Welcome to the world of Blue Screen / Green Screen compositing! Once the exclusive domain of Hollywood special effects artists, blue screen compositing expanded to include video and computer imaging. There are many mysteries to the succesful execution of a blue screen composite and considerable confusion as to what a blue screen composite is.

What is Blue Screen Imaging?

(First a note about terminology: when I first wrote this page in 1995, the common term in use was "blue screen" compositing. Since then the vogue has shifted to calling it "green screen". The broader term from the days of film optical effects is "traveling matte composite", but that has fallen out of favor. For now, this page will mainly refer to the process as blue screen, but almost everything here applies to green screen effects too, except where noted.)

Creating a blue screen composite image starts by photographing a subject in front of an evenly lit, bright, pure blue (or green) background. The compositing process, whether photo-chemical or digital, replaces all the blue in the picture with another image, known as the background plate.

Blue screen composites can be made optically for still photos or movies, with dedicated real time hardware for live video, and digitally using software to composite still and motion images. Until the the 1990s most blue screen compositing for films was done optically, and all television composites were done using analog real time hardware.

In addition to blue, other colors can be used. While green has become the most common; sometimes red has been used for special purposes.

Another term for Blue Screen is Chroma-Key. Chroma-Key is a television process only. A more sophisticated television process is Ultimatte; also the name of the company that manufactures Ultimatte equipment. Ultimatte has been the ultimate in video compositing for 20 years. With an Ultimatte unit it is possible to create composites that include smoke, transparent objects, different shades of blue, and shadows. Ultimatte now makes software that works with other programs to create digital mattes, either as a standalone program, or as a filter for programs such as Photoshop and After Effects from Adobe.

How does Chroma Key work?

The Chroma Key process is based on the luminance key. In a luminance key, everything in the image over (or under) a set brightness level is "keyed" out and replaced by either another image, or a color from a color generator. (Think of a keyhole or a cookie-cutter.) For example, a title card with white on black titles is prepared and placed in front of a camera. The camera signal is fed into the keyer's foreground input. The background video is fed into the keyer. The level control knob on the keyer is adjusted to cause all the black on the title card to be replaced by the background video. The white letters now appear over the background image.

Luminance keying works great with titles, but not so great for making live action composites. When we want to key people over a background image, problems arise because people and their clothing have a wide range of luminance tones. Hair, shoes and shadow areas may be very dark, while eyes, skin highlights and shirt collars can approach 100% white. Those areas might key through along with the backdrop.

Chroma Key creates keys on just one color channel. Broadcast and high end consumer cameras cameras use three independent sensors, one for each primary color-- Red, Green and Blue. Many cameras can output these RGB signals separately from the composite video signal. So the original chroma key was probably created by feeding the blue channel of a camera into a luminance keyer. This works, sort of, but soon manufacturers created dedicated chromakeyers that could accept all 3 colors, plus the background composite signal, and the foreground composite signal. This made it possible to select any color for the key and fine tune the selection of the color tint, chroma level and luminance level.

As keyers became more sophisticated, with finer control of the transition between background and foreground, the effect became less obvious and jarring. Today's high-end keyers can make a soft key that is essentially undetectable. Some of the best modern Special Effects Generator Switchers from Grass Valley Group, Sony, and others can create composites rivaling the performance of a dedicated Ultimatte unit. (Though they are not as good at removing blue spill, working through water or fabric, etc.)

Why Blue? Can't other colors be used?

Red, green and blue channels have all been used, but blue has been favored for several reasons. Blue is the complementary color to flesh tone--since the most common color in most scenes is flesh tone, the opposite color is the logical choice to avoid conflicts. Historically, cameras and film have been most sensitive to blue light, although this is less true today.

Green has its own advantages, beyond the obvious one of greater flexibility in matting with blue foreground objects. Green paint has greater reflectance than blue paint, which can make matting easier. Also, video cameras are usually most sensitive in the green channel, and often have the best resolution and detail in that channel. A disadvantage is that green spill is almost always objectionable and obvious even in small amounts, while blue can sometimes slip by unnoticed.

Sometimes (usually) the background color reflects onto the foreground talent creating a slight blue tinge around the edges. This is known as blue spill. It doesn't look nearly as bad as green spill, which one would get from green.

Traditionally, a single camera was used as the Chroma Key camera. This creates a problem on three camera sets; the other cameras can see the blue screen. The screen must be integrated into the set design, and it is easier to design around a bright sky blue than an intense green or red. However, modern Special Effects Generators can accommodate multiple camera sources, whether as RGB analog, or SDI video, inputs.

