Color Management

The phrase “Color Management” refers to a set of hardware, software and procedures intended to deliver consistent color from one device to the next. The problem of predictable and consistent color is a critical one in all digital reproduction, as anyone can attest to who has watched in horror as the beautiful image on their monitor rolls out of their printer looking as if it had undergone an unexpected (and usually unpleasant) transformation.

Why Is Color Management Necessary?

Why doesn’t all of this expensive equipment simply work? Most typical digital files that are in the RGB or CMYK color model consist entirely of numbers which represent particular hues, saturations and densities. Each device in the digital workflow chain (scanners, monitors and printers) will likely produce at least slightly different colors from these numbers depending on their particular specifications and current conditions. This is true not only for devices that are different models or made by different manufacturers, but also true of two identical models from the same manufacturer. How a number in a file gets represented as a color depends not only on the number itself but on the current characteristics of the device interpreting it. For this reason, RGB and CMYK are referred to as device-dependent color models.

It is usually possible through trial and error to force your own equipment to produce fairly predictable color by manually altering each device until it does so. However, this methodology is extremely limited - the introduction of any new papers, inks or equipment forces you to start this tedious and expensive process over. And it is almost impossible to integrate your work with anyone else’s equipment and achieve predictable results.

Color management measures and controls device specific variation to generate the same colors on different devices without creating binding interdependencies between them. There are some limitations to this goal caused by differences in media which we will mention later.

Three Steps to Color Management

There are three basic steps one must go through with each piece of equipment in the digital darkroom (scanner, monitor and printer) in order to attain the goal of consistent color.

First, each device must be brought to a known state or condition, a process known as **calibration**. This condition is usually some industry or device specific “standard” state for the device to be in and serves as a target against which the device can be measured. For example, monitors are calibrated to a certain color temperature, brightness level and gamma level such as 5000 degrees, 1.8 gamma and a brightness between 85 and 95 candelas/m2.

Once the device has been calibrated to the chosen target it is **characterized**. In this step, the difference between the intended calibration state and the state actually achieved during calibration is measured. There is typically some small difference since the calibration state is a theoretical target which is not always actually achieved.

Finally a **profile** is built that represents this difference and can be used by the device to compensate for it. So two devices, given the same numbers from the digital file, will output the same color because the profile allows them adjust for their own individual differences.

ICC Profiles

In 1993, an industry organization known as the International Color Consortium (ICC), was founded to develop standards for the definition, creation and use of these profiles across different equipment and computing platforms. More and more equipment manufacturers are supporting ICC standards, allowing greater color control across hardware and software platforms.

Color Folio has made a strong commitment to the use of ICC standards from its inception. Every device we use in the studio has an ICC profile, usually created and customized by us to extract the ultimate degree of control and accuracy as possible. We often share these profiles with our customers and help them integrate their digital darkrooms with our own to allow collaborative projects to occur successfully.

Color Management Components

There are three main components in an ICC color managed environment. The first are the **ICC profiles** we’ve just discussed. Typically there are unique profiles for scanners (often one for each film stock), monitors and printers (one for each ink/paper combination for CMYK printers and one for each paper for RGB printers).

Next is the **color matching engine (CMM)** which is a software component that actually uses the profiles to convert the values in the digital file allowing the device to produce the expected colors. This conversion is the critical step in color management in which variations between devices are “neutralized” by adjusting the values in the digital file based on the differences measured in the characterization step described above.

Finally, there is the **Lab color space** which serves as an internal translation space for use by the CMM as it is converting numerical values using ICC profiles. The CMM first translates the digital file numbers to Lab and then converts from Lab to the destination device values.

Different software applications integrate into an ICC workflow in different ways. Fortunately, Adobe Photoshop™ offers excellent ICC color management support, particularly in versions 6.0 and later. It is critical to master Photoshop’s color management capabilities in order to get the results you expect in your prints. *Real World Photoshop CS2* by David Blatner and

Color Management

Bruce Fraser [Peachpit Press] is an excellent reference guide on Photoshop in general and it's color management features.

