

An Introduction To Colour Management

By

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Introduction

Colour management, or the ability to produce on inkjet paper what is captured in the camera, is a subject that is little understood by many photographers but is essential in order to produce consistent, accurate output. There is a perception among photographers that colour management is expensive and difficult and at one time that was the case. Expensive proprietary systems were required and were really only within the scope of large colour bureaus. That is not now the case and colour management is well within the scope of amateur as well as professional photographers. Additionally, it is no more difficult to implement than many other aspects of digital photography. Photographers soon learn the complexities of image resolution and manipulation in order to produce their images properly. Colour management is no more difficult than those aspects and actually much easier than some other aspects of digital photography.

The object of this paper is to introduce you to colour management by explaining the basic theory and discussing the procedure for setting up and implementation.

The points to be discussed are:

- What colour management is
- Why colour management is needed
- Understanding colour spaces
- An introduction to ICC profiles
- Profiling and calibration
- Colour management workflow
- Rendering Intents
- Setting up and implementing colour management

What is Colour Management?

Quite simply, colour management is the process of managing colour from capture to output whilst maintaining the original colour integrity.

Why Colour Management Is Needed?

Analogue photographers have had much less need for colour management because they have usually had a standard reference to guide them in producing accurate colour; the colour transparency. Digital photographers do not have any reference at all. It's important to remember that a digital file is made up of pure numbers, there is no colour in the image at all so there is nothing definitive to refer to. Two cameras shooting exactly the same scene will produce two differing sets of RGB numbers while capturing the same colour. The resulting RGB numbers are dependent upon the particular camera that captures them.

One of the main frustrations of digital printing is the inaccuracy and inconsistency of inkjet output. The colours reproduced on the inkjet paper aren't necessarily what is shown on screen. The reason for this is that each device in the chain; camera, monitor and, particularly the printer,

is interpreting colour it's own individual way. All colour devices produce colour unique to themselves. This is known as 'device dependent' colour.

A good analogy is a TV showroom. Walk into any TV showroom and you will see that the TV screens on display, quite probably all receiving the same TV channel, will be displaying different colour. This is because they are all interpreting the transmitted signal in their own unique way.

They are all device dependent.

We need to be able to control the colour in our workflow in order to reach accurate results. This is why we need colour management.

Colour Spaces – Device Dependent

Colour spaces are based upon their origin. A scanner or digital camera will create data specific to that device. Other colour spaces are synthetic and have no relationship to any specific device. A good example are colour spaces created for editing images. Within Photoshop these are referred to as 'working spaces'.

The 2 most common colour models we work with are RGB (Red-Green-Blue) and CMYK (Cyan-Magenta-Yellow-Black).

All cameras and scanners will produce some unique form of RGB.

All monitors will display some unique form of RGB.

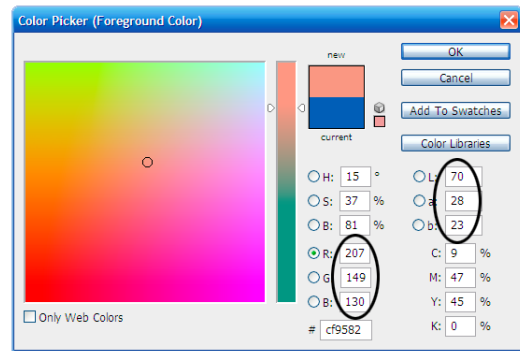
Inkjet printers, in general, utilize CMYK ink to produce their output but they require the data that is sent to them to be in RGB.

These are device dependent colour spaces. This means that if we send an identical file (which is just numbers) to 'n' printers we would end up with 'n' results. The devices themselves take the same numbers and produce different colour prints. Conversely, if we had 'n' printers and wanted to produce identical results on each we would need 'n' colour spaces. This makes life somewhat complicated. Fortunately, colour management allows us to create the correct values for each device.

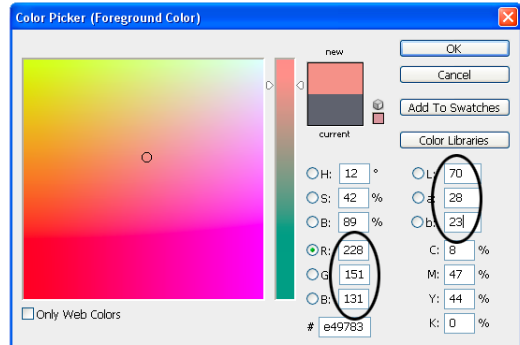
Colour Spaces – Device Independent

As well as device dependent colour models there are device independent colour models. The most common is CIELAB, which is usually shorted to Lab. L is the lightness channel and a and b are the colour channels. This is a theoretical colour space based on human vision and covers all the colours known to man. The important difference between the two colour models is that Lab is consistent. The numbers that make up a specific colour will be the same on every computer. Using the eyedropper tool, select a colour in your image and then look at the RGB numbers and equivalent Lab numbers. Now if you go to another computer and, using the colour picker set up the same Lab numbers and you will note that the RGB numbers will differ from that of the previous computer. Lab values are constant from device to device but the RGB numbers differ. The colour value is the same. The diagrams on the next page illustrates the point.

