



Image Integration is proud to provide the most complete resource for those working with digital images.

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Color informs our visual perception. Besides the original intent of the color itself, color also influences our perception of shadows and highlights, intensity and subtlety, and contrast. Without accurate color rendition we do not fully perceive an image. Yet we all have seen for ourselves that colors change as we view the same image on different workstations. How can we share an image electronically so others see what we see? The answer: we must manage the delivery of color. In other words, we must control the three processes which define color in electronic display - Gamma, Brightness and Hue - at all stages of a digital image file's existence. Welcome to the world of Color Management.

The different stages at which color management plays a crucial part in an image's life:

- Creation stage - the scanner or digital camera and its software
- Correction stage - image work stations and image manipulation software
- Production stage - workstations and multimedia authoring software
- Viewing stage - the end user's monitor, its display settings and viewing environment, plus the software displaying the image

Fortunately the printing world has been trying to resolve the problem of color accuracy for quite some time; with the advent of web printing, first steps have been taken towards addressing color issues in online delivery. For the near future, we will have an interim stage of evolving web images. You may have to trade the rich color depth of which digital technology is capable for consistency of appearance when creating your web images. However, you can still prepare for future when master archive images will be the direct source of electronic display, while in the meantime producing web images which are good and consistent within the current parameters. In order to be prepared for the future while making the most of the present, you must learn about color management.

Please note:

I will be discussing images meant for electronic display only. Images meant for other publication techniques or archival purposes will have other color needs. All Websites mentioned in the body of this text are listed as complete URLs in the resource section at the end of this article.

## Color Management and Calibration

Controlling the color rendition of images is called color management. As we just noted, different workstations display colors differently. The current technical description is that a monitor inhabits its own device dependent color space. A color space is a collection of mathematical formulas (machine language) by which a device knows how to display color. The goal of a Color Management System (CMS) is to establish a device independent color space to which each device refers as a common language. The most common device independent color space is CIELAB. Both Color Sync (Apple) and ICM2 (Windows) use it. There are also good proprietary systems such as ColorBlind (ITEC), which can be used to calibrate your devices as well.

Calibrating your equipment to a color space means creating a profile for each piece. Most of the time, the calibration process tends to feel rather complex, like tuning all the instruments in a symphony orchestra simultaneously. However when all is said and done, the process is as simple as "match this to that". In fact you may have already been requested to calibrate your monitor by an application such as PhotoShop. Or, if your use a Kodak product, you may have seen references to ICC profiles. The International Color Consortium, a vendor organization, is the leading group in establishing standard profiles and open platform

color management systems. When you calibrate your equipment, in particular your monitor, you are creating a profile of the Gamma, Brightness and Hue settings in a particular color space for your images. By mapping device dependent characteristics to a device independent color space as a common exchange language, the CMS makes profiles meaningful to devices such as your printer and other monitors viewing the same image.

## Gamma

Anyone who has touched a digital image digitally should know about gamma. Many people work with gamma without knowing what it actually is. They do know that gamma is adjustable and that most monitors are set at 2.2, except Apple's, which are set at 1.8. They also know that when an image is created or modified on an Apple monitor, it appears darker when viewed on a non-Apple monitor. The term "gamma" comes from the Cathode Ray Tube (Television) technology to which computer monitors are similar and is an exponent describing the distribution of the intensity of light. The starting point - black - and the finish - white - are not impacted by the gamma, but the rate of increase is. As a result, the apparent brightness of an image, mainly in the mid tones, will appear differently in different gamma environments.

Timo Autiokari shows several examples of the effect of changing the gamma setting on the perception of images in his very helpful Accurate Image Manipulation web site. However, it is important to note while reviewing Timo's work that his discussion revolves around the printing process, which has different needs than electronic display.

