

# Background Information

Color Management describes a process that is intended to enable predictable color reproduction at any point in the production process. Compliance with guidelines is the basis for the profitable use of this technology in the creation, processing and output of PDF files. We'll cover the following topics in this chapter

- A general overview of Color Management
- What a **Color Gamut** is, **Colors Engines**, what an **ICC profile** is as well as defining **Rendering Intents**
- Which **problem areas** need to be addressed

## 1. Technology Overview

The purpose of digital Color Management is primarily to ensure the correct reproduction of colors on output devices such as monitors or printers. Color Management ensures as well as possible that the representation of certain color values on different input and output devices is »synchronised« for the human eye. RGB or CMYK values must be changed to create a uniform visual representation.

### 1.1. Problem areas

When we speak of colors such as orange, red, green, etc., each of us has a certain idea in our heads of what the color looks like. If colors are given in the form of color values such as 0|100|100|0 in CMYK, we can assume that the color will be defined as red. If a color value of 255|0|0 is specified in RGB, we also know that the monitor will display a red color. But the complications begin when we start asking questions such as "which red is this exactly?".

- **Problem 1** – Colors can be numerically described in different color systems, but the way they are displayed depends on different factors.
- **Problem 2** – The fact that there are different color systems - additive and subtractive - is not itself a problem, the problem, however, is that the number of reproducible colors (also called Color Gamut) can be different with different color systems.
- **Problem 3** – Even when using the same color system, e.g. CMYK, depending on the substrate, the same color value may be presented differently.

- **Problem 4** – If colors have to be converted between different color systems, it is necessary to consider how colors from the source color space which are unavailable in the target color space can be mapped.

The list of problems is almost indefinite. The four challenges above are intended to highlight the fact that when we talk about color, we are not talking about absolute values or states, but rather about interpreted, perceived, and adjusted color relationships.

## 1.2. The components of Color Management

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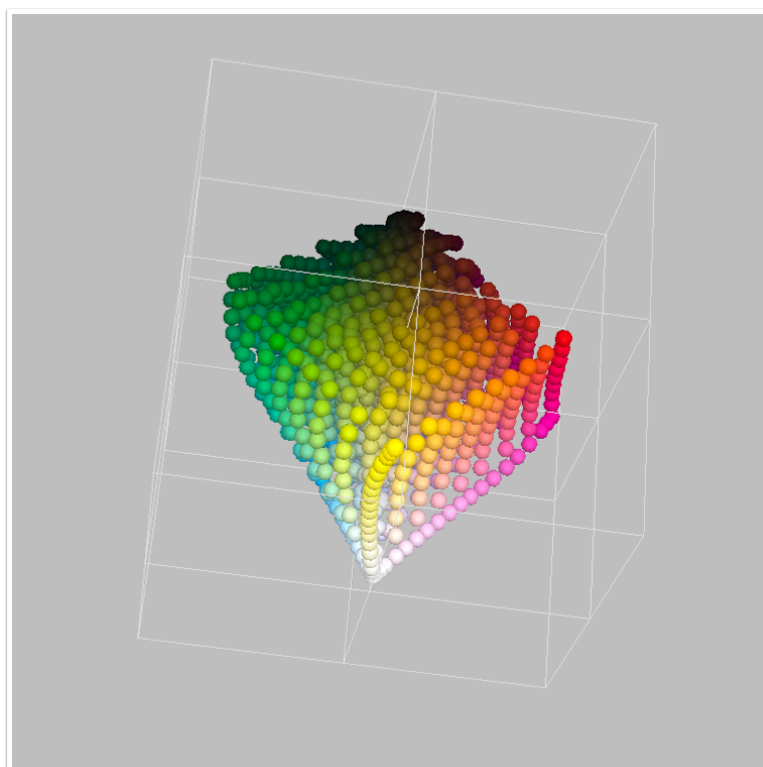
To understand how *Color Management* works, we'll discuss the following four topics in detail:

### 1.2.1. Color Gamut

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**Color gamut** is the color pallet that a given technology or process is capable of reproducing. This indicates the number of colors of the medium to be reproduced, such as monitor, beamer, digital camera sensor, scanner sensor, printout on an inkjet printing system on a specific substrate to be printed.

**Figure 1:** 3D Color Gamut Model of a Print-Substrate combination within the theoretically visible color space **Lab** (white cube)



### 1.2.2. Color Engine

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The conversion of the colors from the source space to the target color space is done by a small piece of software called - a **Color Engine**. The details of the conversion - for example: which color value is used when a color is allocated twice or when a color is unavailable - are left to the respective Color Engine. This transformation can lead to different results if another Color Engine is used. The main tasks of a Color Engine are:

1. Conversion of the color values of the source color space to the target color space
2. Calculates intermediate values for values that do not exist in the source and/or target color spaces.
3. Uses the calculation specifications provided by the Rendering Intent



#### Color Engine for MacOS or Windows

The Color Engine for MacOS is provided by **ColorSync**, Windows 7, 8 or 10 uses the **WCS** Color Engine. In addition to these Color Engines, **Adobe ACE** and the **Heidelberg Color Engine** are well known in the graphic industry. The ColorLogic Color Engine – **CrossXColor** – is currently used in the Workflow.

