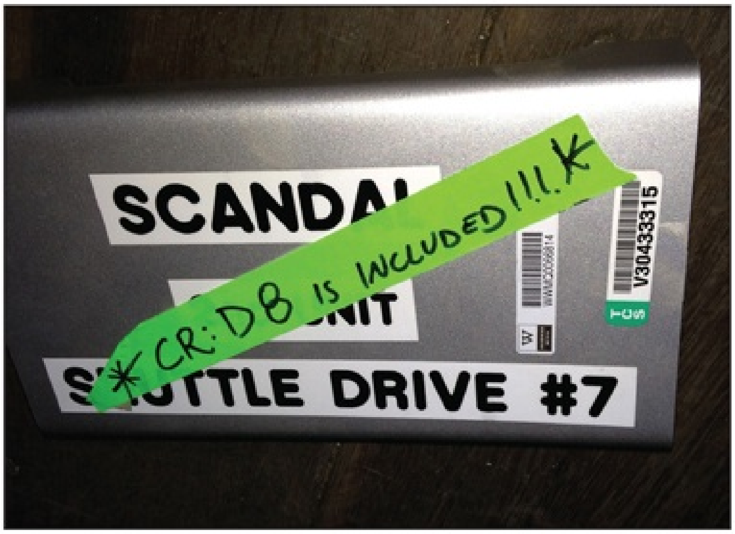


Figure 17.4. A shuttle drive for a TV show. Labeling is critical in data management. (Courtesy Evan Nesbit).

GET YOUR SIGNALS STRAIGHT

Without a doubt, the greatest fear is that someone might erase/format a card or hard drive that has footage on it that has not been stored elsewhere. There is no DIT, loader, or camera assistant on earth that has not had this nightmare. The protection, as always, is to develop procedures, make sure the whole crew knows what they are and then stick to them. Is this card ready for formatting? There are many systems but perhaps the most reliable is to use paper tape, always available as the Second AC carries several colors of 1” paper tape. Typically, green means “It’s OK to format.” Also, say something like “This drive is ready for formatting.” Red tape means “Not Ready for format.” Keep the red tape on it until you are absolutely sure it is finished and you have two tested backups.

Use paper tape for marking cards and SSDs, not camera tape or gaffer tape. Camera tape can leave a sticky gum residue on the media and who wants to put that into a camera? There are no hard and fast rules; it is whatever the crew agrees on. The important thing is consistency and communication. Many people make it a practice to not only mark the cards but to add a verbal signal as well, such as “these cards are ready for formatting.” Always putting them in a consistent

We usually have a pouch/bag that stays by camera with two colour-coded compartments—Green for mags that are ready to be used, and Red for ‘hot’ mags… if a

> take runs long and you've got to quickly reload it reflects better on the camera crew if you can do it immediately rather than having to run to the DIT cart.
>
> Stu McOmie, UK Camera Assistant

location is important too. This might mean a small box on the DIT cart or something similar.

ALWAYS SCRUB

Make it a habit to always *scrub through* (preview) the footage, even if only at high speed. A visual check is the only way to be certain the footage is good. You can also be watching for other problemst—if you catch something no one else noticed, be sure to let them know. It is always best for a production to know about problems right away, when a reshoot is not a huge problem, as it will become once they have wrapped that location or set.

Download>Scrub to check>Mark as ready for format.

Do not scrub through the original media. This has two potential problems: one, having done that, you may think that you have downloaded the footage and two, it is what really gets downloaded to the hard drives that matters.

	A	B	C	D	E	F	G	H	I
1	Production Name: The End Is Near!								1/1/16
2	Producer:			Director:			DIT:		
3	Alexander Bigbux			Alan Smithee			D. Everest		
4									
5	Camera	Reel	Backup 1	Backup 2	Size (GB)	Dailies	Clip Qty	Scene #	Card #
6	A	01	drive-001	drive-002	12.3	x	6	1,1a,1b	1
7	B	B01	drive-001	drive-002	12.1	x	5	1,1a,1b	3
8	A	02	drive-001	drive-002	9.4	x	6	2, 2a, 2b	4
9	A	02	drive-001	drive-002	28.6	x	12	2,2a,2b	2
10	TOTALS				62.4		29		

	A	B	C	D	E	F
1	Production Name: The End Is Near!				Memory Card/SSD Report	
2	Producer:			Director:	DIT:	
3	Alexander Bigbux			Alan Smithee	D. Everest	
4						
5	Card Label#	Type	Capacity	Manufacturer	Serial # (If Available)	Notes
6	01	RED	128gb	RED	ABC-123	Damaged
7	02	RED	64gb	RED	ABC-234	OK
8	03	CF	16gb	Sandisk	N/A	OK

Figure 17.5. A downloadable *DIT Log* and *Camera Media* report in Excel form from *Fallen Empire Digital Production Services*.

THREE DRIVES

Most DITs consider three copies of the footage to be a minimum. Hard drives die; files get corrupted. Backups are your only protection. Hard drives that are used to transfer the footage to post, archives, or the production company are called *shuttle drives* (Figure 17.4). As an example, the three storage hard drives might be:

- One for the editor.
- One backup for the client/producer.
- One backup for you (so you can be the hero when something bad happens).

An alternate process might be:

- All files on the DIT's RAID drives.
- A shuttle drive of all files delivered to the producer.
- A shuttle drive of all files delivered to the post house.

The VFX people may also need files delivered separately—they may also need them *transcoded* differently. Obviously, the DIT can erase all drives on the DIT cart once the shuttle drives have been delivered to the producer/post house and checked, but many DITs prefer to keep the files live on their hard drives as long as possible (meaning until the next job) just as an emergency backup. To be prudent, production and the post house should also make backups of all files as soon as they are received; it's just common sense. Archiving to *LTO tapes* as soon as possible is a sensible method of protecting against unforeseen disasters. We'll talk about LTO tapes in a moment.

Some productions do not allow the media to be erased until it has been confirmed by the post house; often this is a requirement of the insurance company. Some insurance companies will not give clearance to format the media until it has been transferred to LTO tape and stored in a vault. Obviously, this requirement has a big effect on the amount of media (SSD drives, Phantom mags, compact flash, SxS cards, and so on) that need to be ordered and also has meaning for the planning of the DIT/post workflow. This again points to the

> Assuming you're using the usual software it'll be doing checks in the background, but I like to manually look at the checksum before scrubbing. I'd also always watch a few seconds (of action!) in realtime… I've been in a few situaltions with issues I wouldn't have spotted by just scrubbing alone—including one with where I wasn't listened to, and it resulted in a week of reshoots six months later!
>
> Stu McOmie

importance of having a preproduction planning meeting which gets all of the parties together to work out the details of how it's going to be done. Since downloading drives takes time, some DITs request that they get the media before it is filled up completely. Some crews make it a practice to only fill up drives half way for this reason.

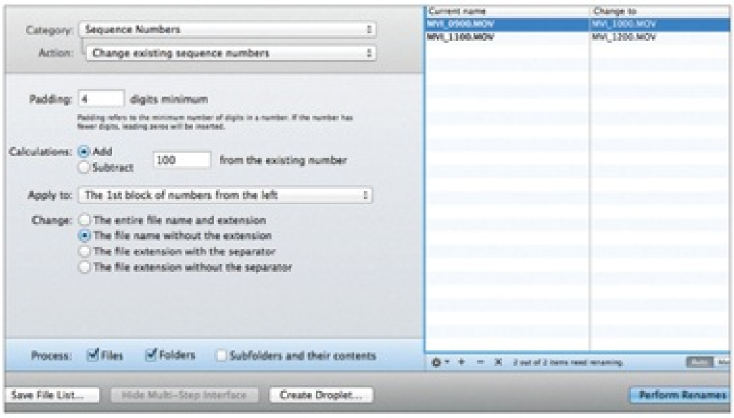


Figure 17.6. Proper naming of files is critical. The application *A Better File Renamer* partially automates this process.

DO NOR DRAG AND DROP

One principle that is universal no matter what procedures are in play: never "drag and drop." Anyone who uses computers is familiar with the idea of grabbing a folder or file with the mouse and dragging it to a new location. It's simple enough but for a couple of reasons, it is to be avoided with video files. Some cameras produce video files that are far more complex than just "file.one, file.two," *etc.* There are often associated files in addition to the video clips. It also does not do *redundancy checks* as does software designed for this purpose.

Logs

Logs are something you normally don't think about much, but they can be very important. Most file copy applications can generate logs which record every detail of the copy and backup process. Some logs can be remarkably verbose, recording details that you might think you'll never need; however, it is this thoroughness that may save your career some day. These are the kinds of things that really differentiate the professional from the wannabe.

Logs usually only come into play when there is a corrupted or lost file; when this happens, it can often turn into a blame game and for a DIT or loader to lamely say "I'm pretty sure I copied that file," just isn't good enough—the log is your backup and paper trail. In a professional situation, it is critical to have the software generate logs and that you keep them or to make your own. To have the download software do it usually involves a selection in the preferences section of any application, you need to select that the software will generate the logs and that you keep track of what folder they are kept in. You'll want to backup this folder and in many cases, provide copies of the logs to the editor, the producer or even the insurance company. Beyond the computer files downloading software generates, most DITs and loaders maintain separate logs of all operations, either handwritten or on a computer or tablet, as in Figure 17.5.

FILE MANAGEMENT

Download everything—this is crucial; so make sure you have plenty of hard drive space at the start of the shoot (see the hard drive storage calculators elsewhere in this chapter). Picking clips can be dangerous unless you have a specific plan or instructions to dump rejects—in general, it's a very dangerous idea. Retain file structure! Don't change file names or locations, particularly with .r3d (Red) files. Notes can be kept in "Read Me" text files, which are easy to keep right with the files on hard drives.

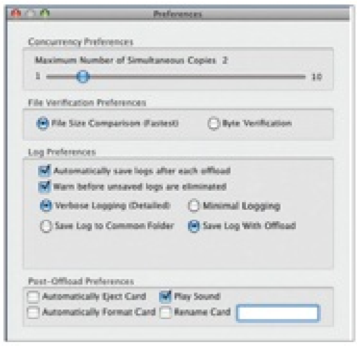


Figure 17.7. Selectable options for *ShotPut Pro*.

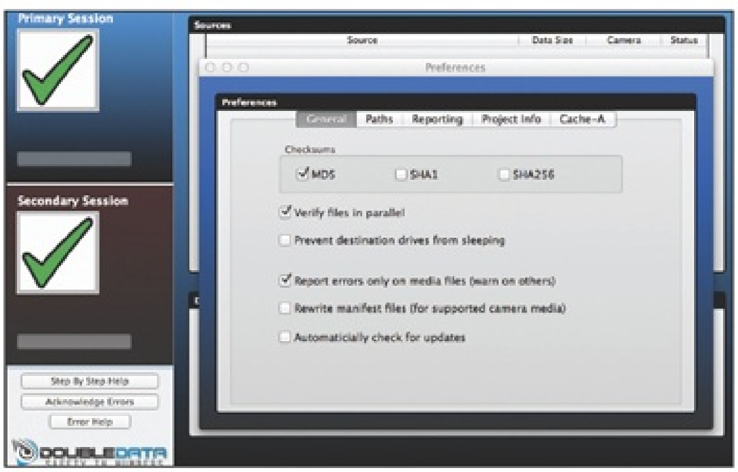


Figure 17.8. *Double Data* takes a different approach to data ingest. It is designed to manage your data all the way through the process.

FILE NAMING

It is crucial to establish a consistent file naming convention for every project. The cameras themselves generate file names that are orderly and useful. In the end, the editor is likely to have the final say on file naming as they are the ones who have to deal with the long-term consequences of how the files are named and organized. Again, this shows the importance of that preproduction meeting, phone calls, or exchange of emails—the editor and VFX people need to be part of that conversation. See Figure 17.6.

DOWNLOAD/INGEST SOFTWARE

There are several software applications specifically for downloading and backing up video/audio files within the specific needs of handling data on the set. In some cases, they can also transcode the files. All of these applications offer safeties, such *cyclic redundancy check* (*CRC*), an error-detecting code that detects accidental changes in raw data. They also offer a range of choices for these checks. Most also allow naming of reels/mags and automatically incrementing those numbers with each download. Some DITs use scripts in Apple's *Terminal* to handle download tasks. For more on error detection, file structure, and protecting data, see *The Filmmaker's Guide to Digital Imaging* by the same author.