## Brightness

Brightness is the intensity of light. It is best understood in a sales pitch for high end LCD Projectors. As the projector vendor will tell you, "the brighter the projection, the greater the range between black (no light) and white (all light), thus the greater the range for each of your hues." Furthermore, not all lights have the same color of white. We all know about the yellow cast of tungsten lighting. This difference is expressed as the white point of a light source. When you use a digital camera you may have a "White Balance" option, which adjusts the color balance to remove the color cast the current lighting conditions may cause. You can also adjust your monitors white point to reflect different lighting conditions. Tungsten lighting has a white point of 2800 K, while daylight has 6500 K and computer monitors 9300 K. When you calibrate your equipment, you establish in its profile its range of brightness and the white point for the display environment.

## Hue

Hue is probably self-explanatory. The additional factor in electronic display is not what hue, but how many. Actually, we can't even see all 16.7 million possible color definitions most computers now offer, but they do enable us to show greater detail and blending of colors. When I started out in this field, I was asked to put together a slide show on a machine which was only capable of displaying 16 colors. Fortunately those days are over. If you want to see what difference more colors make, just change your monitor display to fewer colors. In calibrating your equipment you establish the brightness or range in each of the three colors - Red, Green, and Blue - used in electronic display. Then you select a Color Space.

As a quick aside: you may have heard about websafe colors. They are "safe" in that they tend to look the same across different platforms. These are specific individual colors, however, and they do not help in the quest for displaying photographic images accurately. They are the colors you might choose for a graphic element, text or background on a web page. If you are interested in that area of color, you might look at Lynda Weinman's site. She is a leading Web Graphics Guru. For viewing photographic images with accurate color there is no safe color, only safe color spaces in which many display devices can perform.

## Color Space

As mentioned earlier, the most common color space used is CIElab. Kodak's has its own version of CIElab called PhotoYcc, which is used in the PhotoCD ImagePak format. Keep in mind that you will lose the PhotoCD's CMS capability if you edit or modify the images within your system. For the time being, however, this is a moot point as current browsers can not perceive these color spaces. The web world is developing sRGB, a Standard Default Color Space for the Internet which was introduced in 1996 by Hewlett Packard and Microsoft. sRGB was developed as a safe space. Keep in mind, however, that it is a limited space with a narrow color range and certainly not appropriate for archival purposes. At this time in the web's evolution, sRGB is the color space in which most display devices can function accurately, making it the color space of

choice for displaying images on the web. Many image software companies including Corel and Adobe have accepted it. In fact, the default color space in Photoshop 5.5 is sRGB, although you can choose CIE Lab if you wish. While sRGB has its limits, at this time, it is the best color space for electronic display.

As a sidebar: Photoshop 5.5 also defaults to a gamma of 2.2, which as mentioned earlier is the standard for most monitors. This way, most of the time color will be consistent between display devices.

Other groups are developing color management systems which can inhabit broader and deeper color spaces in order to replicate their image's color as accurately as possible. If you work in the press world, you might have access to the International Press Telecommunications Council's Digital Newsphoto Parameter Record (DNPR) version 4. As the tech specs state, "this is the lower level file format for encapsulating digital news photographic data. It allows for editorial and technical information to be carried in the same file. Version 4 just released incorporates datasets for an ICC Device Color Profile". Okay. Gamma is set, the white point and brightness range in each color established and a color space chosen. Ready to manage your color for the web? Let's start with the first stage - Creation and Correction.

## Controlling the processes at the Creation and Correction Stages

The first step is to calibrate the equipment used at the creation and correction stage. This calibration will become the profile information for your images. Some of your devices come with profiles. If you go into your monitor control panel you will be asked to select your type of monitor. Your color management system can then plug in the factory suggested device profile. If you have newer operating systems with more fully developed color management systems, you can also create your own custom profile for your devices. This can be especially important as ambient light and environment will have an impact on display.