### 1.2.3. ICC Profile

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**ICC-profiles** describe the color reproduction-specific character of the color space of a device in an absolute color space. In other words, a profile is a table that lists the color values (either RGB or CMYK) of all available device colors and the corresponding color values in Lab (the color number description of the absolute color space). The creation of a profile is based almost exclusively on the spectral measurement of reproduced color values of a device or substrate. During the measurement, spectral measurement results are mapped to the values of a mathematical color space – ICC-profiles use **Lab**.

**Figure 2:** An overview of RGB and CMKY color profiles

R	G	B		L	a	b		L	a	b		C	M	Y	K
255	255	255	▶	100	0	0		100	0	0	▶	0	0	0	0
255	255	254	▶	100	0	1		100	0	1	▶	0	0	1	0
255	255	253	▶	100	0	1		100	1	1	▶	0	1	1	0
...	...	...		...	...	...		...	...	...		...	...	...	...
146	237	89	▶	81	-71	62		81	-71	62	▶	72	0	97	0
147	236	89	▶	81	-70	62		81	-70	62	▶	72	0	96	0
147	236	90	▶	81	-70	62		81	-70	61	▶	72	0	96	0
147	236	91	▶	81	-70	61		81	-70	60	▶	73	0	95	0
147	236	92	▶	81	-70	61		81	-69	60	▶	72	0	95	0
...	...	...		...	...	...		...	...	...		...	...	...	...
5	0	0	▶	1	3	1		1	1	2	▶	80	78	72	92
4	0	0	▶	1	2	1		1	1	1	▶	80	78	69	92
3	0	0	▶	1	2	1		1	1	0	▶	84	79	66	92
2	0	0	▶	1	1	0		0	1	0	▶	86	81	64	92
1	0	0	▶	0	1	0		0	0	0	▶	88	79	65	93

#### 1.2.4. Rendering Intents

When transforming from a source to a target color space, non-reproducible colors of the source color space must be »reasonably« moved to the next possible color in the target color space. A color space projection must be carried out in such a way that the color is visually matched and optimised. In print reproduction, this process usually involves color space compression (Gamut-Mapping). Since there are different reproduction intentions in reproduction technology, the ICC has defined four different rendering intents (RI):

**Perceptive:** Perceptive adjustment causes the best possible shift of the source color space to the target color space according to visual perception. The colors of an image are mapped to the target color space in such a way that all colors are changed slightly to make room for the colors outside the displayable color space. The color space is compressed in such a way that as many colors as possible that could be distinguished before the transformation remain distinguishable afterwards.

This rendering intent is mainly used in the separation of images for the harmonious reproduction of original colors. However, the result will be brighter over all.

**Absolute colorimetric:** The absolute colorimetric adjustment ensures that all colors within the target color space, including the white point (paper white is simulated), are reproduced identically. All colors outside the target color space are shifted to the edge of the color space in the direction of the paper white; they are clipped.

This color gamut adjustment is recommended if the color spaces of the source and target color spaces are almost identical (very large) or if the target color space is larger than the source color space. When creating a soft or paper proof, it is recommended to use the Absolute Colorimetric, as this preserves the white point (the paper white) of the output color space to be simulated in the proof, which approximates and imitates the substrate to be reproduced.