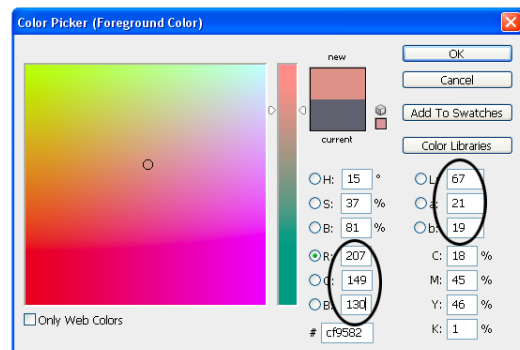
On my desktop computer I selected the colour picker and picked a colour at random. The RGB numbers are 207, 149, 130. The equivalent Lab numbers are 70, 28, 23.



On my laptop I selected the colour picker and entered the Lab values shown above. The RGB values that were generated were 228, 151, 131. The colour is identical but is represented on a different computer as different RGB values. Note that the CMYK values are almost the same as the values in the colour picker above.



I then entered the original RGB values on my laptop computer and noted the difference in the Lab values: 67, 21, 19. So, the same RGB values on different computers will result in different Lab values. This would result in a different colour being reproduced. The colour is not significantly different but it is different, reinforcing the fact that RGB values are device dependent. Note that although the RGB values are the same as the original values the CMYK values, like the Lab values are significantly different.



Colour management utilizes both device dependent and device independent colour models.

Introducing ICC Profiles

In 1939 a group of colour scientists formed The Commission Internationale L'Éclairage conducted a series of tests and experiments on people to determine how they see colour. They produced a mathematical model based on how humans see colour.

In the early 1990s a group of proprietary companies (Kodak, Agfa, HP and others), led by Apple, got together and formed the International Color Consortium (ICC). They used the model devised in 1931 as the baseline and agreed to develop an 'open source' cross platform colour management system. This would enable an image created on one system to be produced on some other system without loss of integrity. For example an ICC profile created with a Kodak product on an Apple platform could be translated on a Windows based computer using an software that was ICC aware. Software manufacturers wishing to utilize colour management could implement their products to work with these ICC profiles. A leader in this field is Adobe.

Like the original model this a theoretical model based on human vision, not dependent upon any device and is consistent.

As mentioned, device dependent colour spaces are unique to their device. Device independent colour spaces encompass all of human vision and are not linked to a specific device. Capture and output devices cannot directly reproduce CIELAB but this colour space allows the translation of any colour from one device to another.

ICC profiles can be assigned to individual images and saved within the image data. This is known as *'embedding'* a profile or *'tagging'* an image. This allows any ICC aware application to process the image and correctly reproduce the colour accurately. A file that does not have a profile embedded in it is known as *'untagged'* because the colour within it has no colorimetric meaning.

Here's an analogy. You have a roll of film that you give to a lab for processing; nothing is written on the film cassette. They have no idea what type of film it is; colour (negative or positive) or monochrome, what ISO is the film and what was it rated at. This is untagged film and they would have no idea how to process it correctly. However, if you write on the film cassette: Fuji Sensia 100, rated at ISO 200, you have *'embedded'* a profile to the film and the lab will know exactly how to process it correctly. The information that you wrote on the cassette did not change the physical properties of the film; it just provided a description of it's properties. This is analogous to how a profile gives meaning the image data within a file.

Also, it is important to understand the difference between profiling and calibration. You now know that embedding a profile in an image file does not change it in any way; it just provides a description of the colour behaviour. Calibration of a device changes its physical properties. A good analogy here would be correcting the time on a watch or clock or resetting the pressure value on a barometer. In correcting the time you would be physically changing the properties of the device to bring it to a baseline standard. Calibration in digital imaging is relevant to display monitors. Calibration of display monitors is something that needs to be done on a regular basis as, like a watch or clock, the colour will drift over a period of time. Additionally, if we understand that a profile describes the behavior of a device, we should be aware that if the device changes it's behaviour then the profile will become invalid. A new profile would need to be created to reflect the new device behaviour.

Profiling and Calibration

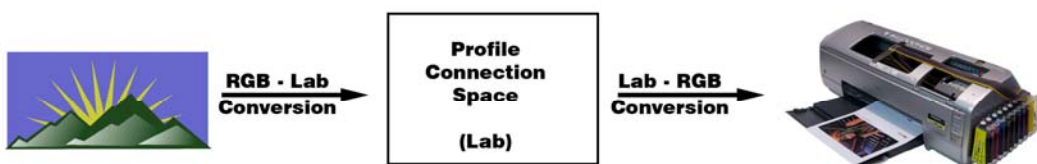
It is important to understand the difference between profiling and calibration. A profile, as discussed above, is purely a description of the way a device behaves. It does not change the physical properties of the device. Calibration does. If you consider the times you may correct a watch or perhaps a chronometer to bring the device into line with known standards then you are calibrating those devices. In digital imaging this is a necessary element that is required of the monitor. Calibration of the monitor brings it into line with a known ICC standard, determined by whatever calibration device you are using. There are a range of colorimeter devices available for monitor calibration. Using one is the only guarantee that you have that your monitor is displaying accurate colour. If your monitor is displaying a colour cast and you are unaware of it you will introduce that colour cast in your manipulation processes and introduce a colour cast to your output. Calibration of the monitor also results in a profile that is automatically installed on your computer system and is loaded each time the computer boots up. However, unlike a profile, which is just a file and should never alter, the colours displayed by your monitor will drift and so calibration is a process that should be carried out at regular intervals. If you are serious

about colour management this should be done on a monthly basis. If you would like to discuss this aspect further then please contact Fotospeed on 01249 714555.

