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

**What is Blue Screen Imaging?**

Creating a blue screen composite image starts with a subject that has been photographed in front of an evenly lit, bright, pure blue background. The compositing process, whether photographic or electronic, 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, electronically for live video, and digitally to computer images. Until very recently all blue screen compositing for films was done optically and all television composites were done using analog real time circuits.

In addition to blue, other colors can be used, green is the most common, although 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 Aftereffects.
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.) Primarily this is used in the creation of titles. 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 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 background.

Chroma Key creates keys on just one color channel. Broadcast cameras use three independent sensors, one for each color, Red, Green and Blue. Most 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 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.

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 basically invisible.

Recently I have been working with the Grass Valley Digital 4000 special effects switcher. This unit makes beautiful chromakeys from a good source. In combination with Hitachi SK2700w studio cameras the results are stunning. Fine hair detail is not lost and shadows and other variations in the backing can be maintained or dialed out. However it doesn't have the capability to remove blue spill, as an Ultimatte does.

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 it's 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, whereas 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.

Usually only one camera is 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.

**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 must 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.

A great deal depends on what 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 (perhaps someone with greater experience in that area can create a page for film matting?)

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, 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 lighting scheme on the talent to minimize the shadows.

Many different lights work well for lighting the blue. Cyc lights are the old standard. A newer light rig called a "Space Light" also works well. This is a set of lights pointing up and down into a cylinder of white diffusing fabric. The new florescent 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 florescents.

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 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 video level 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 is so much more useful in this case than a spotmeter.

Paints and Backings

The standard paints which almost everyone uses are from Rosco, the light 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. Modern units from the Model V on up can 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. The Current Model is the "9" and there are also models for High Definition work.

In addition, there are very useful Ultimatte plugin filters for Adobe Photoshop and AfterEffects--among other programs. Although the After Effects production bundle 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 unevenness 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 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 composites 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, almost all of which 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 it's 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 suddenly has no side light, and 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. In the last ten years, most feature films have 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. One advance is from Eastman Kodak. Their motion picture film division has created a new stock specifically for shooting foreground film elements. The name of the stock is SFX200 and is only available in 35mm. I've used it once, and it seems to perform quite well.

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) 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.

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 4 thousand dollar cameras aren't going to give the same results as a US$50K Hitachi or Ikegami camera, but they can give good, believable results.

At the present time, the lowest end three chip cameras are available from Canon, Sony, and Panasonic. Sony introduced the first one, the famous VX1000. I've seen it give good results in AfterEffects composites. There was a pro version, the VX2000, which was operationally different, but about the same in quality. Since then they've introduced the TRV900 and it's companion Prosumer version the PD100a. They followed these up with the PD150, which is still under $4000.

Canon's Entries are the XL1, the GL1, and the upgrade to the XL1, the XL1s. The XL1's advantage is better, interchangeable lenses. The GL1 is a smaller camera, which seems to give similar results to the PD150, and is technically more of a consumer grade camera. The current "s" version of the XL1 adds an analog video input, and a continuously variable shutter for synchronizing to computer displays. These two features are a great addition to this camera.

Panasonic also sells a couple of cameras in this Price Range, though the model numbers seem to change more frequently than for the other cameras. The ones I've used have seemed similar in quality to the Sonys.

My own personal opinion is that the Canon XL1s is the best of this group, for resolution and general image quality. The others are good cameras, and I've used most of them, but generally for projects where it was more important to have a smaller camera.

Here's an interesting shot of a challenging shoot I did a few years ago. Ultimatte compositing combined with 3D Video. The Ultimatte used was an Ultimatte 45, and the camera is the innovative Ikegami LK-33--a stereoscopic video camera with matched zoom lenses. The trick in this shoot was to place Mr. Hennessy of Hennessy Cognac into a still of a French chateau interior. The normal perspective and alignment challenges were increased by the neccessity to place Mr. Hennesy in the correct spot in 3D space. For more information on shooting 3D video, check out Stereomedia!

Blue Screen Links!

I've set up links to buy paint, tape, and fabric for blue and green screen shooting through StudioDepot.com.

StudioDepot online is a great place to get all your expendables needs. They have it all, foamcore, books, rope, gels, the works!

Bob Kertesz is the Grandmaster of Ultimatte. His page is www.bluescreen.com. He's also developed a refinement of Ultimatte techniques to create very useful on set alignment mattes for film shoots. And, he now sells Ultimatte software online. Ultimatte specializes in matting hardware and software for motion pictures, stills and video. Photron sells a chroma key plugin for Photoshop

Books About Special Effects

There used to be no books available on this topic, now there are a few about digital compositing, though not about analog compositing or lighting:

Digital Compositing for Film and Video by Steve Wright

This new book seems very useful for anyone making digital composites from either film or electronic masters. It is not specific to any one software package, but rather focuses on the tools that all have in common, and more importantly really explains well how they all work.

The Art and Science of Digital Compositing by Ron Brinkmann

Another interesting book is Digital Compositing in Depth by Doug Kelly. It includes a CD-Rom and is specific to Digital Fusion and other software programs.

The following is a good general text on Special Effects:
   The Technique of Special Effects Cinematography Raymond Fielding's classic. It is about film optical/mechanical effects; not video or digital effects.
   Here is a page of Useful Books on Film and Video topics.

Feedback!

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Other pages by me that may be of interest:

The NTSC Video Signal

D/Vision Pro Non-Linear Editing Tips

My Home Page, with more links, and a resume.