The State of the Art in Extended-Gamut Printing

Part 1

Introduction

We have seen, in preceding blogs, an entertaining history of attempts to achieve more colorful results by overcoming the limitations of 4-color printing. But what of the situation today? What does “Extended Gamut” mean in the present context; what do these solutions look like? EG systems now range from simple arrangements consisting of nothing more than Photoshop and a multichannel output profile to entire integrated workflows with proofing and elaborate options for spot color handling. But for all the recent attention paid to the subject, there is still a lack of industry consensus on just what a constitutes a proper EG separation, and any effort to make sense of the subject typically faces a mixture of conflicting proprietary claims, incomplete studies, and persistent misconceptions. It is still the Wild West. Perhaps by considering how these systems came to exist we might better understand what they actually do and how well they fulfill their purpose.

Extended-gamut today: a dual heritage

We can simplify the origins of all EG systems to two distinct lineages, each corresponding to a different need: Systems that convert images and those that convert spot colors. Combining and reconciling these two functions is the key challenge faced by designers of EG systems today.

Spot color conversion systems: a tyranny of rules

As we read earlier, several decades ago some clever individuals saw that one might reproduce a wide range of spot colors as equivalent process builds using CMYK with the addition of secondary inks such as a red, orange, green, blue, or violet. This was in the days before digital color management, so lookup tables were laboriously built from trial press runs and served as guides for converting colors, object by object. These systems mostly used AM screening, so immediately the question of screen angles had to be addressed. The usual scheme of 0, 15, 45, and 75 degrees was seen as imperfect because it forced a choice of either creating additional intermediate screen angles, increasing the risk of moiré, or sharing screening angles among complimentary colors such as cyan and red/orange and magenta and green, an unpopular choice as it raised the risk of color shifts caused by misregistration on press—a reasonable concern when printing vector objects, with their well-defined boundaries. A near-consensus converged around two simple rules for multicolor separations:

1. No color shall be converted to more than 4 process colors. Three is even better.

2. Complimentary overprints, such as cyan-red/orange and magenta-green, must be prevented. Who needs them, anyway?

These rules continue to be applied in a majority of EG systems, even those updated with automatic color-managed conversions. Spot color tints and overprints are handled by arithmetic interpolation or other simple means. The intricacies, and limitations, of these schemes will be discussed in the next blog. For the remainder of this one, we’ll focus on image conversions.

Images conversion systems: the rise of multichannel ICC profiles

While those brave pioneers were building their lookup tables, deft prepress workers were enhancing CMYK images with “touch” or “bump” plates of stronger colors. This practice can be seen as the true progenitor of multichannel extended-gamut systems.

With rare exceptions, modern image conversion methods rely on ICC color management. For generating multicolor (CMYK+N) press separations a basic system includes two profiles, one for the source color apace (often RGB) and one for the multicolor destination space, a CMM (Color Matching Method), AKA a “color engine,” and an application such as a RIP, color server, or other color-managed program such as Photoshop to interpret the source pixels and build the new image.

The profiles contain lookup tables that translate color appearance values (XYZ or Lab, AKA the PCS, or Profile Connection Space) to device values and vice versa. The CMM draws smooth curves through the LUT points and interpolates all intermediate values. PCS to device (or B2A) tables may contain a good deal of “secret sauce” for enhancing printability, saving ink, increasing the amount of black in neutrals, etc.; separate tables are built for different *rendering intents* or gamut mapping strategies. On top of this, device-link profiles may be employed to bypass the PCS conversion and apply even more rules, e.g., to exempt certain colors from the conversion. The key points to know about multicolor ICC systems are:

They are automatic, fast, and precise.

They are able to juggle multiple objectives, the two most important being accuracy and smoothness of output color.

Any combination of output channels may be used to fulfill objectives.

