





Alice in Bluescreen Land

The Art and Science of Optical Compositing

Illustration by Kevin Marburg.
Photography by Mark Madeo.

Optical Compositing has been at or near the heart of film and video effects for almost as long as there have been special effects. But even though the process is commonplace, general understanding of the process isn't. Join us as we detail how to shoot a subject, such as an actor, against a solid blue or green background, and then replace that background with scenery from a separate source.

by Mark Christiansen

The first challenge of this article is to simply decide on a generic term for the process we're describing. Optical composite, bluescreen, greenscreen, color key, matte pulling, and color difference are all used fairly interchangeably to describe the same process. Chroma key is sometimes also considered synonymous, but that term generally specifies the cruder composites generated by analog video equipment. Envision a TV weatherman standing in front of a satellite map. Let's go with bluescreen.

You might ask what's so tough about deriving an alpha matte from the blue or green areas of an image. Photoshop's Magic Wand tool does that in one step. The difference between the Magic Wand's crude bitmap-based key or a matte from an old fashioned chroma keyer and an elegant optical composite is found in soft-edge subtleties, in fine details such as hair, and in semi-opaque objects such as glass, smoke, and shadows. Realistically marrying this subtle imagery to a separate background is the true art of the bluescreen process and we'll explore that in this article.

Just as they revolutionized everything else, computers also revolutionized the

process of deriving a matte from a key color. Even so, if there's one message that should be gleaned from this discussion it's this: No amount of clever post production can undo the damage of poorly recorded source material. Shooting on a bluescreen set can be expensive, and directors often rush through the shoot chanting a little mantra: "fix it in post, fix it in post." In many cases, the mantra isn't enough.

I will attempt to clarify what can, in fact, be easily fixed with commercial desktop software, and what must be carefully corrected on set.

The modern color compositing process has three essential steps: Preparing and lighting the set, recording and transferring the moving images to a digital format, and processing those images. The chronological order of these steps happens to reflect their decreasing order of importance.

Preparing the set

The shoot determines 90 percent of the success or failure of an optical composite shot. And, unlike with the steps that follow, the shoot can't be fixed later unless you're working with unlimited time and an unlimited budget. These exist only in fables. During the shoot, get things right the first time.

The success of your project doesn't depend on whether you choose a blue or green background color. Just satisfy the one fundamental color requirement: Ensure that the background and the subject are different colors. That's it.

Okay, but how different must they be? Not very. For this article we shot Alice in a light blue dress against a pure blue background. We played it fast and loose because her dress is a different shade of blue; it's lighter and it contains quite a bit of green and a little red.

If you're concerned that you haven't worked with bluescreen enough to easily spot the green and red components of the dress's blue, don't worry. On your projects, you can always shoot a still of your costume and props, digitize it into your computer, and analyze the RGB composition of the digitized image with image editing software.

While you can be flexible with your choice of costume and props, you must remain a purist when it comes to choosing a background color. The background should ideally be either a pure blue or a pure green with no red. Red is the color most present in all human flesh tones. Pinkish humans are photographic subjects far more often than greenish alligators. ➤



Color Levels

We placed Alice in front of a bluescreen instead of a greenscreen because the fabric of her dress held considerable green and red components (see top image). Our background wasn't pure blue, however. When fully lit, it registered no red and half as much green as blue (see middle image). Bluescreens with a bit of green in them, are common and generally acceptable. But since Alice's dress also has green in it, a pure blue or green background would have been better for our shoot.

If you have the budget, rent a stage with a hard cyclorama (cyc), which is far preferable to using a portable cloth chroma key backdrop. While the cloth backdrop will cost about \$150 per day and a cyc can run to \$600 or more per day, the extra expense is worth it. A cyclorama has smooth rounded corners and no wrinkles. Corners and wrinkles induce shadows and uneven lighting.

Beware of and avoid cycs with imperfections such as plaster fills. Such problems create shadows under hard light. The cyc should be painted using only Rosco-brand

paints. Rosco makes blue and green paints specifically for bluescreen work. A gallon costs about \$50. Look for Rosco Blue, Green, or Gothic Ultra Blue.