SHOTPUT PRO

This application is widely used for downloading recorded media on the set (Figure 17.7). It is specifically designed for this purpose and offers all the options a loader or DIT will normally need: multiple copies to different hard drives, logs, and several different methods of file verification. Versions are available for both Mac and Windows operating systems. The company describes it like this: "ShotPut Pro is an automated copy utility application for HD video and photo files. ShotPut Pro is the industry de-facto standard offloading application for professionals. The simple user interface and robust copy speeds make it indispensable for today's tapeless HD workflows."

SILVERSTACK

Pomfort's Silverstack performs media download but also quite a bit more (Figure 17.9). Silverstack can ingest all camera media types and all file formats. It can do checksum-verified, high-speed backup to multiple destinations. According to Pomfort, "Ingesting source material and creating backups of media from a digital film camera is a repetitive, but responsible task. This process just got a whole lot easier, faster and more secure thanks to Silverstack's accelerated copy feature. Combining the parallel ability to read, verify and write in one operation and leveraging the full bandwidth of your hardware allows you to copy a large number of files conveniently and securely."

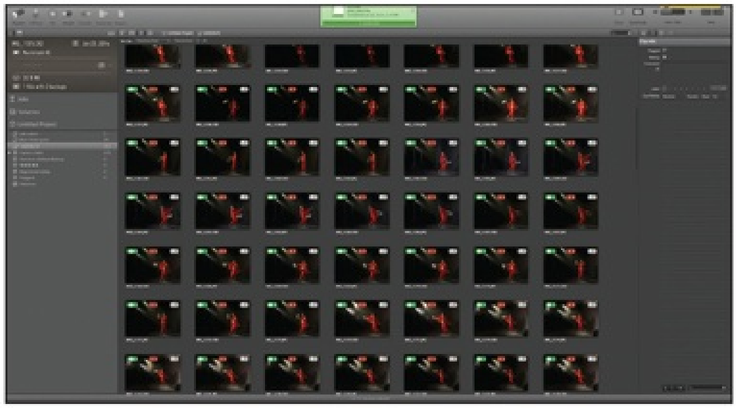


Figure 17.9. Pomfort's *Silverstack* offers a wide variety of features in addition to ingest: a clip library, transcoding, native playback, metadata search, user metadata and even clipping warnings and focus assist for help when viewing on small screens. It also generates reports as XML, HTML, or PDF as well as *Final Cut Pro XML* files.

Additionally, Silverstack has a full featured clip library and can do transcoding/export, QC (quality control), and native playback (for certain cameras). Finally, it can output customized reports for production and postproduction.

DOUBLE DATA

Originating as *R3D Data Manager* and its companion *Al3xa Data Manager, Double Data* (which combines the two) approaches data management with a definite philosophy (Figure 17.8). In addition to standard copying with verification, it is capable of what the company calls *Automatic Multiple Sessions Management* which they describe like this: "Double Data takes a different approach to on-set and post data management than other software. The idea is that your workflow involves, or can be split up into, phases. The first phase would be to get your shots off the original camera media to a high-speed RAID or similar device. From there you will copy to slower speed destinations for redundant copies or shuttle/transfer drives.

"Double Data has two 'sessions,' the idea being that you will quickly offload files in the first session to a primary RAID, then in the second session copy from that primary RAID to other slower destinations. Double Data will keep track of where each camera media is in the process and automate your sequential backups for best performance, for example only copying things in the second session when the first is standing by. Of course, if you would rather just copy to all your destinations at once without using the second session, that is also possible to do. Double Data can write a single camera media to four destinations simultaneously.”

PROPRIETARY DATA MANAGEMENT SOFTWARE

All camera companies make some sort of file transfer software for the types of media their cameras use, and they make this software available for free download. Arri, Sony, Red, Canon, Panasonic, Blackmagic, and others have software applications with various capabilities. Some are basic data management and some, such as *RedCineX Pro*, have color correction and transcoding as well.

Figure 17.10. An iPhone based calculator for video storage requirements; there are many available. Running out of hard drives is as unforgiveable in the digital age as it was to run out of raw stock when shooting film.

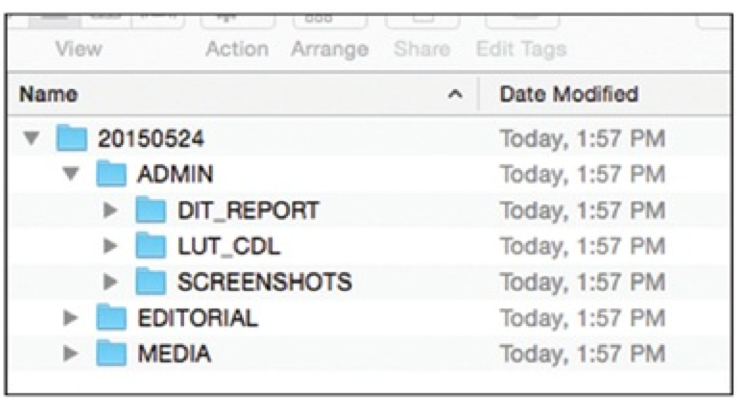


Figure 17.11. The free app *DIT Folder Structure* automatically generates the proper folders for data management.

EXTERNAL RECORDERS

Most cameras are engineered to record clips internally, although not all of them will record their full resolution in RAW form internally. The original Red, for example, recorded onto *Compact Flash* cards. Sony cameras have long used *SxS cards* (pronounced "S by S"). Resolution and frame rates sometimes exceed the capacity of Compact Flash and even SxS cards. The Alexa is a good example of this; only Quicktime files are recorded directly on the camera—on dual SxS cards which can easily be downloaded onto a laptop and external drives. In order to record ArriRAW files, an off-board recorder can be used (an internal XR drive is also an option). The *Codex* (Figures 17.14 and 17.15) is produced specifically for this purpose and is engineered to work with various cameras. It is fairly small and light, and even Steadicam operators find it easy to work with. As with many things in the digital post-HD world, it's new and developing and practically a full-time job to keep up with new workflows. External recorders include those made by *Ki-Pro*, *Codex*, *CineDeck*, *Odyssey*, and *Atomos*. Another example is the *Convergent Design Gemini 4:4:4:4* recorder which can handle *Arri RAW* (as an option), Canon *4K RAW*, and other formats. It records to removable *solid-state hard drives* (*SSDs*). It is small enough to be camera mounted and includes a small monitor for reviewing footage.

HARD DRIVES & RAIDS

In dealing with hard drives, whether spinning drives or solid state, it is important to remember that there are only two types of hard drives: those that have died and those that are going to die. This is what makes backups and redundancy so critical. The same applies to flash storage as well—media fails, it happens all the time. Expect it. Be ready for it. When you calculate how many hard drives you will need for a job, include some redundancy for potential drive failure.

RAID

Most DITs run *RAIDs* (*Redundant Array of Independent Disks*) for immediate storage of video that is downloaded from camera media. There are several reasons for this. They offer a speed advantage and have much greater capacity than a single hard drive is capable of but they also offer built-in backup—that is the redundancy in the name.

TRANSFER/SHUTTLE DRIVES

At the end of the job, the files need to be delivered to the editor, producer, VFX house, and other parties. For this purpose, shuttle or *transfer drives* are used. Since multiple copies of the day's footage are absolutely a must, these shuttle drives need not be RAID storage. However, many DITs keep the job on their RAID until they have assurance that postproduction, the producer, or even the insurance companies have transferred the data to their own systems. Many DITs have achieved hero status by having these files available when production suffered some disaster and thought all was lost.

Figure 17.12. A Thunderbolt RAID storage unit on the ingest cart—the workstation for the data manager. (Courtesy DIT Evan Nesbit).

HOW MUCH STORAGE DO YOU NEED?

Some things are unforgiveable on a film set. In digital filmmaking, they include running out of charged batteries and not having enough storage in the form of camera cards and hard drives. (The list is longer, of course, but these are the things that concern us here.)

How much on-board storage you need for the camera (whether they be P2, Compact Flash, SxS, SD cards, solid-state hard drives, etc.) and hard drives for offloading at the DIT cart depends on many factors: how many days of shooting, how many cameras, whether it's a feature, commercial, music video, industrial, or documentary. Budget is always a consideration in film production, but it's more than just "how many hard drives is production willing to pay for?" There's a big trade-off. If a production manager is complaining about the cost of buying hard drives or renting storage for the camera, it is often sufficient to ask them to compare this relatively minor cost with the huge cost that can be incurred by having the entire production come to a halt while the filled up camera cards or drives are downloaded and backed up, a process that can take a surprisingly long time; or to ask them to think about the unacceptable risk of not having all the data properly backed up. This is usually enough to convince even the most tight-fisted producer.

> Producers sometimes balk at the number of hard drives I recommend they buy or the quality that costs a little more.
>
> I just ask them to think about what it will cost them if an entire day's footage is lost due to faulty hard drives or the costly delays in production when there aren't enough. Works every time.
>
> Von Thomas, DIT

Another factor in determining hard drive space for the DIT cart is formats and transcoding. In some cases, the media might be in a fairly compact codec to begin with; for example, if the camera is recording H.264 or ProRes. In most cases, the camera will be shooting RAW and the files will be kept RAW for delivery to post. However, there might be transcoding to a more efficient format for dailies (such as H.264 for the director to review) or to the more space-consuming DPX files. As always, a preproduction meeting or at least phone calls and emails are important to determine who needs what. Frequently, this type of transcoding will take place off-site or perhaps overnight on the set. In any case, it is critical to have enough drive space to handle these transcoded files as well as preserving multiple copies of the original files. In the end, the only practical solution is to use a video space calculator. Fortunately, there are many excellent ones available, both online and as computer, phone, and tablet apps. Figure 17.10 shows one of these calculators.

Figure 17.13. The *Samurai* on-board recorder from *Atomos*. Here it is also being used as a monitor for the camera assistant. (Courtesy of Atomos).

Figure 17.14. A Codex download station. (Courtesy Codex).

Figure 17.15. A *Codex* record module mounted on a *Canon C500*. (Courtesy of Codex).

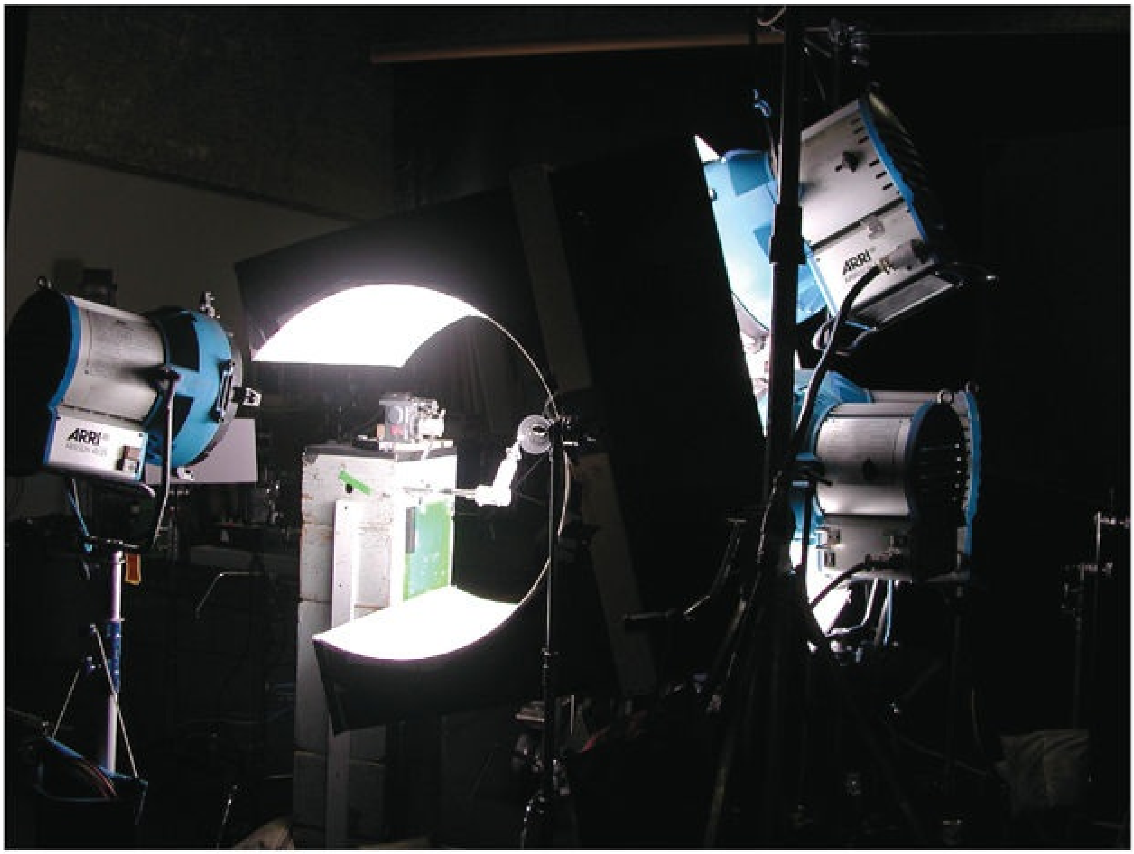


Figure 18.1. Extremely high frame rate shots require intense amounts of light as in this setup by DP/director Ben Dolphin. (Photo courtesy Ben Dolphin)

technical issues

SHOOTING GREENSCREEN/BLUESCREEN

Chroma key, known as *bluescreen*, *greenscreen*, or *process photography*, is a method of producing mattes for *compositing*. The basic principle is the same for all processes and for both film and video: by including an area of a pure color in the scene, that color can then be made transparent, and another image can be substituted for it.

