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Principles of Color Management

A brief look at why we need color management, how it works & how to get the most out of it.

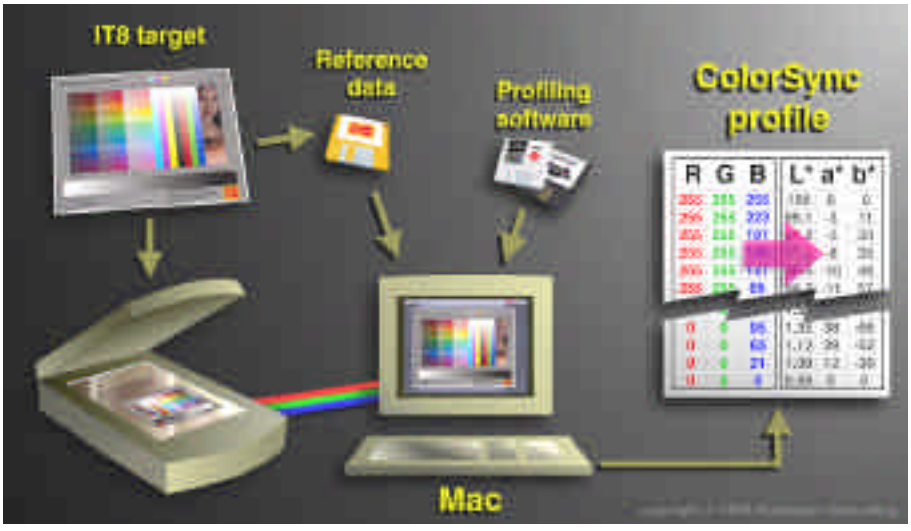
Color management simplifies and improves the exchange and reproduction of images across a wide range of industries. It solves the basic problem that no two devices produce the same visual color from the same digital values. Without color management, reproducing an image created on one device (e.g. a color scanner) on another (e.g. a press) requires trial-and-error testing or years of experience. Color management automates the process, offering better quality, efficiency and ease.

The first 'open' color management system was Apple Computer's ColorSync™ which, like its Microsoft clone, ICM™, allows any scanner, camera, printer or monitor to be defined in terms of a standard 'color space'[1], through 'device profiles'[2]. Guidelines established by the International Color Consortium (ICC) define profile structures and other rules of today's color management. System-level Color Management Modules (CMMs) like ColorSync and ICM provide utilities that any software can use for any color transformation task.

Generic profiles are available free for many scanners, monitors and printers, but these are seldom of real value as the variation between any specific unit and the group average can be large. Serious users should profile their own devices using software available from several vendors.

Scanner (Input) Profiles

Scanner profiles translate raw digital RGB values into a standard color space like CIELab. The profile is generated by scanning an 'IT8' color target. Profiling software combines the digital scanner values with data measured from the target to form a 'source' profile which translates RGB into CIELab.