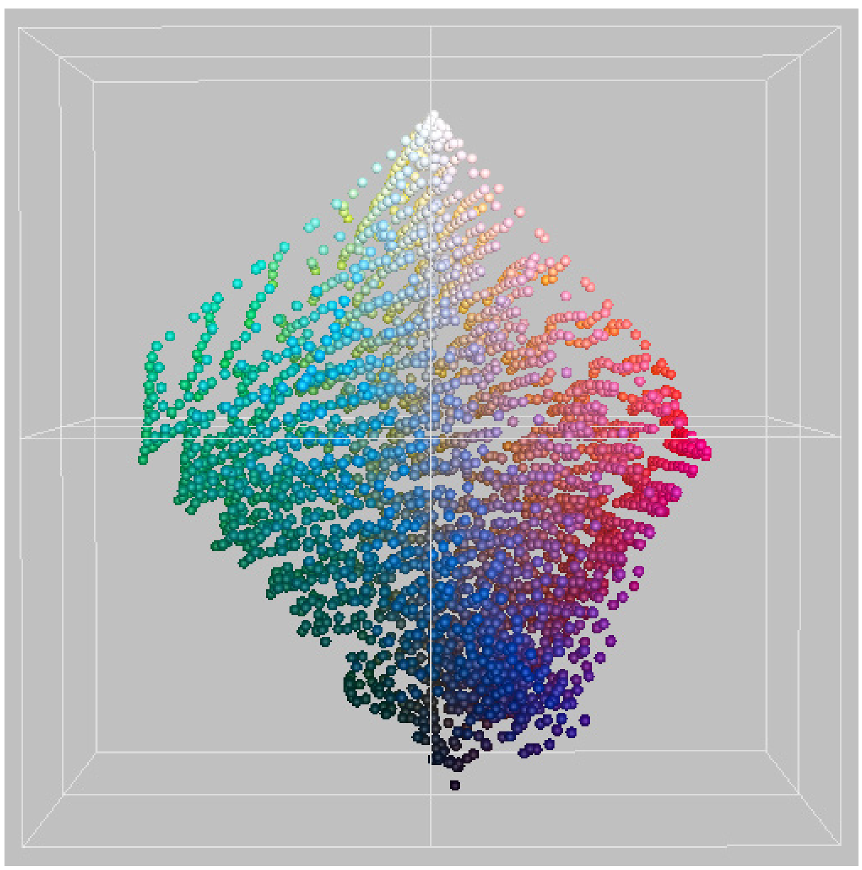
Results are conditioned by the quality and completeness of underlying measurement data.

Two systems, two outcomes

Image conversion is still an important function of EG, and systems do perform differently depending on their underlying logic. To illustrate this we can look at the results from converting an RGB test image with two very different solutions, one developed primarily for simulation of spot colors—you might say an heir to those clever lookup tables—and the other a typical representative of ICC color-management, the current default method for converting images. The test image contains a smorgasbord of truly devilish color conversion challenges: delicate flesh tones, textures and smooth gradations in deep, saturated colors, and full-tone black and white images. Any serious defect in a color conversion system is unlikely to escape detection here.

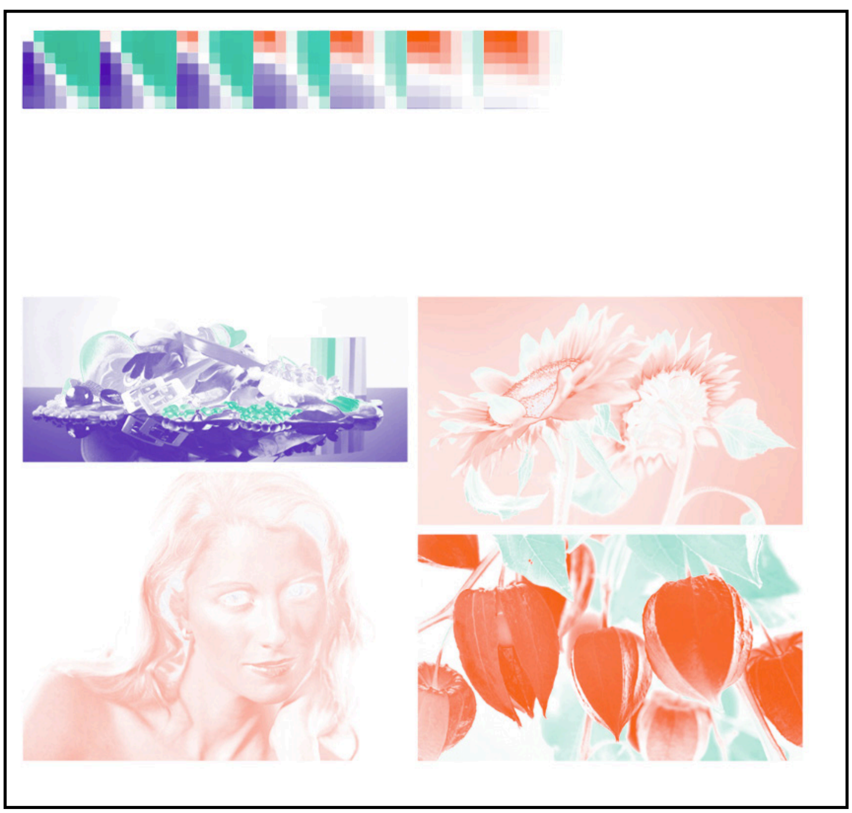
Details: Some gamut compression will be required convert these images to these smaller multicolor output spaces: In the first example perceptual rendering intent was used; in the second, relative colorimetric with black point compensation was chosen as the best available option with that system. Black generation (GCR) was adjusted to be as similar as possible in both cases.