The people or objects you are shooting is called the *foreground plate*, and what you will eventually put in to replace the green or blue screen is called the *background plate*. Green and blue are the most common colors used, but in theory, any color can be used. There is one fundamental principle that must be remembered: whatever color you are using to become transparent will be replaced for the entire scene. Thus, if the background is green and the actor has a bright green shirt, his torso will become transparent.

If there is any camera movement in a matte shot, you should always include *tracking marks* (Figure 18.9). These can be as simple as crosses of tape on the background as a clue to the movement that will be required of the background element that is to be laid in.

Another important practice is to shoot a reference frame (screen correction plate). This is a shot of the same green or bluescreen background without the foreground element—just the screen itself, in case there is any problem with the matte. Other recommendations:

- Use the lowest-grain film possible (low ISO) or native ISO on an HD/UHD camera. Grain and video noise can make compositing more difficult and also it may be difficult to match the grain/noise level between foreground and back ground.
- In video use the highest resolution format possible.

> Be sure that the file format/codec and camera are good for shooting green screen. Codecs with 4:2:2 chroma subsampling are not always good for green screen as edges can be soft. Some long-GOP codecs cause edges to dance to the point where the screen is unusable.

- Check that the codec and file format you are using is appropriate for chromakey work.
- Do not use diffusion over the lens. Avoid heavy smoke effects. Keying software can deal with some smoke effects, but there are limits.
- Always shoot a grayscale lit with neutral light (3200K or 5500K) at the beginning of each roll when shooting on film.
- Try to avoid shooting with the lens wide open. The reason for this is that many camera lenses vignette slightly when wide open, which can create problems with the matte.

> Always test in advance, or work from experience. Whenever possible, talk to post about what they need. When in doubt, a 4:4:4 codec at a high bitrate shot at a low ISO is generally a good bet.
>
> Art Adams

- In video, never compensate for low light levels by boosting the gain, which will increase noise.
- To match the depth-of-field of the foreground, shoot the background plate with the focus set at where it would be if the foreground object was actually there.
- The perspective of foreground and background plates must match. Use the same camera, or one with the same sensor size, the same lens, camera height, and angle of tilt for both.
- Plan the lighting, screen direction, and perspective of the background plates; they must match the foreground plate.

LIGHTING FOR GREENSCREEN/BLUESCREEN

Most important is that the lighting be even across the background screen. Optimum exposure levels for the green or blue screen depend on the nature of the subject and the setup. In general, you want the exposure of the screen to be about the same as the foreground. There is no general agreement on this. Some people set them to be the same; some people underexpose the background by up to one stop, and some people light the background by as much as one stop hotter than the foreground. The bottom line is simple: ask the person who will be doing the final composite—the compositor or effects supervisor. Different visual effects houses will have varying preferences that may be based on the hardware/software combination they use. Always consult with your effects people before shooting. This is the golden rule of shooting any type of effects:

always talk to the postproduction people who will be dealing with the footage: ultimately they are the ones who are going to have to deal with any problems.

Figure 18.2. through **18.4.** A greenscreen lighting setup and the resulting final composite. Since there are no tracking marks, we can assume that the camera was static for this shot. (Courtesy China Film Group).

Lighting the background can be done in many ways using tungsten units, HMIs, or even

The golden rule of shooting any

daylight. Kino Flo makes special bulbs for lighting backgrounds; they are available in both green and blue. Figures 18.5 and 18.6 show Kino Flo's recommendations for using their units to light a background.

type of effects: always talk to the postproduction people who will be dealing with the footage. They are the ones who are going to have to deal with the footage.

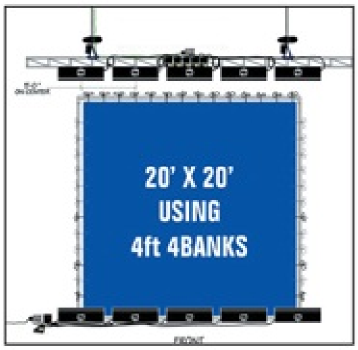


Figure 18.5. Typical bluescreen (or greenscreen) lighting setup with Kino Flos. (Photo courtesy of Kino Flo).

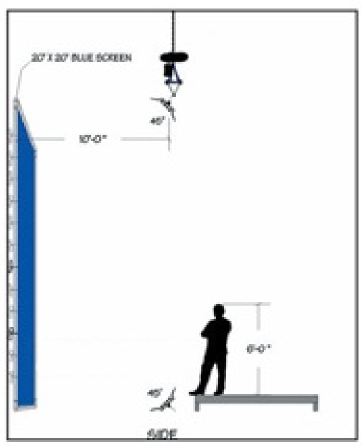


Figure 18.6. Spacing is important for even illumination of the cyc, which is critical for a good process shot. (Photo courtesy of Kino Flo).

Figure 18.7. A green screen shoot for *Assassin's Creed*. Note the tracking marks on the green screen. The backdrop is evenly illuminated to the same exposure as the foreground elements, which are lit by some floating soft lights.

Nothing will undermine the believability of a composite more than a mismatch of lighting in the foreground and background plate. Attention must be made to recreating the look, direction, and quality of the lighting in the background plate. When shooting greenscreen/bluescreen:

- Keep the actors as far away from the background as you can to guard against backsplash, 12 to 15 feet if possible.
- Light the background as evenly as possible: within 1/3 stop variation on any part of the screen is ideal.
- Don't include the matte color in the scene; for example, when shooting greenscreen, don't have green props or anybody wearing green wardrobe.
- Use the waveform monitor or a spot meter to read the greenscreen/bluescreen; use an incident meter to read the subject.
- In general, greenscreen is used for HD video and bluescreen is used for film. This is based on differences in how film and video react to colors with the least amount of noise.

The reason you use an incident meter to read the subject and a spot meter (reflectance meter) for the background is that greenscreen/bluescreen materials vary in their reflectivity. We are not concerned with how much light is hitting the background, only how much light it is reflecting back toward the camera. The best exposure indicator for exposing your green or blue screen is the waveform monitor, you are looking for a thin flat line for the background, the vectorscope will show you the saturation. Ask the EFX house what IRE they want the screen value to be but it will generally be between 40 and 55 IRE.

For the subjects (actors or whatever) being photographed, we read them as we normally would, with an incident meter. Using a spot meter on an actor can be tricky. What part of them do you read? Their forehead? Their shirt? Their hair? With a reflectance meter those are all likely to be different readings. Which one of them represents the actual exposure, the f/stop the lens should be set at? Yes, you can do it, if you have a good understanding of the Zone system, as discussed in the chapter *Exposure*. It is possible, but not usually necessary; an incident meter gives us an excellent reading when used properly as previously discussed: holding the meter so that it is receiving the same lighting as the subject, receptor aimed at the camera, and a hand shielding the meter from backlight, kickers or any other stray light that might not be relevant to the subject exposure. In video, the waveform monitor is useful in judging exposure and balance; a vectorscope can reveal any color problems.

Figure 18.8. A set built to exactly re-create the subway station in Figure 16.9 (*Set Operations*) in order to accommodate the green screen, which wouldn't be possible in a working subway station. (Photo courtesy Michael Gallart).

DIMMERS

There are a number of ways we control the intensity of a light's output at the unit itself:

- Flood-spot.
- Wire scrims.
- Grip nets.
- Diffusion.
- Neutral density filters.
- Aim (spilling the beam).
- Switching bulbs on and off in multi-bulb units (multi-PARs or soft lights).

The alternative is to control the power input into the light with dimmers. There are advantages and disadvantages. The advantages are:

- Fine degree of control.
- Ability to control inaccessible units.
- Ability to quickly look at different combinations.
- Ability to do cues.
- Ability to preset scene combinations.
- Ability to save energy and heat buildup by cooling down between takes.

The disadvantages are:

- Lights change color as they dim.
- Dimming can cause flicker in some lights, especially LEDs.
- Some lights cannot be dimmed externally such as HMIs.
- Necessity of additional cabling.
- Never use dimmers when lighting a green/blue screen.

The first dimmers invented were resistance units. They operate by placing a variable resistance in the power line. The excess energy is burned off as heat. The major problem with resistance dimmers is that they must be loaded to at least 80% of their capacity in order to operate. If you put a 5K on a 10K dimmer, for example, the dimmer will only reduce the output a small amount; you won't be able to dim all the way down. This sometimes necessitates the use of a dummy load to operate.

Figures 18.9. and **18.10.** An example of greenscreen used to fill in a window on a set. The *tracking marks* on the green screen are essential if there is any camera movement at all, including a tilt up or down. On the right is the final result after the *background plate* has been composited in.

The next generation of dimmers were *autotransformers*. They operate as variable transformers and alter the voltage. They do not have to be loaded to capacity, and they don't generate excessive heat, but they do operate only on AC. Known as variacs (for variable AC), they are used, particularly in the 1K and 2K sizes, although they are bulky and heavy.

For larger applications, *silicon-controlled rectifiers* are used. Known as *SCRs*, these are electronic devices that are small in size, quiet, and relatively low cost. They can be controlled remotely by dimmer boards, which means that the dimmer packs themselves can be near the lights, which saves cabling; only a small control cable needs to run from the board to the dimmer packs. The remote cable carries a control voltage of 0 to 10 volts and can be run up to 200 feet. The signal is multiplex and can run up to 192 dimmers.

SCR dimmers do not alter the voltage; they work by clipping the waveform so that the voltage is heating the filament for a shorter time. The result of this is that the output cannot be read with an ordinary voltage meter, only a *VOM* (*volt-ohm meter*), which reads *root mean square voltage* (*RMS*) such as the will work.

There must be a load on the circuit to read the output. The shorter rise time can sometimes cause filament sing. In most cases, with properly grounded audio systems, there should be no problem, but a portable radio can be used to test and find the source of any trouble. When using an SCR dimmer with a generator, the gennie must be frequency controlled, or the loss of sync will cause flicker; also, since most dimmers are voltage regulated, raising the voltage of the generator will not increase the output. An anomaly of these systems is that the neutral load can, in some cases, be higher than the hot line.

SCR dimmers are basically theatrical equipment, so their connectors will often not be compatible with the rest of your equipment. As a rule the outputs will be theatrical three-pin connectors, either 60 amp or 100 amp. It is important to order adapters compatible with whatever plugging system you are using.

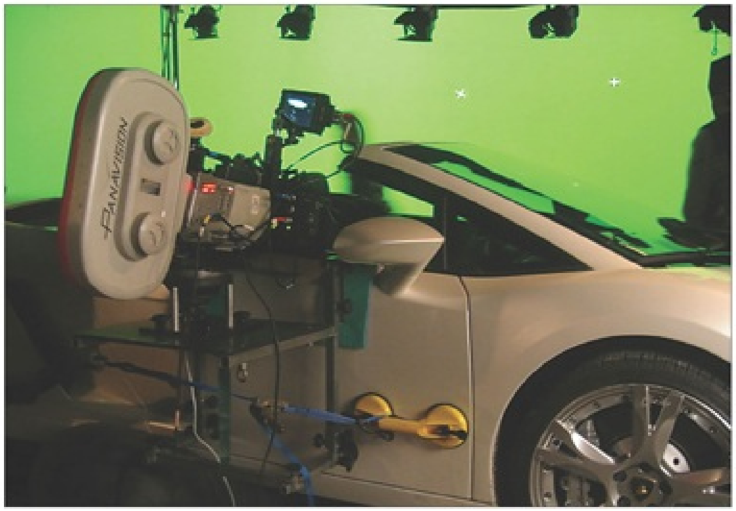


Figure 18.11. A hostess tray mount for the Panavision allows for some vehicle movement in this greenscreen setup. (Photo courtesy of CaryCrane).