How Do I Use Color Management?

There are several key tasks you must accomplish to begin to use ICC color management on your own. We'll discuss them in the order we recommend you implement them.

The place to start is to produce a high quality monitor profile. You should have a relatively new monitor and a monitor profiling package, such as ColorVision Optical™, to accomplish this [see white paper on Equipment Recommendations for more details].

Once you know that the colors on your monitor are accurate, you can address how to make your printer output the image to match closely what is displayed. This entails getting printer profiles for different papers and ink combinations (assuming you are using something like an Epson desktop printer). There are several approaches to this:

- custom made profiles (Chromix.com)
- semi-custom profiles (Inkjetmall.com).
- "canned" profiles (such as those supplied by Epson)

There are also several printer profiling packages available to make your own profiles. However, unless you plan on using many different papers where the cost of buying profiles becomes prohibitive, we recommend that you have someone make profiles for you using expensive state-of-the-art equipment rather than make your own using inexpensive profiling packages. It isn't worth the time and effort you'll expend getting good results from low priced equipment.

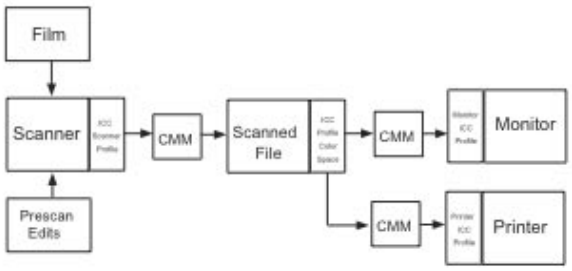
If you are outsourcing your printing, you should obtain the ICC profiles from the vendor for that printer so you can use it for softproofing in Photoshop. For example, Color Folio can provide you with profiles for our Color Giclée printer. You will have to learn the correct way to apply these profiles, which differs a bit from printer to printer.

There are situations where your print will still differ from the display, even with the use of excellent ICC profiles. To begin with, there will always be some slight difference just because a monitor is using projected light while a print is seen with reflected light. Secondly each printer has a range of color it can reproduce, known as **color gamut**. These gamuts can vary considerably from printer to printer - typically RGB printers such as an Epson 9800™, have a larger gamut than CMYK printers. If you send a color to a printer that is "out of gamut", the printer will in general try to print the closest color to the one requested as possible. Note that the primary role of rendering intents is to cause the CMM to change these out of gamut colors using different strategies. There are ways to check for out of gamut colors in Photoshop using the printer profile so you can see in advance if there will be any surprises.

Now you know that when you open your scan on your monitor it is being displayed accurately and that if you print it the result will look similar to your monitor. But what about the scan itself? Ideally your scanner will have a custom profile to account for variations in it's sensors, but many consumer level scanners do not allow the use of profiles. This means that the initial scan may be somewhat less accurate and that more Photoshop work may be necessary.

The file itself is usually an RGB or CMYK file - we recommend all files be scanned as RGB even if intended for CMYK output as RGB has a larger gamut and thus more color is retained in the original file. A conversion to CMYK is always possible later. There are different types of RGB each having a different gamut, white point and gamma. In an ICC workflow you must choose which type of RGB the file will be so that the CMM knows how to interpret the numbers in the file. For fine art printing it is important to choose one which has a wide gamut. Photoshop comes with several built in options, the best of which for this purpose is Adobe RGB (1998). At Color Folio we use an RGB color space developed by Joseph Holmes known as J. Holmes Ektaspace 5. It is architected to contain all of the colors captured on Fuji and Kodak E6 film. Many scanners will embed a profile describing the file's RGB type and Photoshop will certainly embed one if set up properly. This is important so that the CMM knows how to interpret the file as it transforms it using ICC profiles.

Here is a diagram of a typical ICC workflow:



Note that the transformation by the CMM to the monitor is done on the fly and does not change the contents of the file. The transformation to the printer is sometimes done on the fly by the printer driver (or RIP) or sometimes a copy of the file is made and actually changed before being sent to the printer.