System A. This is a conventional ICC-based system, available as a standalone profiling application (to be used in ICC-compliant workflows) and optional color server, which was employed here for the conversion. The underlying measurement data of the profile (for coated packaging board) is plotted in Lab space below. It shows a good balance of shadow, mid-tone, and highlight samples. A modest number of complementary color pairs (C-O, M-G) and extra-color overprints (O-G, V-G, OV, OVG) are present.

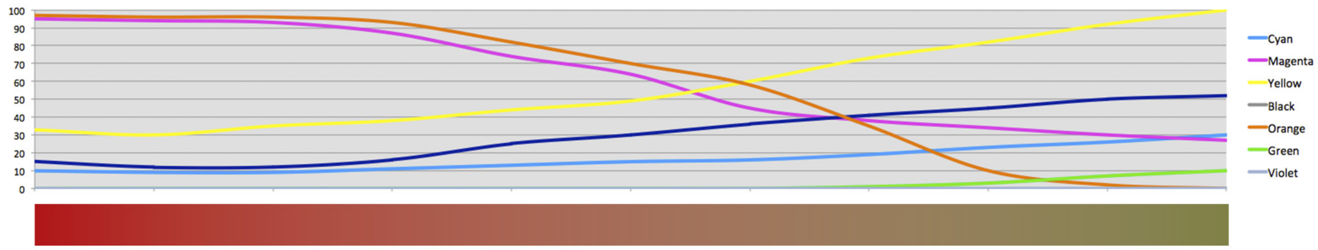


The results, shown below, are good. Details and tonal separations are preserved in the deepest and most saturated colors; gray balance is excellent, and no contouring, banding, or posterization is evident. Gradations are smooth.

The OGV separation view below shows a long scale for the OGV channels; they extend deep into colors that are printable with CMYK alone (flesh tones, underside of sunflower).