While Rosco aims Ultra Blue at film shoots (which can handle more contrast than video can) with subjects that aren't bright white, I have successfully used it shooting reflective white costumes on Beta SP. Ultra Blue is also advantageous in that as a darker shade it generates fewer hot spots and reflections.

If you're on a tight budget and won't have to move your set (or pan across corners), consider buying a roll of linoleum floor covering and paint the back side. That will give you a smooth transition from the backdrop to the floor. But you'll be limited to a width of about eight feet.

Even the best paint can vary its color from batch to batch. In bluescreen photography terms, batches of the same paint can vary up to a full stop. As a preventative against this variance, mix all of your background paint together in one big vat before you paint your background.

Ultimatte wisely warns against using many of the seamless paper backgrounds that can be purchased at photo supply outlets. Reportedly, the the catch here is that the process of adding fire retardant to the paper also adds red.

When considering building your own set, remember that time is money. The less perfect your background, the more difficult it will be to light, shoot, and process your subject. Renting can be the most economical way to get the set you need.

If you decide to shoot on green, make sure to find a color that you can stare at for long periods. One production used a green paint so chartreuse that the crew repainted the set blue to reduce their nausea.

Of red, green, and blue, I personally prefer blue—it's the least present in skin tones. I can't stand what green does to light hair and skin tones, even though green's effects can be corrected. I also find blue more soothing to look at on the set and during those long hours of post production.

Moreover, blue's digitally-opposite color is yellow, while green's opposite is magenta. If you are lighting your subject for daylight or with normal incandescent light, your yellow lighting will help control any reflective items, such as eyeglasses or white shoes, that your subjects may be wearing

On the other hand, JPEG-like compression doesn't subject green to as much compression as it does blue. We'll talk about this more later.

Previewing on set

The two factors that most give away the illusion of a smooth bluescreen shot are discrepancies in lighting and in perspective between the foreground subjects and background matter. There are some clever methods for avoiding these problems by first deciding what your final background will look like before your shoot takes place.

I'm not suggesting that background art must be completed before any footage can be shot. Rather, the crew on the set will work efficiently if they know what lighting and camera placement they're trying to match.

Generate the shot's background image with a computer or videotape and use a low-end chroma keyer to make a live test composite on the set before you roll the cameras. But don't go too low-end. A consumer chromakey switcher will stumble on lighting situations that are no problem for a more sophisticated hardware keyer.

I've had good success using an older version of a hardware Ultimatte. The Ultimatte 4 is cheap to rent because it's so old, but it's still sophisticated enough to let you know if the set is well lit, and to give you a good representation of how the final composite will look. If you're shooting film, you'll need a video tap for the hardware keyer.

Make your background image as good a representation of the final background as possible. A photograph, a rendering of a 3D computer model, or even a sketch is better than nothing. Ideally, your image should specifically describe the perspective, placement of key lights, the relative light level, and any objects with which the foreground characters will interact. The image will help your camera operator find a good camera position. It will also help the gaffer and grips match the lighting and, if applicable, the scenery of your background.

If you roughed out the image with 3D software, having a computer on set allows you to make subtle changes ➤



in perspective. For example, if your original rendering placed the virtual camera higher than you can actually get with a real camera on set, you can make a quick change to your 3D background and evaluate it with the set.

Such a mockup will also help you to keep in mind your best digital friend, the garbage matte. This is one fix-it-in-post solution that always works reliably. Don't fall into the mindset that everything you monitor on the set needs to be filled with the background color. If you are absolutely certain your foreground subject never passes in front of a given area of the set, don't worry about it. Digital compositing tools make easy work of masking out the edge of the set, the ceiling grid, or whatever might show up at the periphery of the action.

Good lighting is essential

Lighting your background correctly is every bit as important as lighting your subjects, and the two should be lit separately. It's a job best suited to a seasoned pro.

Even experienced camera operators can run into trouble on their first bluescreen shoot. For example, on one of my shoots the lighting person prelit the background very brightly. Since the background lighting forced the camera to be stopped down to f11, we had to add nearly a dozen spotlights to the foreground to keep the actors from appearing in silhouette.