The input side of most dimmer packs are *Camloc* connectors. Frequently the neutral is reversed (male instead of female); the easiest way to run into trouble with dimmer orders is to forget to order feeder cable with the neutral reversed or “turnarounds”: female to female connectors. Besides SCRs there are several types of electronic dimmers that work in various ways to reduce the ability of the electricity to make the tungsten filament produce light. These electronic dimmers are also used to control other types of sources such as LEDs, HMIs, fluorescents, or neon lights.

DIMMING LEDS

There are two major approaches to dimming LEDs: *PWM* (*pulse width modulation*) and analog. Both approaches have advantages and disadvantages. PWM dimming reduces color changes in the LED with varying brightness levels, because the LED runs at a constant current when it is on and at no current when it is off. However, this advantage comes at the expense of additional circuitry to create the PWM waveforms.

Analog dimming is simpler, but the variable current supplied to the LED means that the regulator supplying the current to the LED must soak up any power not going to the LED. This additional power arises from the difference between the raw supply voltage powering the LED/regulator subsystem and the voltage at the LED. That power produces heat. Analog dimming may be inappropriate for applications that require a constant color temperature. LED's color will change depending on the current driven.

Any time you work with a dimmer that clips the waveform (PWM), you must be careful to watch for flicker, especially on rolling shutter cameras where flicker can be hard to spot on set (but is always visible in post for some reason). PWM is especially deadly on LEDs. It's the cheapest way to make them dim, but they'll often flicker like crazy if you go too far.

DIMMER BOARDS

Control panels (dimmer boards) vary in sophistication. Some are simply sets of slider switches, one for each circuit, and others include masters and sub-masters and may have separate banks for X and Y scenes, making it possible to do a cue from one preset to another. The next level is *soft patching*, which allows for electronic routing of each line to a dimming circuit. The most advanced feature computer control, timed cues, and other sophisticated control features. Most dimmer boards will run any set of dimmers. The standard for remotely controlling dimmers is called *DMX*; make sure that your control board and your dimmers match in terms of control standards and connectors. It is possible to use dimming to establish a warm color look for the scene.

Figure 18.12. A PhantomFlex highspeed camera on an exterior shoot. (Courtesy LoveHighSpeed).

WORKING WITH STROBES

There are several types of strobe lighting for cinematography. The most widely known is *Unilux*. Strobes are generally used to create a different look for a shot. The fact that the strobe fires for a very short time means they have the ability to freeze motion. Several units can be controlled together for a greater number of heads. Very high frame rates are possible. The strobes are fired by a pulse from the camera that signals when the shutter is open. Any camera that provides such a pulse is compatible with the system.

Strobe lighting in film has three basic uses:

- To light cooler (strobes produce substantially less heat than tungsten heads), which can be a tremendous advantage when shooting ice cream, for example.
- To produce sharper images. The exposure duration for each flash can be as short as 1/100,000th of a second, and as a result, the image is "frozen" and appears sharper than if photographed on moving film at standard exposures.
- To provide sufficient exposure for highspeed photography with a small power input.

It is often used in spray shots of soft drink cans being opened: the strobe effect captures each droplet of spray crisply. In fact, it can be too sharp for some people. In shower scenes for shampoo commercials, it can appear that the shower is a series of razor-sharp drops rather than a soft spray. As a result, for beauty applications, it is common practice to combine strobes with tungsten lighting. In most cases, the strobe light is balanced with an equal amount of tungsten within a range of plus or minus one stop. This presents an interesting exposure problem.

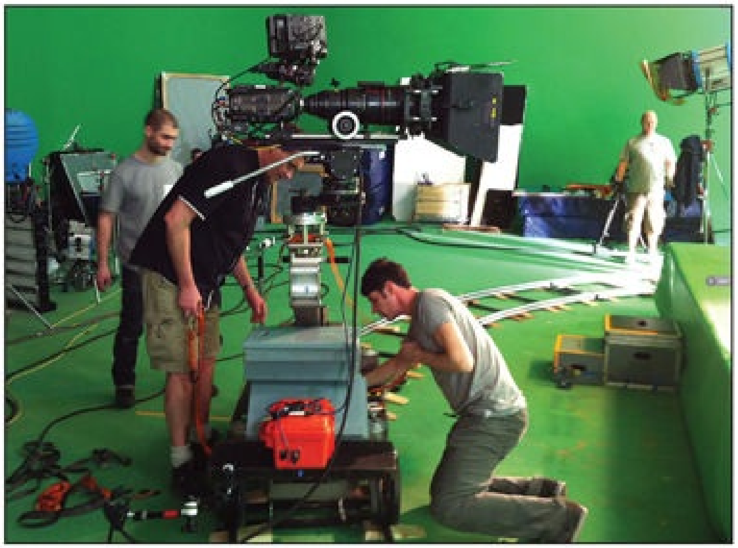


Figure 18.13. Grips and camera assistants prepare a green screen highspeed dolly shot with a Phantom. (Courtesy LoveHighSpeed).

All strobes are daylight balance, and you will need to use gels or filters if you are combining them with incandescent lights, which are often used to avoid flicker. When mixing with tungsten, you can use CTO on the strobes to match color temperature.

STROBE EXPOSURE

Consider this situation: you are shooting at 96 frames per second, and the desired effect is equal amounts of tungsten and strobe lights. Every time you increase the frame rate of a motion picture camera, you are decreasing the amount of time the shutter stays open: you are decreasing exposure. 96 FPS is four times faster than normal, and the shutter speed is 1/200th of a second instead of the normal 1/50th (assuming a 180° shutter). This is an exposure loss of two stops.

This is simple enough to deal with; to achieve an f/5.6, for example, you light to an f/11. But the same is not true of the strobe lighting. The strobe is instantaneous: it fires for only a few thousandths of a second at some time while the shutter is open, and as a result, it is completely independent of the frame rate. It doesn't matter whether the film is moving at six frames a second or 600: the exposure will be the same.

Here's the problem. We read the tungsten and have to compensate, we then read the strobes with a meter and we don't have to compensate; not all light meters can do this—you need a meter that can read strobes. Clearly we can't read them at the same time. How do we arrive at a setting for the lens? The answer is intuitively obvious, but mathematically a bit complex: we read them separately and then add the two exposures. As it turns out, adding f/stops is not especially simple. Let's take the simplest case first. We read the Unilux by itself (and it is very important to turn off all tungsten lights when we do this) and find that they are an f/5.6. We have to balance the tungsten to do that. As we know, at 96 FPS, we have to set the tungsten lights for f/11, which will be f/5.6 at 96 FPS. The temptation might be to average them; that would result in a very incorrect exposure: we must add them.

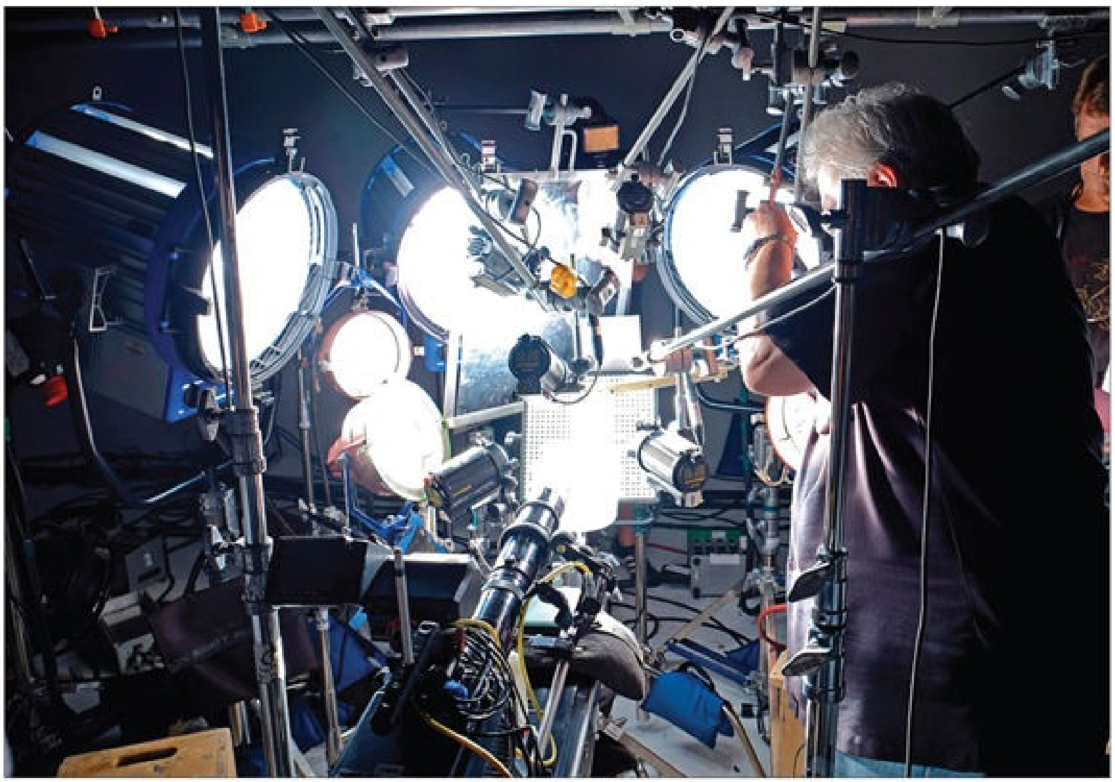


Figure 18.14. A macrophotography setup for jewlery requires an insane amount of lighting for depth-of-field and high speed. The primary lighting here is HMI (a daylight source), but tungsten balance MolePARs are added from some warm highlights. (Photo courtesy A MakoFoto).

Figure 18.15. A multifunction flicker box. (Photo courtesy of McIntire Enterprises).

What is f/5.6 plus f/5.6? No, it's not f/11.2. In effect we are doubling the amount of light: the tungsten is providing f/5.6 and the Unilux is supplying an entirely different illumination, which is also f/5.6. Twice as much light as f/5.6 is f/8. Recall that each f/stop represents a doubling of the amount of light. Now it gets a bit stickier. Let's say that the Unilux is f/8 and the tungsten is f/5.6. Think of it this way: if f/8 is a base of 100%, then the tungsten light is 50% (one stop less equals 1/2 the amount of light). We then have 150% of the base light. 150% of f/8 is 1/2 stop hotter than f/8—f/8 and a half. If one of the sources is f/8 and the other is f/4, the correct exposure is f/8 and 1/4. F/4 is only 25% the amount of light of f/8: 125%. Although a flash meter is the preferred method, many ordinary electronic light meters can read highspeed strobes. The reason is that at 60 flashes per second, it is seen as continuous by some meters.

HIGHSPEED PHOTOGRAPHY

Video cameras are now capable of extremely high frame rates; the *Phantom Flex4K*, for example, can shoot 4K video at up to 1,000 FPS (frames per second). *Vision Research's Phantom* cameras are shown in Figures 18.12 and 18.13. Vastly higher frame rates are possible at lower resolution, up to a million FPS, although the resolution may not be usable for most projects aimed at theatrical, cable, or other types of distribution. Since a higher frame rate means a faster shutter speed highspeed photography differs mainly in the amount of light needed and in the calculation of exposure, as can be seen in Figures 18.1 and 18.14. In some cases, the lighting can be so intense that precautions must be taken not to melt the subject or set something on fire. Variations in frame rate are covered in the chapter on Exposure. Flicker is a major issue when shooting high speed. We'll talk about it later in this chapter.

Figure 18.16. Like rain, smoke is most effective when backlit as in this shot from *Jesse James*, photographed by Roger Deakins, but even without that it can add atmosphere. Very light smoke is often used as diffusion for the image and can add a sense of depth to the shot.

LIGHTING FOR EXTREME CLOSE-UP

There are two basic considerations in lighting for extreme close-up. The first is that due to extremely small depth-of-field (which is inherent in close focusing) and the need to stop down for improved optical performance, very high light levels are needed. Particularly with highspeed photography, an uncorrected stop of f/64 and higher is often called for. Since the area being lit is usually small, there is generally no problem with this, although in dealing with large units it can be quite a job just to get them close together. (Figure 18.14).