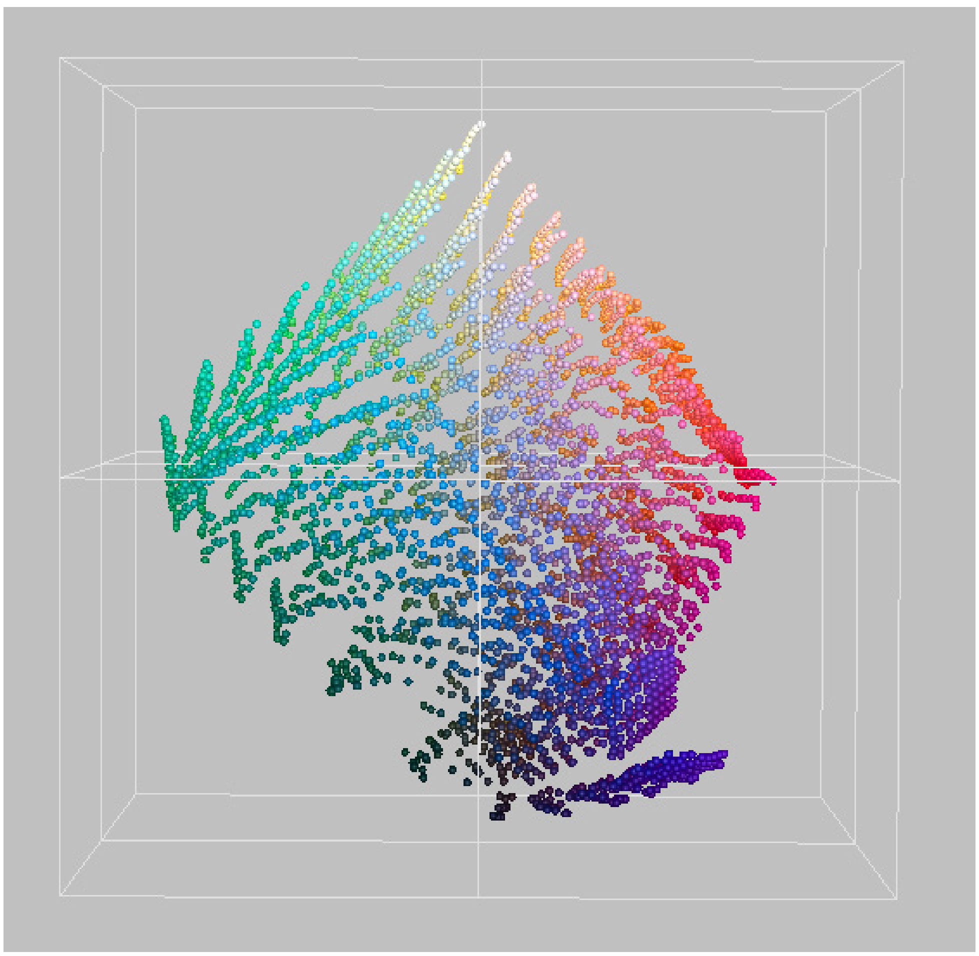


The graph below, derived from the lower-right image of the jack-o-lantern plant, shows how a range of colors from red-orange to dull green is composed. The extensive interleaving of channels, including small amounts of complementary colors, is a very probable contributor to the visual smoothness of the color transitions.



This system would be a good choice for demanding image reproduction work.

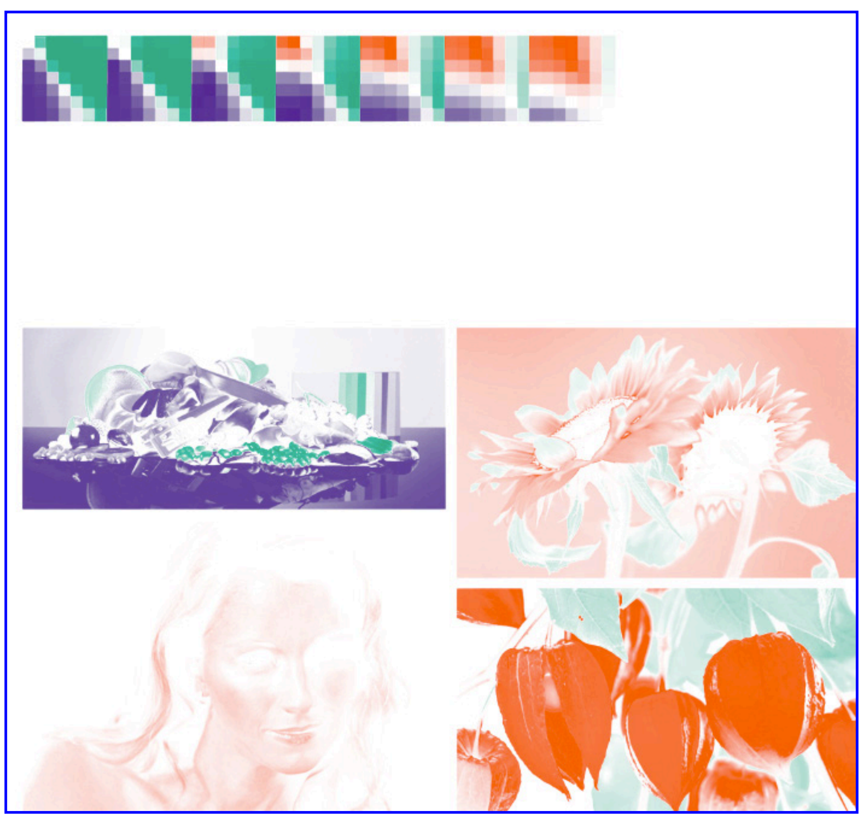
System B. Here we have a non-ICC system sold as an option for a popular workflow suite. It is a bit of a hybrid, its profiling scheme showing echoes of earlier simple spot-color lookup systems: Complimentary colors (C-O, M-G), extra colors (O.G.V) do not overprint, and no build exceeds 4 total colors. Otherwise, its profiles contain an abundance of tint and overprint data, as seen in this Lab plot:

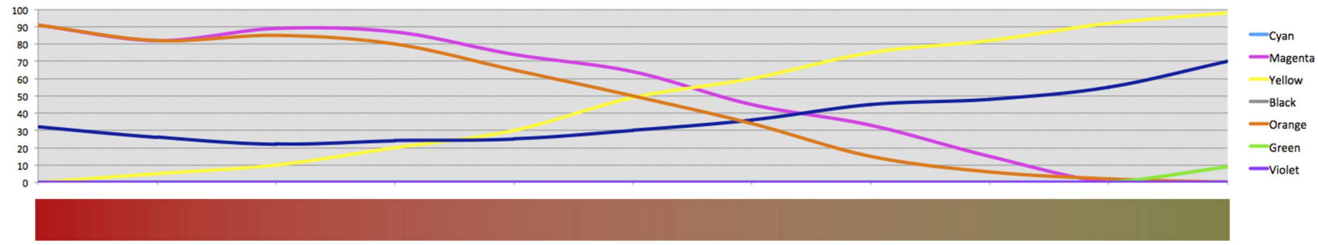


The profile structure is unique, consisting of four 4-color charts, thus simplifying its design. As we'll see, simpler is not necessarily better, as when approaching multidimensional problems like image transforms in 7-color space.

The converted test image below predictably shows some differences with Sample A. Color transitions are more abrupt, as shown clearly in the patch chart at the top of the form.

The OGV separation view shows a more limited replacement of in-gamut CMY by OGV inks, though this reportedly may be adjusted to some degree in the software. Gradations in these channels are noticeably less differentiated than in System A. The overall appearance of the n-channel separations is more like that of old-fashioned touch colors than fully functioning process channels. The red-green transition contains much less channel interleaving than in Sample A.

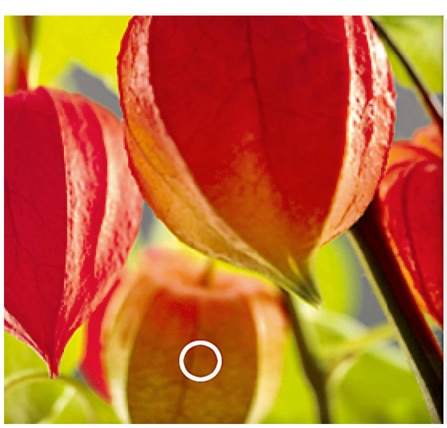


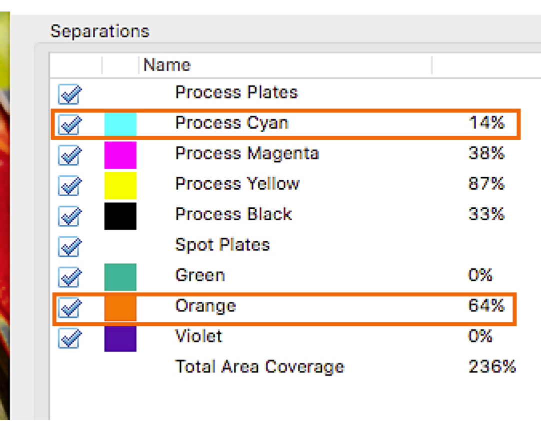


Two image comparisons will suffice to show some implications for these different separation schemes. In the lower area of the still life image below we see the dramatic impact of the compacted tonal scale of the violet channel in System B (right). Deep blues are hollowed out and posterized. Faithful rendering of dark, saturated colors is a critical attribute of any good color reproduction system, and this example is decidedly sub-par. System A (left) shows normal results.