But don't leave your background too dark. Boosting camera gain to compensate for an underlit stage only increases signal noise in the recording. Typically, you light the background first and then light the foreground to the same 1:1 overall level.

Expect to use at least four fill lights, one high and one low on each side, to light a



Illustration by Janell Umemoto. Photography by Mark Madeo.

full-height background. There are two popular types of light for lighting a background.

One type is generally called "space lights," with six 1,000 watt or "1K" lights arranged in a spoke pattern and covered with a white silk sock. These run about four feet high and three feet in diameter. You can hang four above the background of a small stage. The other are "skypanns." All gaffers are familiar with these round 2K or 5K lights with a three-foot diameter. Either of these types of lights can produce an even background.

The most common alternative is to use fluorescent lights, rather than tungsten. The narrow shape of fluorescents makes them

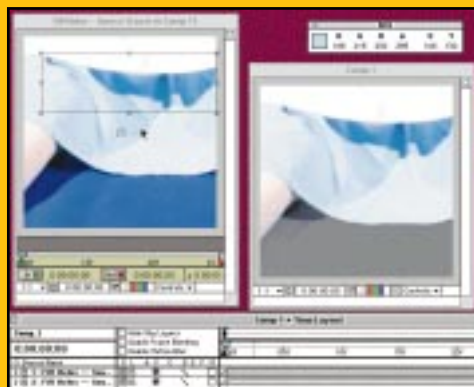
especially useful for fill lighting near the floor. But gaffers don't like fluorescents because it takes more instruments to light the same space.

Keep the background and foreground areas of the set separated by a good deal of space, although "a good deal" is relative to the size of the stage. Try to get ten feet between the subject and the background to allow the background's diffuse light to avoid picking up spots aimed at the foreground.

Your goal with foreground lighting is to match the lighting of the final scene. Use only enough lighting to do that convincingly and no more. To bring out dimen- ➤

Fill Holes

Sometimes it's easiest to spot problem areas by placing an image and its matte over a bright yellow or midlevel grey color that clearly shows holes. In this shot, Alice's apron put part of her dress in shadow, reducing luminance and making separation difficult. If your subject isn't moving a lot in a shot, here's a trick: Fill the hole with a patch of the unmatted source image. Since the backing layer of our unmatted source was well within the boundaries of the matte's edge, we maintained the illusion of a subtle edge.



personality in low- to medium-lit interiors use diffuse fill lights complemented by key lights.

If your foreground subject will appear against a bright background, you may need to incorporate edge and side lighting to avoid a dark line around the subject. Be cautious with this technique, though. Against a dark background, you might create a hot outline around the subject. This outline can only be removed in post by choking the matte, which is a compromise to avoid.

One really nifty budget-saving technique for matching exterior lighting is to actually shoot outside. You may need fill lights to flatten light on the background, but you will avoid the great cost and difficulty of recreating exterior lighting on a stage.

Although a high ratio of key to fill lights may be common, beware of using too many key lights; they represent strong choices that cannot be undone later. In post you can add a certain amount of direction, color, and contrast to a foreground that was shot with soft, diffused

light. A warm fill light can be cooled off in post, but it's nearly impossible to undo a powerful key light that turns out to have been misplaced.

During the shoot, it's best to know how your final background will be lit. If you don't know how it will be lit, use fairly even fill lights complemented by a couple of warm key lights where you'll want some

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contrast, such as on faces. You can then add more color and contrast later.

Beware of hotspots on the set where light is more intense than elsewhere. If you aren't a professional camera operator, these can be difficult to see with the naked eye. Keep a light meter handy.

Don't aim lights straight down. They will reflect white light which washes out the background color and makes it unkeyable. Optical composites rely on a wide dynamic range of luminance and chrominance between the foreground and background. Less dynamic range means less detail in your foreground composite.

I'm a big proponent of lighting for shadows. Shadows help convince the eye that the foreground elements are locked to the background. But shadows make for a more complicated lighting setup and thus more time between setups.

Working in a blue or green void is very difficult for an actor. Giving him or her a physical environment with which to interact

is helpful. But it's also tricky to light. Even an item as simple as a wooden box painted blue can be almost impossible to light without picking up significant hot spots on the top or deep shadows on the sides. To avoid these problems, consider using a regular prop, such as a (non-blue) table.