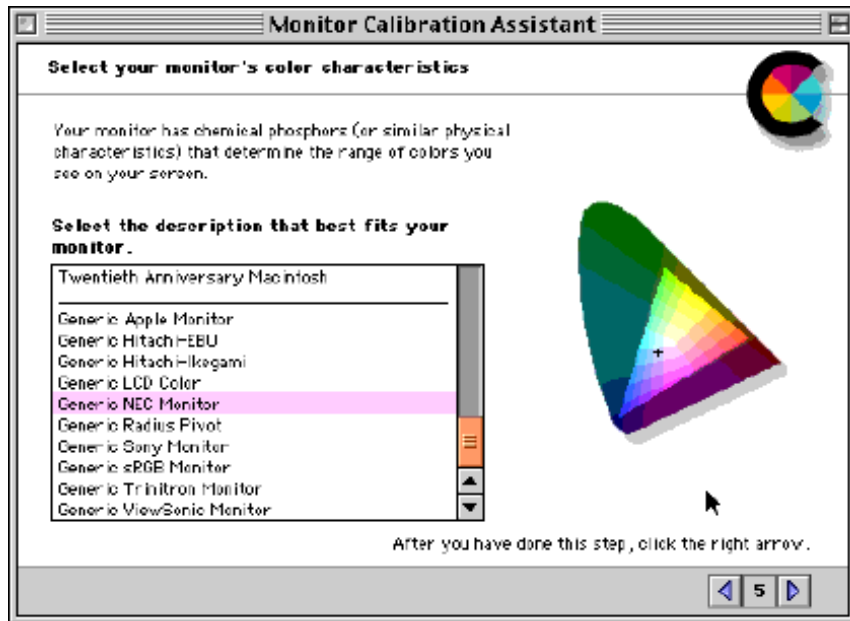


The following is a series of steps that the Mac OS system walks you through to calibrate your monitor. I am using it the Monitor Calibration Assistant as an example because it explains the process. You can do something similar in Windows under Display/Settings/Advanced. Windows will allow you to choose sRGB Color Space Profile or select your monitor, set gamma and adjust color. To adjust color you import a Bitmap image and then adjust your color on your monitor until it looks like the image. On both platforms you can then save your custom profiles.

The first screen after the overview has you adjust your brightness. You set your contrast at its highest and then set your brightness so that a shape is barely visible against the background. Note that ambient lighting has an impact on the apparent brightness of a monitor so try to make the ambient lighting as consistent as possible.

The next step is beginning to set the gamma. In this screen you adjust the midrange of the three color channels red, blue green to balance so that the Apple (object) blends with he background.

Then you select your monitor's color characteristics. Cathode Ray Tubes make images by means of phosphors, which determine the range of colors you can see on your screen, as shown below:



If you want consistent web images, you should select the sRGB profile, which will safely meet most other monitors capabilities.

Then you must select the gamma setting for this monitor. Again, for web images it is recommended that those of you using an Apple monitor in this Non-Apple world adapt by preparing your images for viewing on a monitor with a higher gamma. You can do this by either resetting your gamma setting on your Apple monitor to 2.2 to mimic the other monitors, or by using Photoshop to adjust the gamma level of your images to .8 in the Image - adjust - levels dialog box. Adobe has a quick little tutorial on their site about this adjustment process.

The final step is to set the white point of color to the perceived light you are using. This is usually expressed in terms of daylight or tungsten terminology, as in different lighting situations, warmer or cooler light. D6500 is a standard term.

So now all the images which are created or manipulated using this monitor have a profile which can express digitally exactly what the colors are that you wish to have displayed. How do you communicate that to the viewer's displays?

## Controlling the processes at Production and Viewing Stages

If you do not implement your web images yourself, you can still try to maintain management of the color. For example, if you provide master archive images to an outside service provider, then include with those images the color profiles and insist that this information be embedded in the file and that they not manipulate the image, but only convert and reduce its size. If they do manipulate the image, insist that they maintain a color management system which will provide accurate color profiles to be embedded in the final web image. Many file types can contain this information and many imaging software packages can read it. The common image file formats such as TIF and JPEG as well as Kodak PhotoCD have this capability. PNG, which is actually file format adopted as the new Web image file format to replace the GIF by the World Wide Web Consortium, can also contain ICC profiles. Of course if you are producing your own web images then you should expect the same from yourself.