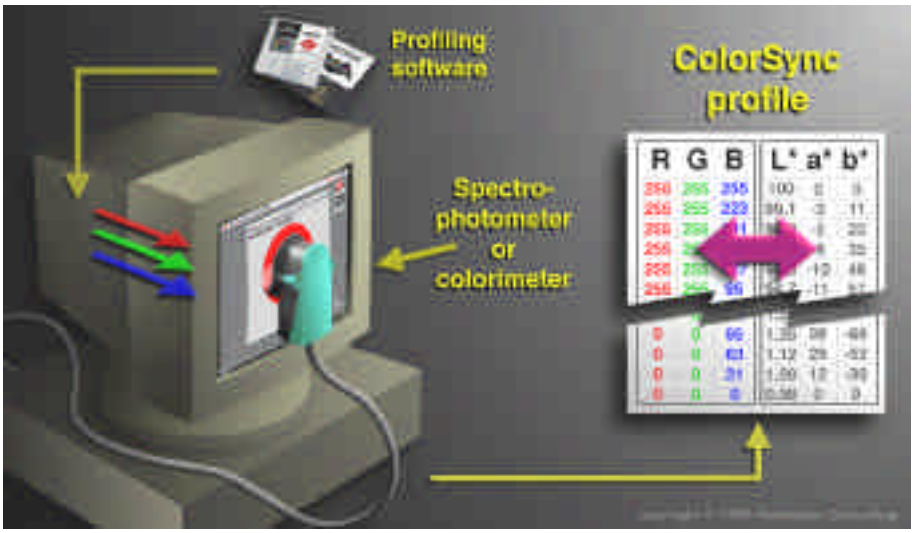
Creating a scanner profile

1 A color space, (e.g. CIELab), is a universally agreed numeric description of how we see color.

2 A device profile is a translation table between the standard color space and device-specific RGB or CMYK.

Monitor (Display) Profiles

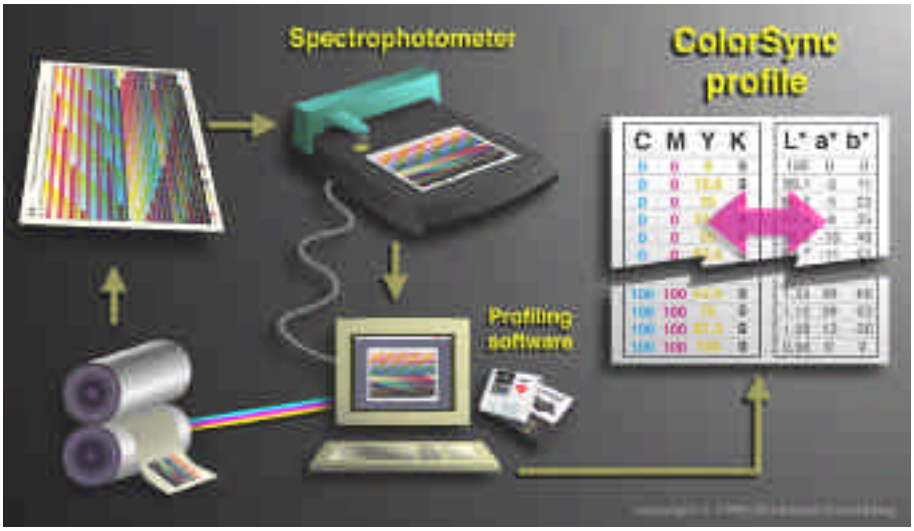
Monitors are profiled by displaying a range of RGB patches and measuring them with a colorimeter or spectrophotometer. Profiling software computes the relationship between the measured CIELab values and the RGB values sent to the screen to form a monitor, or 'display' profile. Display profiles are bi-directional because a monitor can be both a source and destination device.



Creating a monitor profile

Printer (Output) Profiles

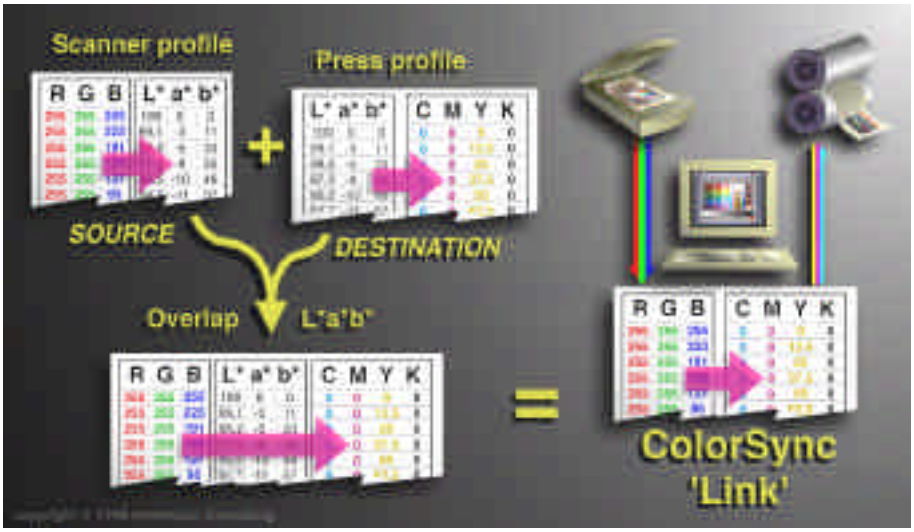
Presses, desktop printers, wide-format printers and film recorders are profiled by printing a color target and measuring the printed patches with a spectrophotometer. Profiling software joins the measured CIELab data with the printed CMYK percentages to form a 'destination', or 'output' profile. Printer profiles are bi-directional because a printer can be both a source and destination device.