Lighting for Blue Screen

A considerable amount of mystery is usually attached to blue screen lighting design. Also, a number of myths have been nurtured through the years, most of which are only half true.

Myth #1 is the flat lighting myth. While it is true that the blue screen should be lit evenly, this is not true for the talent or other foreground subjects. They may be lit as dramatically as you desire. The trick is in lighting the foreground without screwing up the background.

Much depends on which matting process will be used. If you are using Ultimatte, then a great deal of freedom is available. On the other hand, Chroma Key is not nearly so flexible and has more restrictions. I am assuming that most of the readers are most interested in video or computer uses, so I will not cover lighting for film mattes. Also, traditional photochemical film matting has pretty much completely dropped out of use, as the cost of creating digital composites from film masters has plummeted.

Ultimatte units have controls that allow for "cleanup" of an uneven background and other adjustments to fine tune the matte. Ultimatte mattes can also maintain the background through shadows, veils, smoke, water, hair and other semi-transparent objects. Most Chroma Key units cannot even approach this level of subtlety.

One popular technique to minimize "the matte line" around the subject is backlighting. A straw, yellow, or CTO gel on the light helps to wash out blue spilling on the talent's shoulders and hair. (This technique is inappropriate for Ultimatte, as Ultimatte has a circuit that removes blue spill.)

If you are lighting a scene in which the subject does not need to be near the blue backing, then lighting is simpler because you can put distance between the subject and background. Generally you want the level of light on the backing to be the same as the level on the subject from the key light. In video terms, this would be between 60-75 IRE on a waveform monitor (as viewed hitting an 18% grey card, or caucasian face, not the actual screen itself), although slightly lower levels will usually work. It is most important for the screen to be evenly lit. If the talent is standing or sitting on blue, then it is more difficult, almost impossible, to have separate lighting. With primitive chromakey systems, shadows can create a lot of difficulty, and so you must use a flat and very soft lighting scheme on the talent to minimize the shadows.

Many different lights work well for lighting the backing. Cyc lights are the old standard. A newer light rig called a "Space Light" also works well, particularly for the floor. This is a set of lights pointing up and down into a cylinder of white diffusing fabric. The new flourescent fixtures are ideal also. Some people use HMI's, on the theory that they will punch up the blue by using a blue light on the backing and warm

tungsten light on the subject. Some special effects companies use transluscent blue screens that are back lit by dozens, even hundreds, of special blue flourescents.

An old favorite of pros and amateurs alike is a single thermonuclear fusion source, placed 93 million miles away. This light source gives perfect corner to corner illumination and makes a perfect match between the key level and backing level. Shadows are easy as it makes only one set of shadows. If you place a water vapor diffusion screen several thousand feet up, you get a great shadowless light. A thinner water vapor diffusion softens the shadows nicely. Those who are inexperienced at controlling these types of diffusion may want to use a large silk or other diffusion instead.

I'm serious--I've done some great mattes this way. If you're shooting spacecraft models, this can be the best method. Plus the lighting rental charge can't be beat. The Death Star trench scene in Star Wars used this very same light source.

A waveform monitor is an essential accessory on a video blue screen shoot. Since it displays a graphic representation of the lumninance levels in the scene, small variations in brightness are very obvious. A screen that looks good to the eye may have considerable gradual falloff from top to bottom. I would recommend using one on film shoots, in combination with a cheap video camera. The graphic display can be so much more useful in this case than a spotmeter alone.

Paints and Backings

The standard paints which almost everyone uses are from Rosco, the lighting gel manufacturer. They make ChromaKey Blue and Green, as well as Ultimatte Blue and Green. One of the reasons I dislike using green as a backing is that the green paint is difficult to apply and just looks hideous. There is nothing more unsettling than having to work on a stage that is completely covered in Ultimatte Green!

You can buy Rosco blue or green paint, fabrics, tapes and Photoflex backdrops directly from my links to Studio Depot.

Stewart Filmscreen of Torrance CA makes a backlit screen.

What is ULTIMATTE?

Ultimatte is a trademark of the Ultimatte Corporation, of Chatsworth CA. It is an outgrowth of work the company's founder, Petro Vlahos, did in the 1960s for the Motion Picture Research Council. The goal was to invent a better matting system for motion pictures. Electronic technology was not ready then for a film resolution system, but video could be achieved, and so the first Ultimatte units were created in the 70's.