The next image detail is a good test for reproduction of subtle color transitions. As seen in the System A image (left), the jack-o-lantern displays a nicely nuanced transition from orange to yellow-green in which a multitude of slightly varying flecks of yellow-green and yellow-orange can be seen. The System B image (right) looks comparatively crude, with a relatively flat, featureless orange abruptly breaking to an undifferentiated yellow-green. (This may be difficult to see in this low-resolution image.) Such defects are not correctible through image retouching, as the separations simply lack the necessary supporting tonal information.

This image also shows an interesting feature of System A. In the transitional color regions we see the presence of the complementary orange-cyan combination:

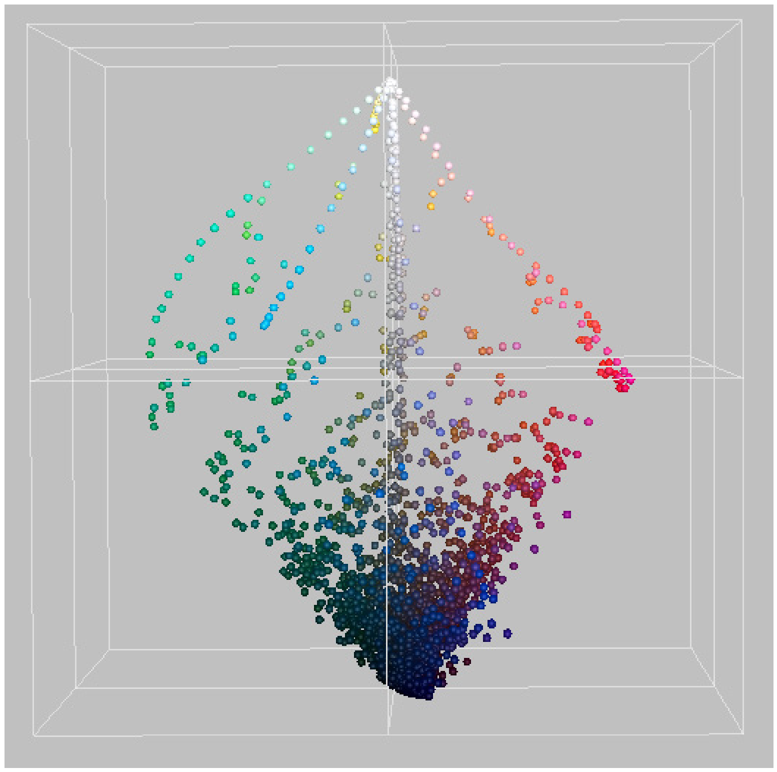




These colors, as well as green and magenta, are of course mutually cancelling and therefore commonly regarded as unnecessary in a press separation, a belief so widely accepted that it might be regarded as one of the tenets of extended-gamut printing. As noted earlier, such combinations are excluded from the separation in System B. However, closer study reveals a useful role for these “interstitial” colors in smoothing transitions.

A Cautionary Note on Profile Accuracy

An otherwise capable multicolor system may be compromised by the sort of measurement data underlying the profile being used. Here is a Lab plot of a typical 7-color measurement set used by a popular ICC profiling application.



Notice the extreme abundance of dark overprints, far in excess of any possible utility, and the skeletal representation of midtones and highlights. This gaping void must be interpolated, literally guessed at by the CMM. The resulting converted images are smooth, but intermediate values are largely fictitious. The less linear the device output is the worse the fiction! There is no known workaround with this application.

Conclusions

Modern multicolor extended-gamut systems must capably convert a variety of elements, including images, vector objects, and spot and process colors, singly and in combination. Systems based on older spot-color matching schemes may have a tougher time converting images compared with systems based on ICC multichannel profiling. Nonetheless, these older systems continue to enjoy popularity in package printing, where the dominance of vector designs gives rise to concerns about printability that may compete with the need for high image fidelity. In the next blog we’ll see how these two schools of thought play out in actual practice, with particular focus on strategies and techniques for converting spot colors. If space allows we’ll also touch upon the arcane subject of EG proofing.

Are you having a multicolor crisis of your own? Are battles over your system configuration leaving you black and blue? Please feel free to post comments and questions here, or send them to mike@mspgraphics.com.