EFFECTS

Effects on the set will, of course, be handled by the special effects team, but they often have special requirements in terms of the lighting; in some cases, lighting is crucial to their success.

SMOKE

Many types of smoke are available for use on sets: incense in beesmokers, smoke cookies, smoke powder, and others; however, many of them have been found to be health hazards. *Cracker smoke* is atomized oil: baby oil, cooking oil, and other types of lightweight oil are used. The oil is atomized by forcing compressed air or nitrogen through extremely small holes. *Hazers* are a type of machine that generates haze effects that have a long hang time. Haze is lighter and less dense that smoke or fog machines.

Smoke, fog, or haze is often used to make beams of light visible. For this to work best, the beams of light need to be coming from the back—light coming from near the camera will not show up as a well-defined beam. See Figures 18.16, and 18.17.

Table 18.1. Magnification requires an increase in exposure.

Magnification ratio	Exposure increase in stops
1:10	1/3
1:6	1/2
1:4	2/3
1:3	1
1:2	1 1/3
1:1.4	1 1/2
1:1.2	1 2/3
1:1	2

FIRE

Real fire frequently needs help. It may deliver enough exposure itself, but if it is in the frame or even near the frame, it will flare the image badly and degrade the shot. The secret of fire shots is to use several sources on dimmers or flicker boxes. Fire jumps around; it doesn't just go up and down in brightness. One light or even two lights on dimmers that just get brighter and darker won't be convincing because the shadows don't flicker and jump like real flame. Fire is established by a low-key orange flickering effect. CTO can be used to warm the light, and the flicker can be accomplished in a variety of ways. Silver foil, waving hands, and rotating mirror drums are used but are generally not very convincing; the simplest and most realistic effect is usually to place several lights on dimmers and have an electrician with an "eye" operate it. It may take two operators if you have three dimmers. It is important that the effect be random enough to not appear as a consistent pattern.

Figure 18.17. Without smoke, this frame from *The Hudsucker Proxy* would be nowhere near as ineresting. The smoke (in this case motivated by the cigar) allows the light from the projector to become a graphic element in the composition.

A more high-tech method is the use of a flicker generator. Two kinds are available. One is a random generator that can be programmed for various rates of random flicker. The other uses an optical sensor to "read" the light of a candle or fire and drives a dimmer in sync with it. This is particularly effective for scenes where the dimmer or fire is the primary source and is visible in the scene. There are many types of flicker boxes that can drive up to 10K dimmers and a smaller unit that directly controls up to a 2K (Figure 18.15)—they all have adjustable settings.

Small handheld candles or oil lamps can be executed with an Inky socket and a small bulb. They can be AC powered with a wire running up the actor's sleeve or DC powered with a battery hidden on the actor's body. Flame bars, which are pipes with holes spaced along them through which gas is pumped, are far more reliable and controllable than real fire.

TV AND PROJECTOR EFFECTS

Like fire effects, the look of a flickering TV is best accomplished with dimmers. The source, which might be a Fresnel or practical bulbs in porcelain sockets with some diffusion, are usually placed in a snoot box to confine the light in a realistic pattern. In general, 1/2 or full CTB cools the light to simulate the blue look of black-and-white television. This is a convention even though most people watch color TV, which projects a variety of colors. Here again, it is important that the person operating the effect have some sensitivity to the mood of the scene and keep it random. Actual television flickers considerably less than is usually portrayed, but the activity helps sell the effect. It isn't really flicker in the usual sense: it is caused by changes in scenes—some scenes are brighter, some darker; color may vary widely as well.

Projection effects can be accomplished the same way, with the addition of sometimes bouncing the light for a softer look: film projection is bounced off a large screen, while television is a smaller direct source. Projection can also be simulated by running actual film through a projector and aiming it at the audience. Obviously it is necessary to defocus the projector or remove the lens so the image won't appear on the faces. One drawback of this method is that most film projectors are far too noisy to be recording dialog; if it's an MOS scene, this won't be a problem. Far simpler, of course, is to use a video projector.

Figure 18.18. Rain can never be effective unless it is backlit, as in this shot from *The Matrix*.

DAY-FOR-NIGHT

Day-for-night was an important technique when it was very difficult to actually shoot at night on location. With the advent of highspeed film and HD video cameras which can operate at very high ISOs, highspeed lenses, high-efficiency HMIs, and sunguns, day-for-night is not done as often.

Traditionally, day-for-night is done at midday, since long shadows will give away the fact that it is day. Of course, showing the sky is strictly forbidden. In color (both film and video), it is possible to achieve a reasonably convincing effect by underexposing from 1–1/2 to 2–1/2 stops. Moonlight blue can be simulated by removing the 85 filter with tungsten balance film or white balancing the video camera for tungsten (see Figure 9.43 in the chapter Exposure).

Harrison and Harrison makes a series of day-for-night filters. The #1 is blue-red; the blue gives the night effect, while the red component helps hold the skin tones in balance. The #2 is the same color but also lowers the contrast, which can help maintain the night illusion; the #3 filter offers a greater degree of contrast control. They have an exposure factor of 2 stops. In other parts of the world, day-for-night is often named for the place where it was presumably invented and is known as *American Night*: in fact, the original European title of François Truffaut's film known in the United States as *Day For Night is La Nuit Américaine*.

MOONLIGHT EFFECT

It is a widely accepted convention that movie moonlight is blue. The use of blue for moonlight varies —some feel it is simply unrealistic, and people purists insist on using no more than 1/2 CTB for the effect. More common is full CTB or double blue; half CTB and 1/4 Plus-green is also popular. Some people also add just a touch of lavender for a romantic look that is slightly more pleasing to the skin tone of the actors. Some cinematographers use more extreme effects, such as cyan.

Figure 18.19. The *Thundervoltz* from Lightning Strikes provides portable power for 70K lightning effects. Undersizing your lightning effects units can be a serious mistake. (Photo courtesy of Lightning Strikes).

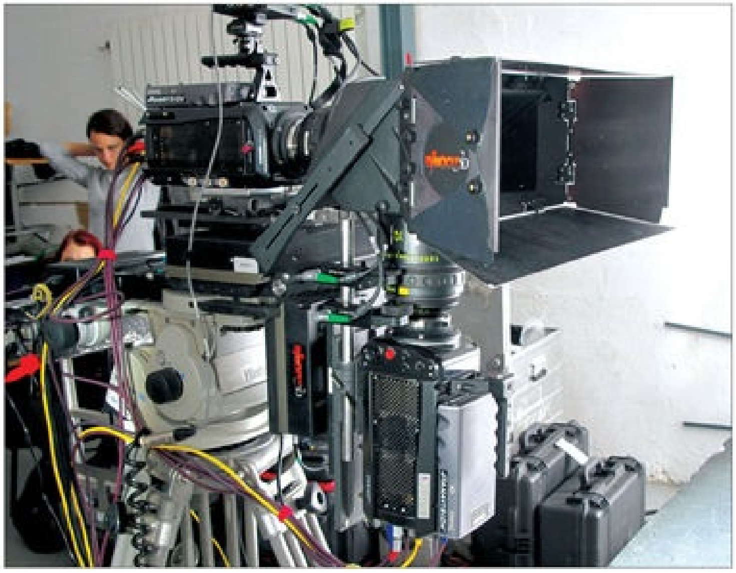


Figure 18.20. A Phantom Flex4K 3D rig. (Photo courtesy of LoveHighSpeed).

WATER EFX

The dapple of light reflected on water can be a beautiful and subtle effect. It can be achieved in a number of ways. Some people use broken mirrors or crumpled aluminum foil to reflect a strong directional light. These tend to be somewhat stilted and artificial and rarely result in a convincing illusion. The best effect is always achieved by using actual water. In a shallow pan with a black backing, plain water can be highly reflective if you use a strong enough unit.

RAIN

Rain is the province of the prop department, but it does have implications for lighting. To be visible, rain must be backlit (Figure 18.18). Front lighting will not work with anything but the most intense downpours, and even then the result will be anemic. Even with the most carefully controlled rain effect, water gets everywhere. Several precautions are necessary:

- Raise all connectors, especially distribution boxes, off the ground on apple boxes. Wrap them in plastic and seal with tape, electrical tape as gaffer tape won't withstand water.
- Ground everything you can.
- Put rain hats on all lights. Protect the lenses of all large lights; water on a hot lens will shatter it with the possibility of glass flying out.
- Cover equipment racks and other spare equipment with heavy plastic.
- Crew members should wear insulating shoes and stand on rubber mats whenever working with electrical equipment.
- Observe all electrical safety rules religiously.

Most rain conditions (which includes real rain as well as rain towers) call for a camera umbrella, which is a large sturdy beach or patio-type umbrella and perhaps an aluminized space blanket or rain cover for the camera. Many cameras have purpose-built rain covers. Be sure that the filters are protected as well; rain drops on the filter or lens are very noticeable. For heavier water conditions, a deflector may be necessary. A rain deflector is a spinning round glass in front of the mirror. It rotates fast enough to spin the water off and keep the lens area clear. One caution: when used with a free-floating camera rig (Steadicam, etc.), the spinning glass acts as a gyro and tends to pull the camera off course. There are other devices that blow either compressed air or nitrogen toward a clear filter to keep water off.

Figure 18.21. Director/cameraman Ben Dolphin shoots a scene in the water with green screen. Obviously a watertight housing is necessary for scenes like this. (Photo courtesy Ben Dolphin).

LIGHTNING

Because lightning must be extremely powerful to be effective, it generally calls for a specially built rig. Nearly universal now is the use of machines from *Lightning Strikes* (Figure 18.19), which are basically incredibly powerful strobes. Included with them is a controller that can vary the timing and intensity of strikes to very accurately reproduce actual lightning. For further realism, several units should be used. Except when a storm is far away, lightning comes from several different angles. Another time-honored method is to use metal shutters on the lights. Shutter units are available for a wide variety of lights and they fit into the slots for the barn doors of the unit.

GUNSHOTS

Gunshots are flashes of short enough duration that they might occur while the shutter is closed. When shooting film, the standard procedure is for the operator to watch for the flashes. If the operator sees them, then they did not get recorded on film. If the operator saw them, it means the flashes occurred while the mirror was reflecting the image to the viewfinder. Depending on how critical they are, another take may be necessary to make sure all the shots are recorded. Several things can be done to alleviate this problem. There are prop guns that do not use gunpowder but instead use an electrical pulse coupled with a chemical charge to produce a flash. This has the added bonus of being much safer.

SAFETY WITH GUNS

Guns should only be handled by a licensed pyrotechnician/armorer; in most places this is a legal requirement. The same applies to bullet hits (*squibs*) planted on people, props, or the set. Squibs are small black powder charges and can be dangerous. If the gun is not firing in the shot, the armorer should open each gun, verify that it is empty, then show it to the actors and camera crew with the action open. If firing of blanks is anywhere near toward the camera, a shield should be set by the grips to cover the camera, the operator, and the focus puller. This is usually done with clear polycarbonate (*Lexan* is a popular type) that is optically smooth enough to shoot through but strong enough to protect the people, the lens, and the camera. This shield needs to be secured and bagged so that it won't get knocked over by an errant diving stunt person or a chair that gets kicked in the action. Great care must be taken by the grips, since the disadvantage of Lexan is that it scratches very easily.

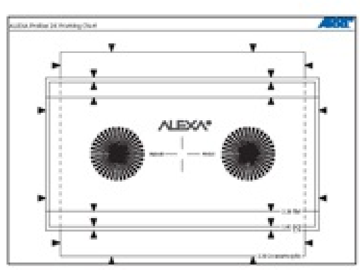


Figure 18.22. This framing chart from Arri includes both frequently used film formats and video 1.78:1(16:9). For more on film aspect ratios, see *Appendix: Film Formats*. (Courtesy Arri Group).

EXPLOSIONS

The same type of shield is necessary for small explosions, rockets, shattering glass, and so on. For small explosions, the camera crew also need to be protected from objects that get blown into the air. For larger explosions, the camera should be either locked down and switched on remotely, or operated with a remote-control head and video assist. In this case, either very heavy duty crash boxes are needed or expendable cameras. Explosions are usually filmed with multiple cameras at various frame rates; at least one or more of the cameras will be run a high frame rate—often up to 250 FPS or more. HMI PARs are available in explosion-proof housings. This does not mean that they are completely impervious to explosions; it just means that they are sealed so that it will not cause an explosion.