Creating a press profile

Converting from RGB to CMYK

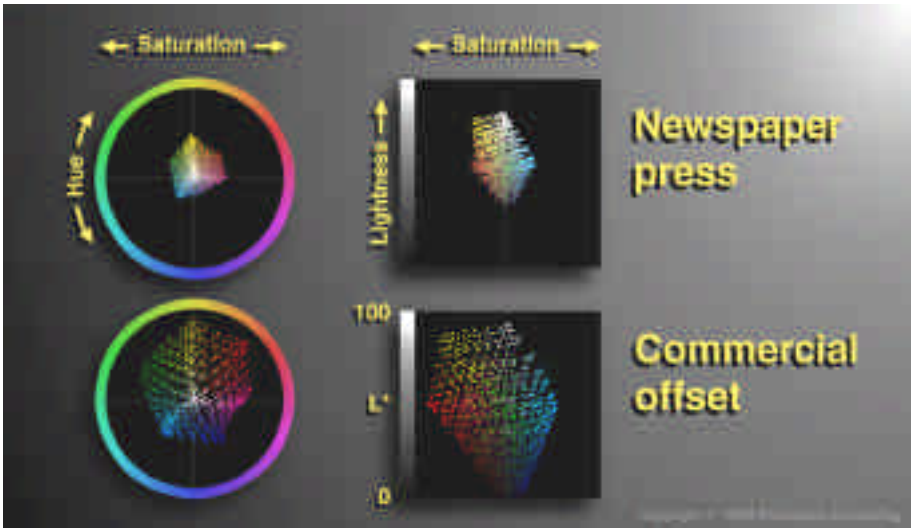
To convert an RGB image to CMYK, the CMM (e.g. ColorSync) builds a ‘Link' which converts directly from RGB to CMYK. To create a link the CMM looks up each RGB value in the scanner profile, then looks up the resulting CIELab value in the press profile to get equivalent CMYK.



Creating a ColorSync Link from source and destination files

Color gamut differences

Every device has its own ‘Color Gamut’, or range of colors it can reproduce. For example, the following chart illustrates the much larger color space in CIELab units between the same CMYK values printed on a commercial press (bottom) and a newspaper press (top.) This explains why newspapers cannot print such rich, saturated colors or intense blacks as a glossy magazine.



Gamut differences between two different CMYK devices

Gamut compression

Out-of-gamut colors are handled by the process of 'gamut compression', which tries for the best overall SIMULATION of the original as shown in the upper example (below.) Gamut compression is built into the output profile but can be customized to suit a particular image in some ICC-based image editing or profile editing software.

Good gamut compression

Good gamut compression (above example) usually results in the most pleasing reproduction from any original, but may not give a truly accurate match of any specific color. Without gamut compression, in-gamut colors mat be more accurately matched, but out-of-gamut colors may be 'clipped', 'plugged' or lost completely, as shown by the lost highlight and shadow detail in the press sheet below[3].

No gamut compression

[3] Printed versions of this document may not show the full difference between these examples

Image Editing

An often neglected fact of color management is that good scanner and printer profiles alone are not enough to guarantee pleasing results. At best, color management can only 'match' an original with all its faults, but most pictures need some deliberate alteration to correct for exposure or development errors or to meet the client's subjective preferences. These 'editorial corrections' which were traditionally done by skilled scanner operators, still require the same skills, but can be done more efficiently and effectively under color management.

When an image needs to be 'color corrected', color editing software like Photoshop 6, ColorBlind™ Edit or LinoColor™ can replace the scanner's software. These programs take full advantage of ICC profiles and best of all, show an accurate 'soft proof' of the final print at all times. Soft proofing allows corrections to be confirmed visually, which simplifies training and operation while allowing more powerful corrections. Seeing a simulated proof after each control move can dramatically reduce re-makes and shorten editing times, however maximum quality and productivity still require training and experience.