It is useful to think of the Ultimatte process as a mixing process, not a keying process. This makes it possible to matte with shadows, hair, water etc. An Ultimatte uses the intensity and purity of the blue signal as a function to determine how much blending to perform between the foreground and background images. Another useful feature of the Ultimatte is the previously mentioned blue spill removal. Other circuits deal with glare, uneven or dirty blue backings, etc. It is possible to independently

adjust the color of the background and foreground plates. An Ultimatte used to have many knobs on its front panel, but the new digital units use a display screen and multifunction controls. There are models for both Standard and High Definition work. These all work in real time directly on the video sources.

In addition, there are very useful Ultimatte plugin filters for Adobe Photoshop, AfterEffects and Premiere Pro, Apple Final Cut Pro, and Avid. Although After Effects has an excellent matting filter of its own, it requires considerable manual tweaking of the controls to perfect the composite. The Ultimatte plug-in automates these functions, making the work of compositing much faster. Highly recommended and worth the cost if you have a lot of mattes to do.

A handy feature is Screen Correction, which allows the operator to create perfect mattes from really mediocre backings. With Screen Correction, a still is first recorded of the backing alone, with no talent or other non blue pieces. This recorded still is then fed into the screen correction input. The circuit cancels out all the uneveness of the backing before any foreground elements enter the scene.

Lighting for Ultimatte

Ultimatte Lighting is not so much difficult as it is misunderstood. Ultimattes can retain shadows onto the background plate. (As can other advanced compositing software programs, such as Aftereffects.) Yet camerapeople often run into trouble trying to create a shadow! This happens because they first light the blue and the subject with an overall flat light and then add a light on the subject to "cast" a shadow. They see a "shadow" on the background, but it doesn't show on the matte. The shadow is still lit by the overall key. The new light is pointlessly creating a brighter area around the shadow.

The backing should be lit to the same intensity as the key light. So to retain shadows, in which the shadow is actually darker than the rest of the backing, the same light should be used to light both. Also the light must be even.
If there are darker corners, then the composited background will be darkened in the corners also! You can use this effect to improve the look or even relight a background plate. Since a shadow on the backing becomes a shadow on the background image, the background can be "touched up". Very useful for backgrounds created in computer modeling programs, which often have very bad and artificial appearing lighting tools.

Blue gels can't be used on the backing, if they will also light the talent. Another big problem (with all blue screen work actually) is blue floors. They invariably have a slightly different shade of blue. This is because the light is glancing off them at a different angle from the wall. (This glare effect can be removed with a polarizing filter. The downside is the two stop loss through the filter. The camera will need to open up two stops or the set will need 4 times more light.) Try to position lights so they are pointing in the same direction as the lens, and not straight down into the floor. This will reduce most glare to a minimum. Where this becomes a bigger problem is set pieces such as blue desks and props that pick up glare from side lights and back lights.

Also, never use dimmers on the lights lighting the background blue or green. If you are in a facility with dimmers, only use the lights at a full 100% This is because lowering a light's intensity with a dimmer also lowers its color temperature, making it more orange, and therefore making the backing more orange, and less pure of a blue.

Another difficulty that causes beginning Ultimatte artists to tear their hair out is a lack of sidelighting. To the naked eye on the set, there may appear to be sufficient illumination on the sides of the subject. But the subject is in what amounts to a brightly lit blue bowl, and is bathed in blue bounce light. When the Ultimatte removes this blue spill, the subject effectively has no side fill light, and thus very dark shadows. If the background plate is bright, say a beach scene, the subject looks very out of place. In fact, the effect will almost look as if there is a brown matte line around the subject. So you need to provide the same fill lighting as the scene you are matting into would provide. This effect is easy to see if you are doing on set matting. If the matte is to be done in post, try to turn off as many lights as possible that only light the backing, while setting the subject's lighting. Generally it is best to start lighting the subject first, then adding fill light to the backing to even it out.

Film Compositing

Creating composites on film, for final display on motion picture film projection, is another specialty onto itself. While the lighting concepts don't really differ, the matting process is done optically and very different from electronic processes. By 2001, most feature films had stopped using the optical processes, in favor of scanning film negatives into digital form, creating the composite on a computer, and scanning them back out to film. I had hoped that someone would create a page detailing the fascinating steps involved in the optical creation of color-difference mattes for film but as of yet, no one has.

It is generally not recommended to shoot any elements destined for compositing in 16mm. This is because 16mm is more prone to image weave and unsteadiness than 35. Even if the camera has perfect registration, the transfer to video is problematic, as most transfer machines are not pin-registered. So the image can weave. Still, it is possible to get good results, but you should be in consultation with both your lab and your video transfer facility before shooting.