TIME-LAPSE PHOTOGRAPHY

Time-lapse is usually done with an *intervalometer*—an electronic device that controls the timing and duration of each exposure. The Norris Intervalometer starts at an exposure of 1/16 of a second and gets longer from there. There are also computer and smartphone apps that will drive a connected camera and function as an intervalometer. The interval between exposures can be anywhere from a fraction of a second up to several hours or even days apart.

With longer exposure you get not only a time-lapse effect but may also get blurring of the subject. This can be strongly visual with subjects such as car lights or moving clouds or a rushing stream. One issue with time-lapse shots is that the exposure may change radically during the shot, especially if it is night-into-day or day-into-night, or if heavy clouds move in during the shot. This can be controlled with a timing device, or it may be necessary to stand by and do exposure changes manually. Also, with long intervals between exposures, it is possible for enough light to leak around the normal camera shutter to fog frames. An additional shutter, known as a *capping shutter*, is added to prevent this. The *Steele Chart* by Lance Steele Rieck (Table 18.2) shows screen time versus event duration for time-lapse.

TIME SLICING

This is the effect that was made famous in *The Matrix*, where a character is suddenly frozen but the camera dollies around the figure. This effect is accomplished with an array of still cameras arranged around the subject. A regular film or video camera can be part of the array. At the moment of freezing the action, the entire circle of cameras is fired. These stills are then scanned and blended together to form a film shot (Figure 18.23). Visualize it this way: imagine a camera on a mount that can be dollied around the subject instantaneously, let's say 90°, with the film running at very high speed. Since the dolly is instant, it "sees" the subject from all points around that arc before the subject can move. This is what the still cameras do: they see the subject from as many points of view as you wish—all at the same time. In practice, the subject is often placed on greenscreen and then the green background is replaced with live-action footage of the original scene, usually matching the dolly action simulated byFigure 18.23. A time slicing rig by the still array. The result is a dolly around a live-action scene with a frozen subject in the middle.

Figure 18.23. A *time slicing* rig by LoveHighSpeed. (Photo courtesy LoveHighSpeed).

TRANSFERRING FILM TO VIDEO

When transferring 24 FPS film to video at 29.97 FPS, there is a mismatch of speed that must be corrected. Interlaced video has 60 fields/second (2 fields per frame), so five fields take 5/60 second = 1/12 second time, which is exactly the amount it takes for a film to show two frames. The solution to the problem is that each frame of film is not transferred to a corresponding frame of video.

The first film frame is transferred to 3 video fields. Next, the second film frame is transferred to 2 video fields. The total time for the original film should be 2/24s = 1/12s, which is exactly the same time it took for NTSC to transfer the same frames (3/30s + 2/60s = 5/60s = 1/12s). This process alternates for successive frames. This is called 3-to-2 pulldown, usually written as 3:2 pulldown. The problem with this is that every other film frame is shown for 1/20 of a second, while every other is shown for 1/30 of a second. This makes pans look less smooth than what they did in the movie theater. Film shot at 25 FPS does not require this process.

FRAMING CHARTS

Another part of your vision that you need to protect with references is the framing. Without a reference the colorist has no way of knowing for certain what your exact framing is. Remember that the colorist can move the frame up/down, left/right, and zoom in or out over the entire area of the negative or positive frame. A framing chart is something the editor or colorist can copy to the frame store and quickly call it up. Figure 18.22 is a typical framing chart.

Table 18.2. The *Steele chart* for calculating time-lapse shots. (Courtesy of Lance Steele Rieck).

THE STEELE CHART
TIME COMPRESSION/INTERVALOMETER

SCREEN TIMES	1S	2S	5S	10S	15S	20S	30S	1M	2M	5M	10M	20M
FRAMES	24	48	120	240	360	480	720	1440	2880	7200	14400	28800
INTERVAL	EVENT DURATION											
12Frm/Sec	2S	4S	10S	20S	30S	40S	1M	2M	4M	10M	20M	40M
8Frm/Sec	3S	6S	15S	30S	45S	1M	90S	3M	6M	15M	30M	1H
6Frm/Sec	4S	8S	20S	40S	1M	80S	2M	4M	8M	20M	40M	80M
4Frm/Sec	6S	12S	30S	1M	90S	2M	3M	6M	12M	30M	1H	2H
3Frm/Sec	8S	16S	40S	80S	2M	2M 40S	4M	8M	16M	40M	80M	2H 40M
2Frm/Sec	12S	24S	1M	2M	3M	4M	6M	12M	24M	1H	2H	4M
1Frm/Sec	24S	48S	2M	4M	6M	8M	12M	24M	48M	2H	4H	8H
2Sec/Frm	48S	96S	4M	8M	12M	16M	24M	48M	96M	4H	8H	16H
3Sec/Frm	72S	2M 24S	6M	12M	18M	24M	36M	72M	2H 24M	6H	12H	24H
4Sec/Frm	96S	3M 12S	8M	16M	24M	32M	48M	96M	3H 12M	8H	16H	32H
5Sec/Frm	2M	4M	10M	20M	30M	40M	1H	2H	4H	10H	20H	40H
8Sec/Frm	3M 12S	6M 24S	16M	32M	48M	64M	96M	3H 12M	6H 24M	16H	32H	2D 16H
10Sec/Frm	4M	8M	20M	40M	1H	80M	2H	4H	8H	20H	40H	3D 8H
15Sec/Frm	6M	12M	30M	1H	90M	2H	3H	6H	12H	30H	2D 12H	5D
20Sec/Frm	8M	16M	40M	80M	2H	2H 40M	4H	8H	16H	40H	3D 8H	6D 16H
30Sec/Frm	12M	24M	1H	2H	3H	4H	6H	12H	24H	2D 12H	5D	10D
1Min/Frm	24M	48M	2H	4H	6H	8H	12H	24H	2D	5D	10D	20D
2Min/Frm	48M	96M	4H	8H	12H	16H	24H	2D	4D	10D	20D	40D
5Min/Frm	2H	4H	10H	20H	30H	40H	2D 12H	5D	10D	25D	50D	100D

STEP 1: Decide how long you want the event to last on screen
STEP 2: Decide how long you want to film the event in real time.
STEP 3: Set interval according to data in the far left column.
NOTE: This chart is a guideline only. If the specific numbers you're looking for are not on the chart, you can use the chart to "guess-timate" by finding the closest corresponding numbers.

EXAMPLE: The DP wants 15 seconds time-lapse footage of clouds passing. You have six hours to film. First, look under Screen Time for “15S”. Follow column down till you find “6H” or six hours. Follow row to the far left Interval column where you will find the interval: 1Min/Frm.
FORMULA: Event duration in seconds divided by screen time in frames equals the interval.

FLICKER

As discussed in the chapter on *The Tools of Lighting*, there are three basic kinds of light sources. One is a filament (usually tungsten) that is heated by electrical current until it glows. The other type is a discharge source. These include fluorescents, HMIs, Xenons, mercury vapor, sodium vapor, and others (LEDs are the third). In all of these, an arc is established between a cathode and an anode. This arc then excites gases or a plasma cloud, inducing them to glow. All discharge sources run on alternating current. Any arc-based bulb powered by alternating current has an output that rises and falls as the waveform varies. Alternating current rises and falls as it heats a tungsten filament as well, but the filament stays hot enough that the light it emits does not vary a great deal. There is some loss of output, but it is minimal, usually only about 10 to 15%, not enough to affect exposure. With discharge sources, the light output does rise and fall significantly throughout the AC cycle.

Table 18.3. Simplified safe frame rates with 24 Hz power supply and 25 Hz power supply.

24FPS/50HZ POWER - SAFE FRAME RATES AT ANY SPEED				
1.000	4.000	6.315	10.000	**24.000**
1.500	4.800	6.666	10.909	30.000
1.875	5.000	7.058	12.000	40.000
2.000	5.217	7.500	13.333	60.000
2.500	5.454	8.000	15.000	120.00
3.000	5.714	8.571	17.143	
3.750	6.000	9.231	20.000	

Table 18.4. Safe frame rates for any shutter speed with 24 Hz power supply.

25FPS/50HZ POWER - SAFE FRAME RATES AT ANY SPEED				
1.000	4.166	6.250	11.111	50.000
1.250	4.347	6.666	12.500	33.333
2.000	4.545	7.142	14.285	100.00
2.500	4.761	7.692	16.666	
3.125	5.000	8.333	20.000	
3.333	5.263	9.090	**25.000**	
4.00	5.882	10.00	33.333	

Table 18.5. (left, below) Safe frame rates for any shutter speed with 25 Hz

power supply.

24 FPS	25 FPS
120	100
60	50
40	25
30	20
24	10
20	5
15	4
12	2
10	1
8	
6	
5	
4	
2	
1	

Rarely perceptible to the eye, flicker appears on the footage as an uneven variation in exposure. This effect is a result of variations in exposure from frame to frame as a result of a mismatch in the output wave form of the light and the frame rate of the camera. Flicker can be bad enough to completely ruin the shot. The output of an AC power source is a sine wave. When the current flow is at the maximum or minimum the output of the light will be maximum: the light doesn't care whether the flow is positive or negative.

When the sine wave crosses the axis, the current flow drops to zero and the bulb produces less output. Since the light is "on" for both the positive and negative side of the sine wave, it reaches its maximum at twice the rate of the AC: 120 cycles per second for 60-hertz current and 100 cycles per second for 50-hertz current. For an HMI with a magnetic ballast (a copper coil wound around a core), the output at the crossover point may be as low as 17% of total output.

With film there is another complication: the shutter is opening and closing at a rate that may be different than the rate at which the light output is varying. When the relationship of the shutter and the light output varies in relation to each other, each film frame is exposed to different amounts of the cycle. The result is exposure that varies enough to be noticeable.

There are three possibilities when shooting film: the frame rate of the camera can be unsteady, the frequency of the electrical supply can fluctuate, or the frame rate of the shutter creates a mismatch in the synchronization of the shutter and the light output. The first two are obvious: if either the shutter rate or the light output are random, it is clear that there will be different amounts of exposure for each frame. The third is a bit more complex. Only certain combinations of shutter speed and power supply frequency can be considered acceptably safe. Deviations from these combinations always risk noticeable flicker. Four conditions are essential to prevent HMI or fluorescent flicker:

- Constant frequency in the AC power supply.
- Constant framing rate in the camera.
- Compatible shutter angle.
- Compatible frame rate.

Figure 18.24. This *virtual reality* rig by Radiant Images employs 16 cameras to capture every angle.

The first two conditions are satisfied with either crystal controls on the generator and camera or by running one or both of them from the local AC mains, which are usually very reliable in frequency.

The shutter angle and frame rate are determined by consulting the appropriate charts. A fifth condition—relationship of AC frequency to shutter—is generally only crucial in highspeed cinematography and is usually not a factor in most filming situations.

At 24 FPS camera speed, if the power supply is stable, shutter angle can vary from 90° to 200° with little risk. The ideal shutter angle is 144°, since this results in an exposure time of 1/60th of a second and so it matches the frequency of the mains power supply. In actual practice, there is little risk in using a 180° shutter if the camera is crystal controlled and the power supply is from the mains or a crystal-controlled generator.

With a 180° shutter opening, the camera is exposing 2–1/2 pulses per frame (rather than the exactly 2 pulses per frame as you would get with 144°) and so exposure can theoretically vary by as much as 9%. In other countries (especially in Europe), with a 50 cycle per second power supply, and shooting at 24 FPS, the ideal shutter angle is 172.8°. Tables 18.4 and 18.5 list the acceptably safe frame rates for shooting at any shutter angle (with either 50 or 60-hertz electrical supplies) and the safe frame rates for specific shutter speeds.

A simple way to think about it is to divide 120 by a whole number—for example, 120/4 = 30, 120/8 = 15. For 50 *hertz* (*Hz*) power systems, divide 100 by a whole number. This results in a simplified series as shown in Table 18.3. Any variation in the frequency of the power supply will result in an exposure fluctuation of approximately .4 f/stop.

Any generator used must be a *crystal controlled*. A *frequency meter* should be used to monitor the generator. For most purposes, plus or minus one-quarter of a cycle is considered acceptable. Flickerfree ballasts are available that minimize the possibility of flicker even under highspeed conditions. They utilize two basic principles: square-wave output and high frequency. Flickerfree ballasts modify the wave form of the power supply by squaring it so that instead of the normal rounded sine wave, the output is angular. This means that the rising and falling sections of the wave are a much smaller portion of the total. As a result, the light output is off for less time.