Major productivity and flexibility benefits result from scanning and editing in RGB rather than CMYK. ICC-based editing software lets the user select from a list of 'Input' and 'Output' profiles to suit the origin and destination of each image. When a CMYK output device is chosen, CMYK changes are allowed, or at least a CMYK dot percentage readout is available, even when the image is still in RGB.

Some packages offer controls that work in LCH (Lightness Chroma & Hue). The huge advantage of LCH over RGB or CMYK is that any LCH value will look the same no matter what device is selected. The visual meaning of any LCH value is the same no matter what input or output device is chosen. No longer do different RGB or CMYK values have to be memorized for each device. LCH is universal, or 'device-independent'—which is the whole point of color management.

Soft Proofing

The value of soft proofing is often under-estimated because it is seldom demonstrated correctly. The secret is controlled ambient lighting, without which the screen cannot be compared fairly to a hard proof. The ideal lighting solution is an intensity-variable 5000K viewing booth such as Graphic Technology Inc's SOFV-1e or PDV-3D alongside the monitor. Dimmers on these booths allow the operator to adjust their brightness till they match a white monitor screen. If the monitor is properly profiled, the match from screen to proof can be astonishingly good and a great aid to image editing.

Houston Chronicle

Matched lighting - the secret to successful soft proofing

Reality check (de-bunking some myths)

- Color management is not a magic bullet. As with any color reproduction method, the stability of each device can dramatically affect the whole system and good quality control is essential.
- Color management will squeeze the best out of your printer but cannot improve its color gamut.
- Color management does NOT eliminate the need for skill and experience. The more you know the better will be the results. A careful novice can get good results with it, but the best people to run a color management system are existing color experts who already understand the conventional process.
- Proper training is essential but color management is not difficult to learn. The only pre-requisite for a traditional scanner operator is an open mind.
- The best color management can do is match the original. Improving it still requires an experienced eye.

Learning more

GATF (Graphic Arts Technical Foundation)

Everyone serious about color management should read **The GATF Practical Guide to Color Management** by Adams and Weisberg. GATF also provides hands-on color management workshops tailored to professional separators & printers. Call (412) 741 6860 or visit www.gatf.org/

ColorSync website

Apple ColorSync is a powerful color management engine built in to the Macintosh operating system. Five years ahead of Microsoft's ICM2 in refinement and support, ColorSync makes Apple computers the easiest and most flexible choice for a color managed system. The ColorSync website www.apple.com/colorsync/ is worth a visit.

ColorSync User's List

Whether you're just thinking about getting into color management or have been using it for years, there's a wealth of color management knowledge and information exchange at colorsync-users@lists.apple.com.

Profiling software & measuring instruments

Profiling software is available from Agfa, GretagMacbeth, Heidelberg, ITEC, Kodak, Monaco, Praxisoft and others. Price, quality and ease vary but all do a reasonable job. To create your own printer or monitor profiles you will need a spectrophotometer from GretagMacbeth gretagmacbeth.com/, X-Rite xrite.com, Color Savvy colorsavvy.com or Spectrostar spectrostar.com.

About the author

Don Hutcheson is an independent consultant who develops and installs ICC-based color management systems. Over thirty years of color scanning help him bridge the gap between traditional CMYK color separation and modern methods. Hutcheson Consulting specializes in custom solutions for exotic or demanding color applications. Clients include commercial and fine art printers, separators, publishers, photolabs, photo and movie studios, art galleries, image banks, billboard printers, magazines, newspapers, and manufacturers of color scanners, printers and related software. See front page for contact information.

NOTICE: These notes are based on real world color management experience gathered at numerous user sites over the last six years. No guarantee of accuracy is implied and no support is available except to customers of Hutcheson Consulting. Many thanks to all who helped discover and share this knowledge, especially Advertisers Printing, Agfa, Apple Computer, Boelte-Hall, Color Solutions, Fortune , J. Paul Getty Museum, GIST, Houston Chronicle, Hunter Editions, ICG, Litho-Krome, People Magazine, Publisher's Clearing House, Publisher's Printing, Simon & Schuster, Time Magazine, Warner Bros. Feature Animation., & others