While it is essential for at least 2 profiles to be available for colour management: A source and a destination profile. It is beneficial to have a third; a monitor profile, which would be produced as a result of calibration.

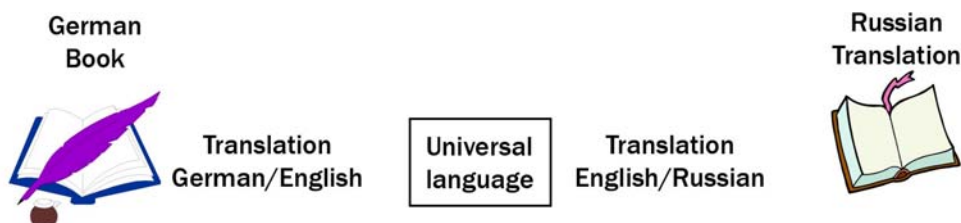
Colour Management Workflow

Now we understand that ICC profiles have a very important role. ICC profiles allow colours in a source image to be mapped to colours in a destination which has a different colour space. This requires a 'translation' from one colour space to another, which is provided by the device independent colour space 'Lab'. All device dependent profiles 'understand' Lab and this is used as the translation area or profile connection space (PCS) The conversion process is shown in the diagram below.



Note, although a printer generally uses CMYK inks it requires the data to be sent to it in RGB.

Thinking in numbers is often difficult for people so if we think laterally and apply the profile conversion method to words it would work in exactly the same way. For instance, imagine a book written in German was required for publication in Russia. In order for the book to be translated it would need to go through the translation process. Applying the same criteria as the profiles would mean that the German publisher would have to provide the conversion from German to a universal language which would be equivalent to Lab. *Remember that all device dependent profiles 'understand' the universal language of Lab. They don't understand device dependent profiles from another colour space.* Once converted into the universal language, in this case we'll call it English, the book can then be translated from English to Russian whilst maintaining the original meaning of the book. The conversion process is shown in the diagram below.



Rendering Intents

A colour management system requires 4 components:

An input profile, a profile connection space, a destination profile and a rendering intent

We have covered the first 3 elements. The 4th element, a rendering intent, is required to handle 'out of gamut' colours and is a very important element in the process.

Each device has a range of colours that it is capable of reproducing and that range is described within the device's colour space. Colours in the original (source) colour space need to be mapped to colours in the destination colour space. Where a source colour space is wider than the destination, which is often, those colours that cannot be mapped are called 'out-of-gamut' colours. These out-of-gamut colours need to be dealt with and that is the job of the rendering intent. There are 4 choices available but only 1, Perceptual, is ideally suited to photographic inkjet printing. The other 3 options are not recommended due to their methods of compression

The differences among the various rendering intents are the methods of compression they use in order to bring colours into gamut. The Perceptual intent compresses the entire gamut of the image to fit within the destination color space. This means that all the colours that are in-gamut as well as those that are out-of-gamut are compressed but all the pixels are adjusted in relation to each other. So although all the colours change the relationship between them remains the same and it is that relationship which is the important factor.

The Saturation intent treats each pixel as an individual item without regard to any surrounding pixels. Using this intent will bring your colours into gamut but the relationship between them will have changed and saturation will be increased. As well as out-of-gamut pixels being brought into gamut those in-gamut pixels will also be changed. This intent is only suitable for business graphics.

The Colorimetric intents (Relative and Absolute) only compress the out-of-gamut colours and each pixel is modified individually without regard to its neighbours, similar to the Saturation intent. Using either of the Colorimetric intents can lead to banding or posterization of the image, particularly when converting from a large colour space to a small one.

Setting Up and Implementing Colour Management

Like most things in life and certainly everything in computing the colour management process has to be set up before it can be implemented. Armed with a basic understanding of the principle of colour management, setting it up and utilizing it should be easier to understand and carried out without difficulty. You should have an appreciation of the processes involved rather than just doing it 'mechanically' and it should assist you in your fault finding methods if something goes wrong.

Setting up your colour management is quite easy to do and the exact process is described in an associated document: *Fotospeed's Test Charting Printing Instructions*. This document fully describes the procedure to set up and implement your colour management process. Another document describes the procedure for setting up your Colour Policies in Photoshop and Elements. This is an essential but very simple process that can be completed in just a couple of minutes but, if not done, colour management cannot be implemented correctly.

Armed with the background information in this document and the specific information in the associated documents mentioned above you should now be in a position to enjoy your photographic experience and fully utilize the capability of your graphics program and enjoy quality printed output.