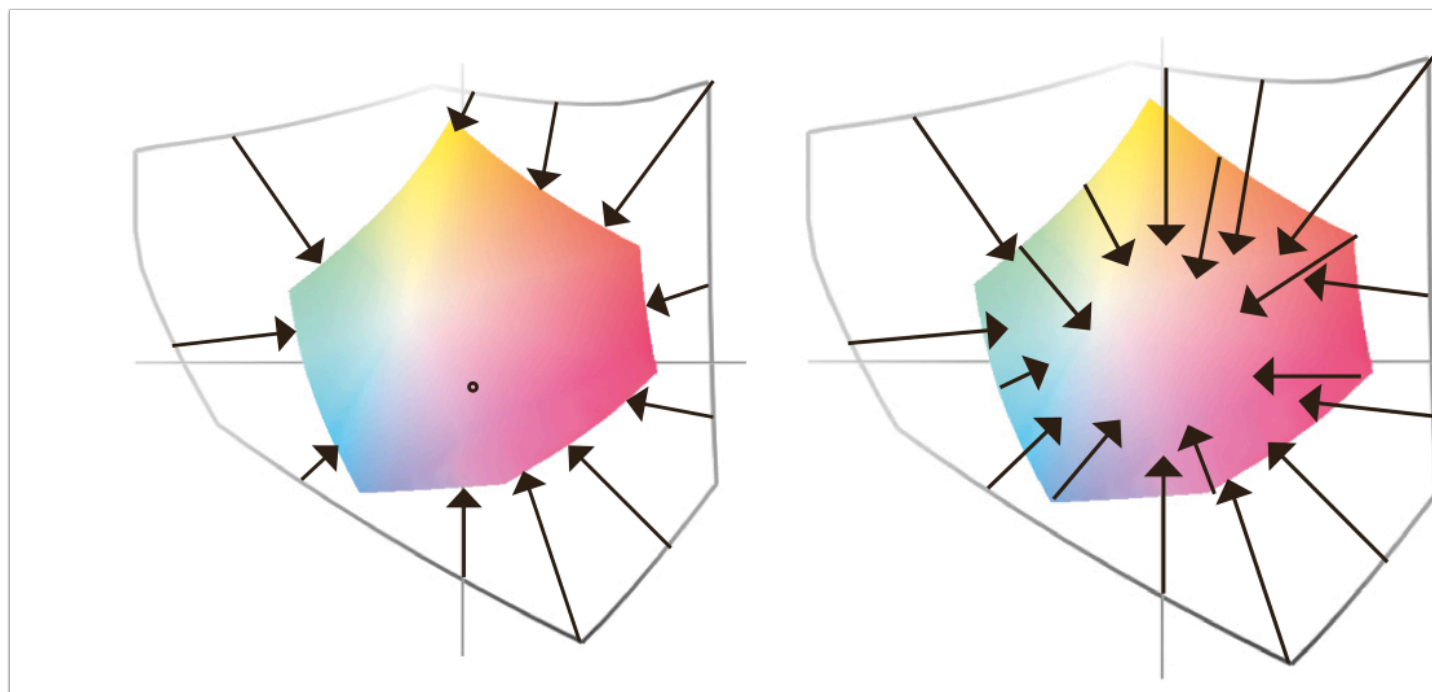
**Relative colorimetric:** The Relative Colorimetric adjustment works like the Absolute Colorimetric rendering intent, but here the white point of the source color space is adjusted to the white point of the target color space, and all printable colors are repositioned relative to the new white point (light white).

This rendering intent is used for exact and media-related reproduction of original colors. A good starting point for this is if the target color space differs only slightly from the source color space or if there are not many "non-printable" colors in the original image. In practice, this rendering intent is the preferred intent because it achieves as many saturated colors as possible and retains white as white for the viewer.

**Saturation:** The Saturation adjustment shifts non-printing colors to the next saturated hue. Shifting does not take place in the direction of the white point, but in the direction of hue saturation. This rendering intent is therefore ideal for the conversion of business graphics.

This rendering intent is recommended for the output of business graphics and presentations, but not for the prepress processing of images.

**Figure 3:** The comparison of Colorimetric (left) or Perceptive Rendering Intents



## 2. Applying Color Management

### 2.1. Why use Color Management?

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Color Management knowledge can be leveraged whenever colors have to be converted between different color spaces with preserving source colors as the goal. The user must accept the fact that 100% accuracy concerning the matching of colors is not possible, due to Color Gamut variations. Using Color Management can help you achieve optimum results in terms of color. Its important to remember that Color Management also has its limits.

Since profiles can be used to describe a wide variety of devices and substrates, a simulation of the final result can be generated on the monitor or with a proof. This increases reproducibility and shortens production times because the user can troubleshoot and make corrections in a relatively quick time frame.

The printing industry is also not exempt from globalisation. For most print projects it is not always clear from the beginning; when, where and with which substrate printing will ultimately take place, Color Management can allow us to postpone the time-consuming part of optimising print data.

Color management also helps us ensure consistent quality over long production periods, this is a reality even for image editing professionals that cannot always deliver the optimum results at all times and under all conditions.

### 2.2. Color Management wisdom

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This list is a concise summary which can aid in the understanding of Color Management.

- Color space conversion always starts with a source color space and converts it to a target color space.
- The color range of the source and target color spaces are described in the form of profiles.
- Each file to be converted must therefore be marked with the source profile. Only if the origin is known, a correct conversion into the target color space can be carried out.
- In classical color management, color conversion always takes place from a device-dependent source color space (described by a profile) to the absolute (Lab) color space and from there to the device-dependent target color space (described by a profile).
- If the color space conversion is mapped via an absolute color space, black tones are also described by the CMYK structure for a grayscale image after CMYK conversion.
- If files have to be converted from one CMYK output color space to another CMYK color space, a completely new separation is created - in addition to generation of black, the color values will also change.
- By converting from one color space to another, pure colors can become slightly dirty/washed out.

- To avoid the pitfalls of traditional color space conversion, DeviceLink profiles can be used, which convert the source to the target color space directly, i.e. not via Lab.
- When converting color spaces back and forth between two color spaces, there may be slight changes in the color numbers. If too many color conversions are performed, the image have color degradation and flattening of optical contrast.