Flickerfree ballasts also use increased frequency. The idea is that with 200 or 250 cycles per second it is less likely that there will be a mismatch from frame to frame. Since there is an increase in the noise from a ballast in flicker-free mode, some flicker-free units can be switched from normal to flicker-free operation. With highspeed shooting, flicker can also sometimes be a problem with small tungsten bulbs, especially if they are on camera because the smaller filaments don’t have the mass to stay heated through the cycle as do larger bulbs.

VIRTUAL REALITY

Virtual reality (*VR*) shooting is usually done with multiple cameras radiating from the same central point. This allows post to knit the many views together into one seamless image. A typical VR rig is shown in 18.24.

the author

Blain Brown is a cinematographer, writer, and director based in Los Angeles. He has been the director of photography, director, producer, and screenwriter on features, commercials, documentaries, and music videos on all types of formats.

dedication

To my wife and inspiration—painter and professor Ada Pullini Brown.

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about the website

Please be sure to visit the companion website for *Cinematography: Theory and Practice*. On the website, you will find instructional videos and examples of techniques discussed in this book, including camera essentials, setting up shots, scene shooting methods, lighting techniques, a day on set, and much more.

www.routledge.com/cw/brown

For initial access, the website requires the use of the access code printed on the inside back cover of this book. If you have purchased an e-book version of the book, please visit the website for further instructions. During the registration process, you will be prompted to create your own username and password for access to the site. Please record this for future reference.

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Page numbers in *italics* refer to figures. Page numbers in **bold** refer to tables.

Figure 19.1. An imax frame from *The Dark Knight*.

appendix—film formats

ASPECT RATIOS

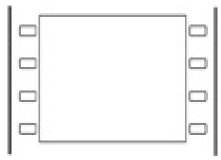

Figure 19.2. Full aperture Aspect ratio: 1.319:1 .980“×735” .72 sq. in 25mm×18.7mm 464.5 sq. mm

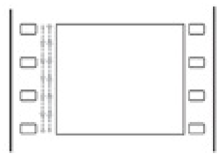

Figure 19.3. Academy aperture Aspect ratio: 1.37:1 .864“×.63” .544 sq. in 21.95mm×18.6mm 351.2 sq. mm

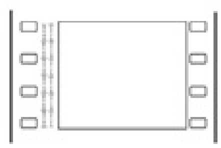

Figure 19.4. Aspect ratio: 1.66:1 .864“×.63” .544 sq. in. 21.95mm×16mm 31.2 sq. mm

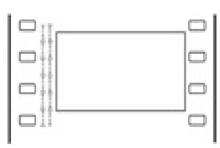

Figure 19.5. Aspect ratio: 1.85:1 .864“×.469” .405 sq. in. 21.95mm×16mm 351.2 sq. mm

Before the introduction of sound, the entire width of the film was exposed. This is called full aperture or silent aperture. It is still used today for formats such as Super35 (see the following). The format is essentially what was developed in the Edison labs at the very invention of motion picture film, now called full aperture (Figure 19.2).

ACADEMY APERTURE

With the introduction of sync sound, the Academy aperture was created in 1932 to allow space for the optical sound track. With the introduction of sound, room had to be made for the optical track. To do this, the size of the aperture was reduced. This was called the Academy aperture (Figure 19.3).

1.66:1 AND 1.85:1

The next step in the evolution was the wider *1.66* frame. After the widescreen craze of the fifties, there was a need for a wider format that did not call for special cameras or widescreen projection equipment. The response to this was the introduction of the *1.85:1* aspect ratio. In the United States, this is still a very common format for anything going to theatrical projection. Anything wider is considered widescreen (Figure 19.5). When shot for television and standard video release, the 1.33 aspect ratio is used.

WIDESCREEN

For true widescreen, anamorphic lenses *squeeze* the image onto 35mm film. In projection, the image is then *unsqueezed* to provide an image wider than standard 1.85. On the camera negative, the aspect ratio is 1.18:1. When unsqueezed, the aspect ratio in projection is generally 2.35:1.

ANAMORPHIC

Anamorphic photography was invented in France in 1927. A special lens was suspended in front of the prime lens that compressed the image horizontally to one-half its width, then unsqueezed it again when projected. The horizontal compression was eventually engineered into the prime lens itself so an additional optic in front of the lens was no longer necessary. Several versions of this system are in use today, and most major lens manufacturers also make high-quality anamorphic lens sets (Figure 19.6).

VISTAVISION

VistaVision runs standard 35mm film horizontally (Figure 19.7). Each frame spans eight perforations, twice the area of a regular frame. It is still in common use, especially for any kind of special effects or plate work. The reason it is used for this type of work is that something that is shot for a background plate or as part of a special effects piece will likely go through several stages of optical printing or perhaps digitizing. The larger format prevents the build up of excessive grain and loss of resolution. 70mm is also used for plate work on films for which the production format is 35mm.

IMAX

Currently, the largest projection format is IMAX, which is 70mm film run through the camera and projector sideways, similar to VistaVision. This results in a negative roughly the size of that produced by a 2–1/4 still camera (Figure 19.8). This very large negative allows for projection screens up to five stories high. Omnimax is a variation which employs a curved screen and anamorphic lens.

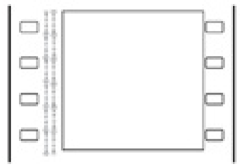

Figure 19.6. Anamorphic Aspect ratio: 1.18:1 .864“×.732” .633 sq. in. 21.95mm×18.6mm 408.27 sq. mm

Figure 19.7. VistaVision frame Aspect ratio: 1.5:1 1.485“×.991” 1.472 sq. in. 37.72mm×25.17mm 949.7 sq. mm

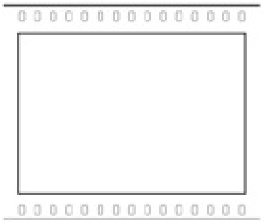

Figure 19.8. The Imax negative is a 15-perf image on 70mm film stock. It runs horizontally, like VistaVision. Aspect ratio: 1.43:1 2.740“×1.910” 5.24 sq. in. 70mm×48.5mm 3430 sq. mm

ALTERNATIVES TO ANAMORPHIC

There are many problems with anamorphic photography. First, anamorphic lenses are never as fast as standard spherical lenses. Second, because of the squeeze, the depth-of-field is 1/2 of that for the same image size. Both of these conditions mean that more lighting is required for anamorphic photography, which can be a problem in terms of time and budget.

All of the following formats are a response to the same problem: film is locked into a relatively square aspect ratio and has been since the days of Edison. On the other hand, film production has tended toward more rectangular wider aspect ratios. This means that the shooting aspect ratio is being shot on cameras that are not really suited for it. These adaptations are ways to address this problem.

SUPER35

One method to answer these problems is *Super35*. The basic concept of Super35 is to use the entire width of the negative: the aperture originally used in silent films (Figures 19.11 through 19.14).

From this full-width negative, a widescreen image is extracted. This is done with an optical print. This optical step is necessary to slightly reduce the image to leave room for the sound track and to squeeze it for anamorphic projection. Although the resulting image is not the full aperture, the original negative uses more of the available space. This is necessary because there is still a need for a sound track. Even though several alternatives have been developed to substitute for the sound track on film, including digital audio, because these systems are not universal, it is usually necessary to give back that audio track space on the side. The Univision format, discussed later, also relies on eliminating audio track.

COMMON TOPLINE

For the DP, the director, and especially for the operator, one of the greatest advantages of Super35 is that a common topline can be used. Because 4:3 video is more square, the top of video is always higher than the top of the widescreen format. As a result, it is necessary to frame for two formats at the same time. This is difficult at best, and it is always a compromise. Since the Super35 format is extracted from the film in an optical process, there is the freedom to extract any part of the negative you like. Thus, the top of the video frame can be the same as top of the widescreen frame, thereby reducing the need to compromise the format.

Having a common top is most important, as the information in the upper part of the frame is nearly always more important than the lower part of the frame. Cutting a character off at the belt instead of across the chest usually makes no difference, whereas cutting off the top of the head can be very awkward. The fact that the sides of the frame are different is still inescapable and will remain so until widescreen TV becomes a standard.

The drawbacks of Super35 are the additional cost of the optical print and the slight increase in grain and contrast due to this extra step. However, with the recent improvements in film stock, these are now quite acceptable. Many major films have been shot in Super35. Nearly all cameras in use today have their optical axis centered on the Academy aperture. As a result they are not centered on the full negative. For Super35, the lens mount must be repositioned by 1mm to recenter it on the full aperture. Only lenses that cover the full area of the negative can be used. The ability to use standard spherical lenses and the lessened requirement for lighting and schedule may offset the cost of the optical print. Once the Super35 full aperture is shot, any number of formats can be extracted from it. Except in unusual cases, a hard matte would not be used to mask the negative. These illustrations demonstrate what would happen in the postproduction process, not what happens in the camera. This is one of the beauties of this process: a single negative can be used for many different formats. See the ground glass chart for some of the combinations of Super35 and other formats (Figure 19.14).

Figure 19.9. A 2.20:1 widescreen aspect ratio on *Blade Runner*. The wide format allows for a graphic use of negative space and an off-balance frame.

If the film is going directly to video, there is no reason to waste film for an optical sound track. In this case, it is possible to use Super35 as it is. This is sometimes called *Super TV*.

3 PERF

All of the above methods are adaptations that deal with one basic built-in drawback of 35mm film; one that goes back to its very invention. Since its inception, 35mm has been advanced by 4 perforations for each frame. Unlike the aperture gate, this is not something that is easily changed. Worldwide, there are tens of thousands of cameras, optical printers, lab equipment, telecines, and theater projectors that are based on this system (Figure 19.15). Some systems advance the film by three perforations for each frame. Specially modified cameras must be used for this process.

Since it would be impossible to change the entire world system to suit this, the 3 perf negative is converted at some stage to 4 perf. The original advantages in shooting remain. If the project is going directly to video, then it is not a problem, except that the telecine must be suited to this process. Arriflex can now make any of their cameras available in 3 perf formats. 3 perf systems have the advantage of using less film stock and longer running times out of each mag. Many television shows shot on film use 3 perf. It is also popular on features with a limited budget.

Figure 19.10. 65mm 5 Perf Aspect ratio: 2.28:1 2.066“×.906” 1.872 sq. in. 54.48mm×23.01mm 1207.58 sq. mm

2-PERF TECHNISCOPE

Invented by Technicolor Rome, *Techniscope* is a 2-perf format for very wide screen but with half the film stock usage of normal 35mm. It was used by Sergio Leone on many of his “spaghetti western” films. This is a popular format again and with the greatly improved film stocks now available, excessive grain is not as much of a problem.

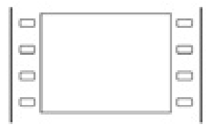

Figure 19.11. Super TV Aspect ratio: 1.33:1 .945“×.709” .67 sq. in. 24mm x18mm 432 sq. mm

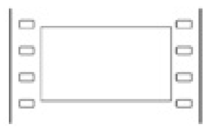

Figure 19.12. Super35 for 16x9 (High-Def). Aspect ratio: 1.78:1 .945“×.561” 24mm×13.5mm 324 sq. mm

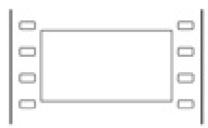

Figure 19.13. Super35 for 1.85. Aspect ratio: 1.85:1 .945“×.511” .483 sq. in. 24mm×12.98mm 311.52 sq. mm