So now that we have color information, how do we relay it to the viewer's display device?

As browsers can not yet read the color profile information you can try some interim steps. For starters, you can simply publish the information on your site, enabling viewers to calibrate their monitors to match your specifications. An example for this strategy can be found on the Accurate Image Manipulation for Desktop

Publishing website. "The AIM color space (and the color space of my original images) is:

- Trinitron Primaries (these are the most common Phosphors used in the CRT monitors)
- White-Point D6500 (this is the daylight, the hue of the actual sunlight at noon).
- Gamma 1.0 (the linear light domain, free from all gamma induced errors).
- A copy of the original is then gamma compensated by 1/2.5 (inverse gamma 2.5) and uploaded to WWW. This is effective from 1.1.1998, some earlier photos are in gamma space 2.2. In addition, for some specific purposes, there are images with different file-gamma, these are explained on those pages."

Or perhaps you might intrigue someone to create an online calibration routine such as Imation and Ecolor provide at their sites. With such a program, you "help" your viewer to calibrate their monitors to match your managed color system.

Ecolor and Imation are software developers providing ecommerce sites with the ability to show true color. Ecolor has you calibrate your monitor online at their web site; the site then places a cookie in your drive that, and when you visit a site which they service it will tell the image server what your monitor profile is. The server then sends you images which your monitor will project accurately. At this time the services costs approximately \$1,500 a month. Soon the browser technology will catch up and be able to perceive color profile information, without needing this intermediary program.

And when the browsers can read it, you will be ready with all your color information. And you will no longer need to be restricted to the sRGB color space or gamma 2.2. The advent of digital imaging has brought digital color and the ability to manage it. Those creating digital images who understand how color is produced on electronic displays can calibrate the pieces of equipment involved in creating and displaying digital images and thus create accurate color profiles. Yes, now instead of saying the red was the color of blood, we can accurately say the red was 54, 73, 43.

For those wishing to learn more, I have assembled a list of resources.

## Resources

### Guides to Web Publishing

- [Photoshop - the secrets of good gamma](#)
- [Chapter 6: Adding Images to Your Site](#) by Philip Greenspun, part of Philip and Alex's Guide to Web Publishing
- [Adobe Online services](#) will prep your images for the web.
- [Accurate Image Manipulation for Desktop Publishing](#)  
Okay, this isn't about web publishing, but Timo has some great examples of "Gamma induced errors" and a lot of other good information.

### Examples of Online calibration

- [Ecolor](#) - click on True Internet Color set up
- Or try out [Imations Verifi's calibration](#).

### Color Management Discussions and Examples

- [Color Management Work flows for Photoshop 5.0](#)
- David Bourgin's [Color Space FAQ published on the AIM site](#). Complete but readable discussion of colorspace
- [Apples' introduction to color management](#).
- [Introduction to Color Management in Windows](#)

### More on Digital Color

- [Understanding Digital Color By Phil Green](#)
- [Kodak: Digital Imaging Fundamentals](#)
- [The Ultimate Internet Coloring Database](#)
- [Browsers ; Color Management Support](#)
- [Lynda Weinman's site](#), leading Web Graphics Guru

#### **Further Information on Publishing Controls being developed.**

- [PNG -Portable Network Graphics](#)
- [IEC](#) publishes first standard in a series on colour management
- [A Standard Default Color Space for the Internet](#) - sRGB ( historical)
- [W3C working Draft on Color](#)
- [Not Just Decoration: quality graphics for the Web](#)

#### **International Standards**

- The [International Color Consortium](#) was established in 1993 by eight industry vendors for the purpose of creating, promoting and encouraging the standardization and evolution of an open, vendor-neutral, cross-platform color management system architecture and components.
- [International Press Telecommunications Council](#) was established in 1965 to safeguard the telecommunications interests of the World's Press.

## **Do You see what I See?**

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