Recording the footage

The other half of a successful optical composite shoot is capturing your images. Just as no amount of digital trickery in post can undo fundamental problems with lighting and perspective, shooting on anything but the best available recording medium can trash your entire project.

Always record in the highest quality, least compressed component video format you can afford. Assuming that 35mm film is out of the question, aim for Beta SP or D-1. If you can knock out your shoot in a day or a weekend, renting a Beta setup will cost about \$400, a reasonable price to help insure success. Avoid S-Video formats such as SVHS and Hi-8. S-Video separates luminance and chrominance but encodes all three-color components into one signal. For optical compositing S-Video is no better than plain composite video.

Moreover, approach with caution the new DV formats that add digital compression to the recording process. Since our eyes don't see color discrepancies in blue, JPEG-based compression schemes such as those used in DV, DVCAM, DVCPRO, and Digital-S reduce the information in the blue channel more than in the red and green channels. You can avoid some this trouble by shooting on green, but you'll still have to contend with compression artifacts.

Digital Betacam, with its 2:1 compression is the most acceptable of the com-



Garbage Matte

Never underestimate the power of the garbage matte. In the image on the left, our camera picked up light stands, equipment, and shadows around Alice's feet. The camera angle made it difficult to move the equipment out of the shot. As long as Alice never crosses in front of this equipment (or "garbage"), it's no problem to eliminate it in post. The yellow area in the image on the right shows the garbage matte masking the unwanted objects without negatively affecting the foreground. Had we shot a scene with Alice exiting the frame, we'd have had to ensure that she didn't cross in front of a light stand. If she had, we couldn't have used a garbage matte and would have had to paint the light stand out by hand.

pressed formats. I have seen it used successfully many times. The DV formats are riskier because of their higher JPEG-like compression ratios of 5:1.

Digitizing the footage

This step is the most straightforward. Use the best video capture you can. I like to use a digital disk recorder (DDR) to transfer from Betacam to Exabyte tape. Then I use Knoll Software's Missing Link to download the footage from Exabyte to my computer.

This transfer method offers the advantage of eliminating questions about the quality of the image transfer. What you see in the footage is the best quality image you can hope to work with to create your mattes.

But unless you have a DDR ready to go this solution can get expensive, especially on a larger shoot. Each Exabyte tape holds about a minute of D-1 quality uncompressed footage. Outside facilities charge about \$100 to digitize a minute of video through a DDR and onto Exabyte.

Let's say that for whatever reason you need to digitize via a digital video capture card instead. You can generally get satisfactory results with most systems that offer 2:1 compression. Artifact trouble begins at ratios above 4:1. Follow the same ground rules as in the previous section on recording footage—stay component, avoid compression—and keep in mind that taking footage shot in a compressed format and redigitizing it with a video board that adds its own compression can geometrically increase artifacts.

Not only do certain compression technologies reduce the blue channel more than others, but certain capture cards add their own problems for bluescreen work. For example, the older NuBus Radius VideoVision Studio may be fine for most video work, but with bluescreen it produces a dark line around the edge of the foreground subject. This line makes pulling a good matte difficult.

Luckily, digitizing, unlike shooting the footage itself, lends itself to trial and error. If you're having problems, send a sample of your footage out for a quick transfer via a higher quality mechanism. That will reveal whether your problem is with digitization or with the footage itself. Then, if you can afford it, you have the option of choosing an alternate mode of digitizing.

Illustration by Janell Umamoto. Photography by Mark Madeo.



Keying and compositing

Just what does separate a good keying tool from a bad one? At the lowest level are the digital equivalents of the old crude "chroma-keyers" like the weatherpeople use when standing in front of a live satellite map. If you look closely, you may see blue or green spill and an occasional chunky looking hole in the image.

Chroma keys deliver a matte signal that is truly bitmap in nature. Each part of the screen is either on or off. Chroma keys have little or no ability to show edge detail at variable opacity. Good-bye subtlety.

The Chroma filter in Premiere and the Color Key that ships with the standard version of After Effects start by making each

pixel fully transparent or opaque. Each adds softening tools that merely add blur to the edge. It's safe to say that any image will benefit from a better method, unless the somewhat retro Chroma look is what you're after.