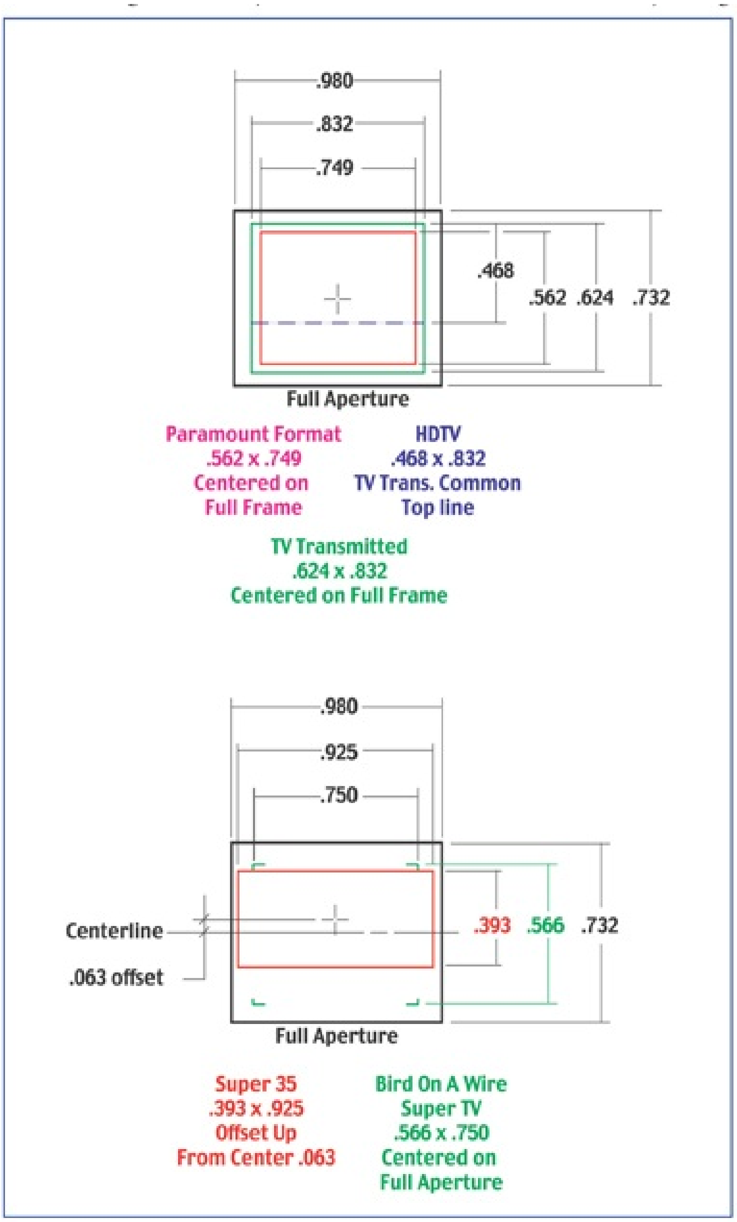

Figure 19.14. (left) Dimensions of some typical Super35 formats.

UNIVISION

Another variation of 3-perf was developed by legendary cinematog-rapher Vittorio Storaro in collaboration with his son. It is called *Univision* (sometimes spelled *Univisium*). Storaro's conclusion was that too much film is being wasted between frames; also, sound tracks are not optical anymore, so it is not necessary to provide room on the negative for them. In his articles and interviews, Storaro makes a convincing argument for this format as more flexible and universal.

Univision as he proposes it has a frame aspect ratio of 2:1, although other aspect ratios are possible within this format.

The following are some of Storaro's observations on this format: in normal widescreen film for theatrical release filmed in 1:1.85, there is a lot of wastage in camera negative. With Univision's 1:2 aspect ratio and digital sound (the sound track not on the film itself), using only three perforations per frame on the 35mm negative and the positive, it is possible to have:

- 25% saved on camera negative, with absolutely no compromise in the quality of the image. It actually increases the average quality of any panoramic and anamorphic picture.
- 25% more shooting time in the camera magazine; less frequent mag changes.
- Quieter running cameras because less film is moved through them.
- No need for anamorphic lenses on cameras and projectors.
- No distortion of horizontal and vertical lines due to the use of anamorphic lenses.
- Greater depth-of-field due to not using anamorphic lenses.
- Less lighting required because of spherical lenses.
- No use of anamorphic lenses.

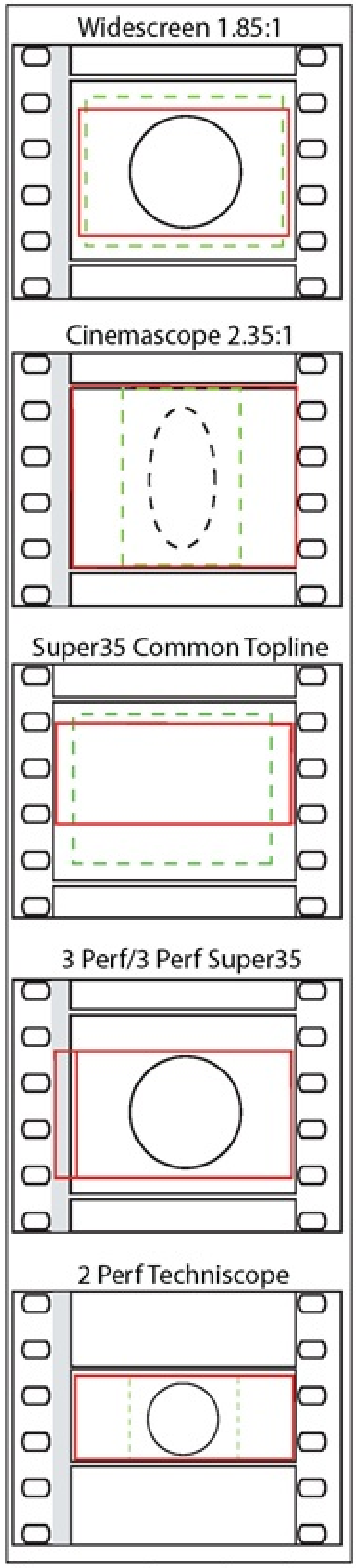

Figure 19.15. Comparison of 35mm film frame formats. (Courtesy of FotoKem)

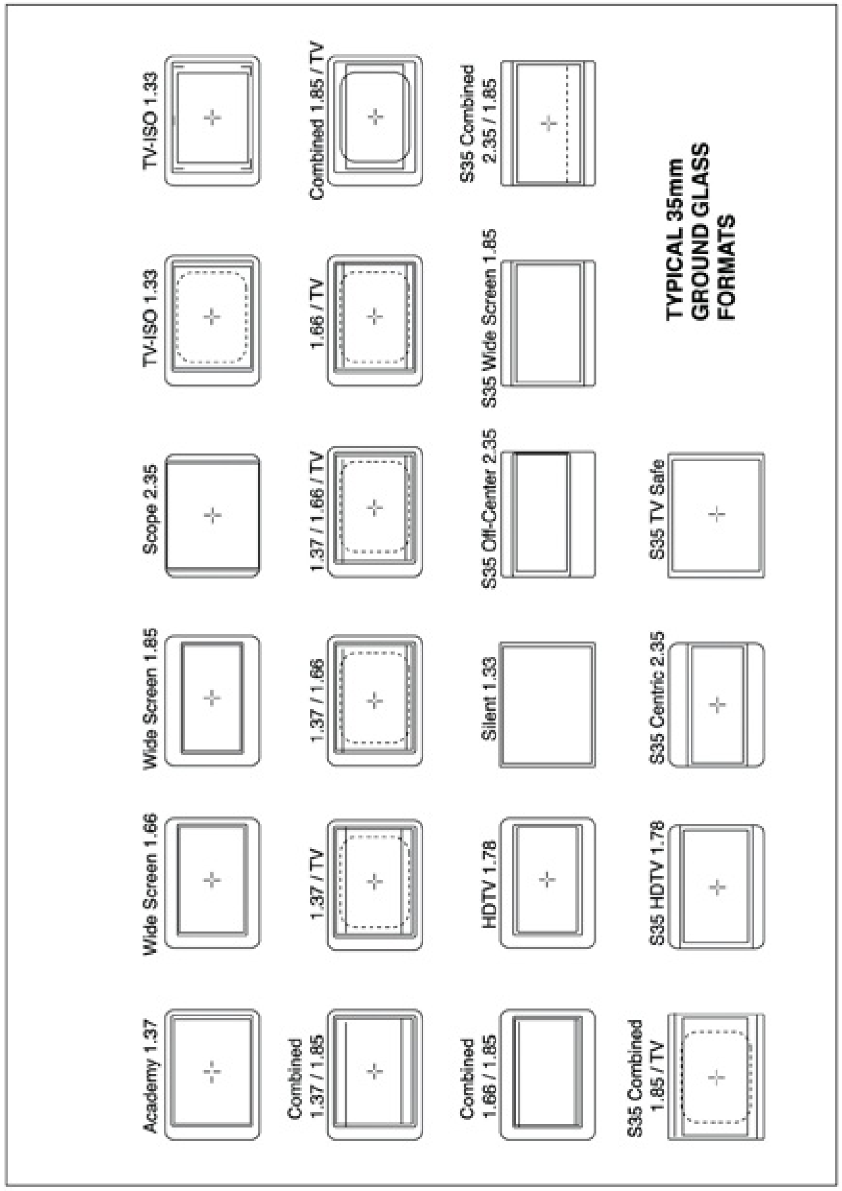

Figure 19.16. Various groundglass markings for 35mm film formats.

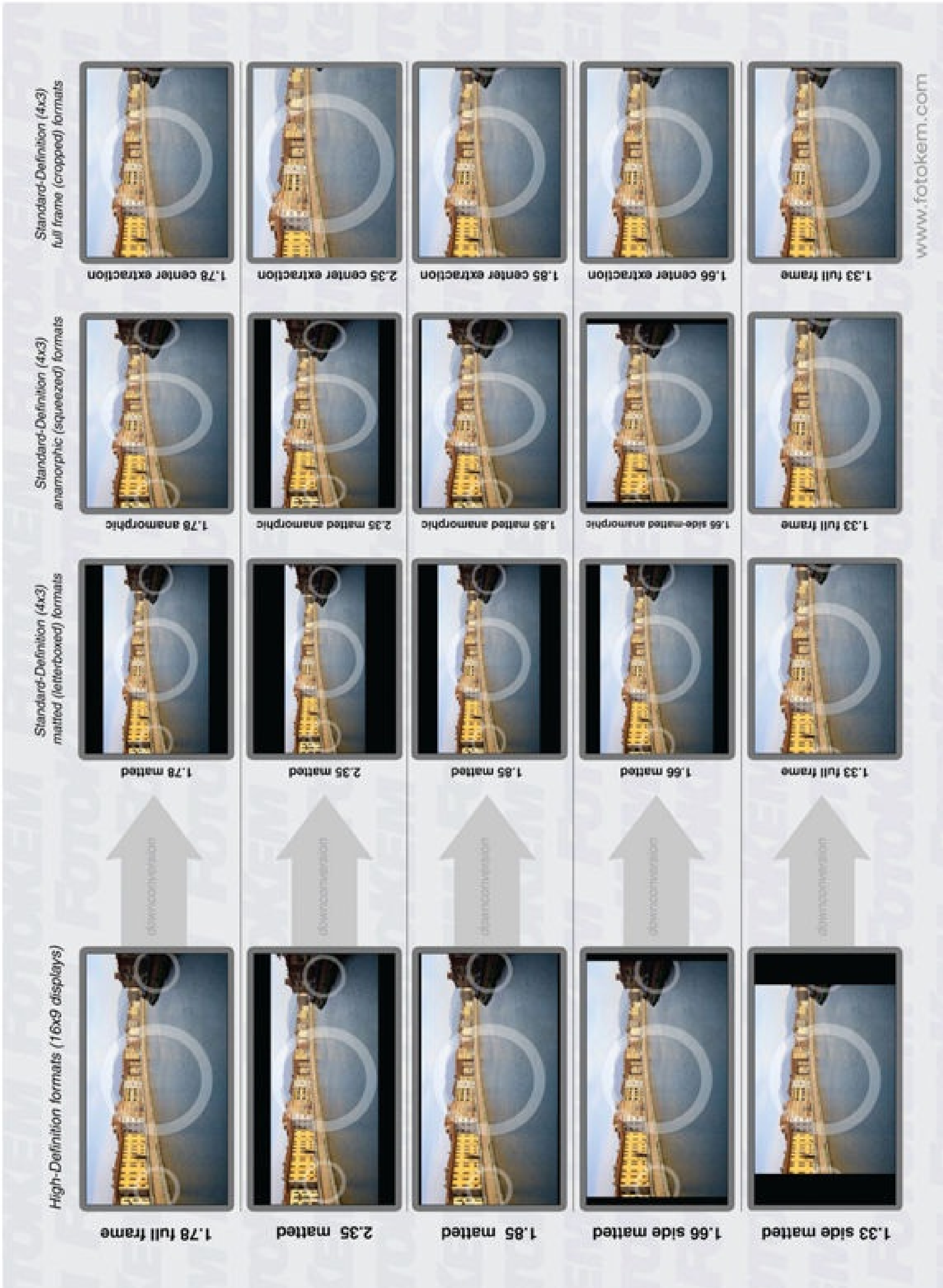

Figure 19.17. A graphic comparison of 35mm formats by FotoKem. The circles help illustrate if there is any anamorphic squeezing. (Courtesy of FotoKem).