Video Camera and Format Recommendations

As a general rule, mattes will only be as good as the camera used to shoot the foreground image. The background might come from any source, and doesn't affect the technical quality of the matte. But the foreground video must be as high in resolution and low in noise as you can afford. The best option is to Use a Studio or EFP Camera feeding an RGB or R-Y B-Y Y (Component signals used for Betacam, etc) or SDI signal directly into the inputs of an the Ultimatte Box or Chromakeyer. Today's high end cameras can achieve amazing resolution, well in excess of most recorders to record it. Next best is to directly record the camera component output through a SDI connection (Serial Digital Interface) directly to a digital format such as D1, D5, (uncompressed formats) DigiBeta, or DVCPro50, (lightly compressed standard definition digital formats.)

After recording, the foreground material can be played back as the foreground source into the keyer or Ultimatte device. Or it can be captured through component inputs to a digital file for use in one of the many compositing programs. DigiBeta, DVCPro50 and D9, though compressed slightly, sample the luminance and chrominance at the same rate as the non-compressed Digital Formats. This is the 4:2:2 sampling rate. In general this is considered more than adequate for most compositing in video.

The DV Format variations, miniDV, DVCam, and DVCPro, all record at the same compression and sampling rate. That is 5 to 1 compression, and 4:1:1 sampling. This means that chroma detail is sampled only half as often as the higher digital formats do, 4:2:2. There's been quite a bit of controversy as to whether or not DV25 formats such as these are even suitable for shooting bluescreens. And people have had some trouble getting them to work right, mainly having trouble with fine detail. My own experience seems to indicate that this is most apparent when compositing material that has been directly captured into a computer through the firewire interface. It's a little too clean, and aliasing and stairstepping seems to occur at edges. It does seem to be affected by the codec used in the software program for DV.

It is possible that it is actually better to capture this material through an analog component interface. This seems to smooth out the detail, so it isn't so sharp and obvious at line edges. In general though, my recommendation is to use at least a camera that records with a 4:2:2 sample rate, such as DVCPro 50 or D9, or one of the more expensive formats, such as Digibeta.
Yet I've seen really great results, composited from material shot on DV, specifically this fun Music Video by Ryan McFaul. It's a tour de force of limited budget After Effects compositing.

Good mattes are affected by several factors, from lens quality to resolution to signal to noise ratio. If you are shopping for an inexpensive camera that can be used to shoot blue screen foregrounds you can't really go any lower than a three chip miniDV camera to get decent results. Single Chip cameras simply don't have the color resolution neccesary. These under $2500 to $9000 cameras aren't going to give the same results as a Panasonic, Sony, or Ikegami camera costing tens of thousands, but they can give very good, believable results.

At the present time, the best low end three chip cameras are available from Canon, and Panasonic. Sony introduced the first one, the famous VX1000. I've seen it give good results in After Effects composites.

Canon's standard def entries are the XL2, and the less expensive, smaller, non-interchangeable lens GL2.. The XL2's advantage is better, interchangeable lenses.

My own **personal** favorite in the standard def miniDV range is the Panasonic AG-DVX100b camera is getting rave reviews. It shoots true progressive frames at 24-fps, for a true film look. The progressive approach really helps with creating composites in digital compositing software, as it eliminates the interline jaggies caused by interlace scanning.

The best way to go nowadays is HD. While Sony, Canon, and JVC all make some great sub $10k HDV cameras, they're not all ideal for use in pulling mattes, because of the huge amount of compression they use to squeeze an HD signal on to an HDV cassette tape. Compositing software benefits from having as much information as possible to get smooth transitions at the edges between the subject and the background, and HDV compression just throws away to much information. What I do like, and have seen great results from, is the Panasonic HVX-200. This camera records the same DVCPro100 format as its bigger cousins, that cost tens of thousands of dollars. It only records to solid state P2 RAM cards. DVCPro100 compression tosses out much less information than what HDV does. Having said that, there are other cameras worth looking into, the Canon XL-H1 and the JVC GY-HD230U. These cameras have uncompressed HD-SDI outputs, though they only record in camera to HDV tape. But it's possible to record their HD-SDI output channel uncompressed to a hard drive RAID, through a Mac or PC equipped with an HD-SDI capture card from AJA or Blackmagic Design. I've used the Canon, it makes a great HD picture for the price, while the JVC has more potential professional production flexibility and some higher quality lenses available.

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