Sometimes, all you'll need is software that makes a single reference to the key color. For example, with Premiere's Bluescreen and Greenscreen controls, you keep two numbered sliders as far from one another as possible. The difference between the numbers describes the range of luminance and chrominance difference between the foreground and background.

The Color Difference Key in After Effects does essentially the same thing but makes two passes. The first compares ➤



Bad Hair Day

Ideally, we'd like to preserve the subtle wisps of Alice's hair that we see in the source image at top. But in this shot, hair pays the price for poor lighting, an uneven background, and a costume color too close to that of the background. Dealing with these problems reduced the amount of detail in semi-opaque objects such as hair. That means we'd have to let the hair be noisy and pixelated as in the middle image, or we would have to choke the matte for better behaving, but clumpy looking, hair like in the bottom image.

light foreground and background pixels, the second compares dark pixels from each image. This method is a little more sophisticated than Premiere's, but the quality of your matte still depends on keeping a 30 to 40 percent difference in value between the input white and input black levels.

The white and black inputs require separate spill suppression where you desaturate the background color that's reflected onto your foreground characters. But this two-channel suppression may leave a light or

dark halo around the subject known as a "matte line." I recall the story of one Industrial Light & Magic (ILM) employee in the early days of digital mattes who became so obsessed with matte lines he started seeing them everywhere, like around freeway signs on his way to work. Don't let this happen to you.

Matte choking, or minimizing the matte channel evenly by a certain amount, starts to introduce some real inaccuracy. Since the choking function no longer refers to your source image, it works only with the alpha channel that your keyer created.

In real world terms this means lots of problems. If you have a lot of blue spill on the shoulder of your actor, you may need to keep the initial matte loose to avoid creating a hole in his or her shoulder (where you see the background through the character). You might also have to sacrifice hair detail in order to keep the shoulder free of halos. Clumpy looking hair is a prime giveaway of mediocre mattes.

Or perhaps the floor got dirty during the shoot and you keyed for shadows. The shadows start out noisy and dance all over the place. Then, when you choke them, they turn into blobby, but still dancing, puddles.

This is when you need an advanced keyer such as the Ultimatte software plug-ins. The Ultimatte plug-ins start at \$1495 and are currently available for many leading Mac, NT, and SGI compositing packages. Versions are available for Discreet Logic's Flint and Flame, Cinefusion, Alias|Wavefront Composer (soon), Adobe Premiere (Mac and NT), Adobe After Effects, and in:sync Speed Razor.

Ultimatte eliminates the need to choke a matte (i.e., reduce blue spill). Instead, it makes a comparison between the original background and the added foreground subject. You roll cameras on a bare stage at the start of each set-up to get a source, or reference image of the background. In post, Ultimatte's Screen Correction difference algorithm makes a pixel-by-pixel comparison between the empty background and your final shot. But as soon as you change the camera position, the screen correction reference is no longer accurate.

Blue spill and dirt on the floor become suddenly manageable. Your foreground doesn't need choking. The shadows are soft and realistic.

Ultimatte knows what you started with and separates dirt in the reference image from shadows your subject creates. The software also helps correct for grainy film and even for grainy compression. If compression is your problem, use the built-in grain killer functions as well as the flare controls.

Get it right the first time

Experts will tell you that each bluescreen shoot brings with it at least one unwelcome surprise. If your budget requires you to decide between fancy equipment or hiring a couple of experts, hire the experts (provided they have solid effects experience).

Hire a lighting person who will work hand in hand on the set with the artist who will perform the compositing later on. Many of the best optical compositing talents won't even bid on, let alone work with, jobs that were shot without their participation. I know I won't. Having an expert on your set will help you forego expensive surprises later on.

If you get things done right on set, everything else will fall into place. Sure, you may need to experiment a bit in post. But mistakes you make on the set will hurt you later on, either in the quality of your final composite or in the size of your budget. No matter how fancy your equipment and no matter how talented your artists, you can't fix everything in post. **DV**

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Rosco Paints	Rosco	RS#205
Ultimatte Plug-ins	Ultimatte	RS#206