Leveraging G7®-based Calibration for Effective Process Control

When we think of color management, we tend to think of measuring color targets and building ICC profiles. When we talk of color management, we tend to talk of instruments, neutral balance and ΔE values. And, when color management fails, we tend to blame the hardware, software or the operator. But while software, instruments and well-trained operators are all critical aspects of the color workflow, color management must be built on a solid foundation of **process control** to be effective.

Consider the myriad Fortune 500 brands we encounter every day — their products all share a common trait: Consistency. For example, Starbucks® has more than 19,000 stores worldwide, nearly 40,000 employees and sells more than $10 billion worth of coffee each year. And yet, regional taste preferences notwithstanding, every barista at any given Starbucks can produce a near identical Frappuccino® due largely to the implementation of effective process control (the secret is the water).

Making coffee on the scale of Starbucks is a manufacturing process; so too is printing. By integrating straightforward process checks into your workflow, you can ensure consistent and predictable results, curb waste and reduce overhead costs. The key is to integrate effective controls into your production workflow:

1. Establish pass/fail criteria based on common aim points
2. Define a universal known good condition that each printer can be calibrated to
3. Implement control checks during production
4. Archive your data to isolate variations, and their causes over time

Control Begins with Printer Calibration

An ICC profile is critical to color management. When you create an ICC profile, your profiling software generates a series of lookup tables based on the way your printer reproduces color at that moment; the profile is a model of how your printer is performing at a given point in time. Should the performance of the printer change — due to any combination of ink or media change, environmental variation, maintenance or mechanical wear — the validity of the profile, and thus the accuracy of your color matches can fall into doubt. The goal of process control is to establish a known good condition for the printer prior to generating the ICC profile. The known good condition is one that can be reliably calibrated

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back to should a change cause color drift, maintaining the accuracy of your profiles through production.

Use of aim points establishes the known good condition. G7® is a registered trademark of IDEAlliance and is a method of calibrating any four-color process device to a common set of colormetrically derived aim points intended to produce prints with a **common visual appearance**.

The G7 specification is also an official ANSI standard; the formal specification — including aim points, viewing and print requirements — is described in ANSI/CGATS Technical Report TR015-2013. The specification is available free of charge from the NPES. The G7 Expert Certification and G7 Master Qualification programs are maintained by the Print Properties and Colorimetric Council of IDEAlliance.

In addition, TR015 is referenced in the new ISO 15339-1 document, currently under review and expected to be published in autumn of 2014. Although a formal ANSI standard, IDEAlliance must certify a product, print system or provider as being G7 compliant; only products and providers certified by IDEAlliance may use the G7 logo for promotional purposes. Software, print systems, print providers and consultants may submit to IDEAlliance for G7 certification.

G7 is not color management, per se, but it does remove the subjective and often ambiguous definition of what defines a 'good' visual reproduction, replacing it with an objective set of aim points based on native media white point (D_{min}) and CMY process black point (D_{max}). It does this by defining the colorimetric relationship of the neutral points lying between D_{min} and D_{max} necessary to produce a visually neutral print density independent of the ink and substrate being used. This is done for both K and CMY process grayscale, and is referred to as a Neutral Print Density Curve (NPDC).

A key aspect of G7 calibration is that it takes the color of the substrate into consideration when building the NPDC. If the substrate has a yellow cast, that same amount of yellow is removed from the Yellow NPDC, thereby removing the influence of the substrate yellow and the subsequent yellow cast it would produce in a printed image. This is how G7 calibrates all devices to a common visual appearance, regardless of gamut, to establish a known good condition for each.

The Science of G7

The science behind G7 goes back nearly a century, to some of the earliest experiments into how a person with normal vision interprets color (known as the Standard Observer). One important discovery was our particular sensitivity to gray balance. Color can be understood as the perception of chroma (color intensity) for a given hue relative to the achromatic (gray) equivalent of the same lightness. We perceive color relative to a neutral stimulus; we may not know if a particular color is correct without a visual point of reference (a proof) but we recognize if an image possesses a color cast, even if subtle.

From the earliest days of color film photography, calibrating the exposure of the red, green and blue plates was accomplished by calibrating to a standard neutral density; the G7 method is based on these same photographic processes. Later methods of calibrating to a common neutral density were used to calibrate high-end color scanners and automatic film processing equipment. So, while G7 as a name and a print specification may appear new, in practice, the fundamentals that underpin G7 have been used to calibrate color output since the first practical color imaging devices appeared in the early 20th century.

Implementing G7 in Printing

In most cases, at least for inkjet applications, G7 calibration can simply replace conventional linearization, avoiding the need to add an additional step in the color workflow. Rather than linearizing the printer in the conventional way (which has the effect of calibrating the printer only to itself), G7 calibrates the printer to a set of system-independent aims derived from the native white and black points unique to the printer, its ink and media. The number of patches necessary to calibrate the printer need be no more than the typical number used for linearization; it requires no more time nor expertise, and the resulting curves can be applied in the same way as conventional linearization curves.

Primary ink limits may still be applied, depending on the printer and the substrate to be printed, but secondary ink limits are generally unnecessary. In some cases, depending on the RIP configuration, the calibration curves can be imported directly into the RIP software in lieu of linearization curves; in other cases, the linearization curves are kept null and the calibration curves are applied as 1D lookup tables inside the ICC profile. Either way, should color

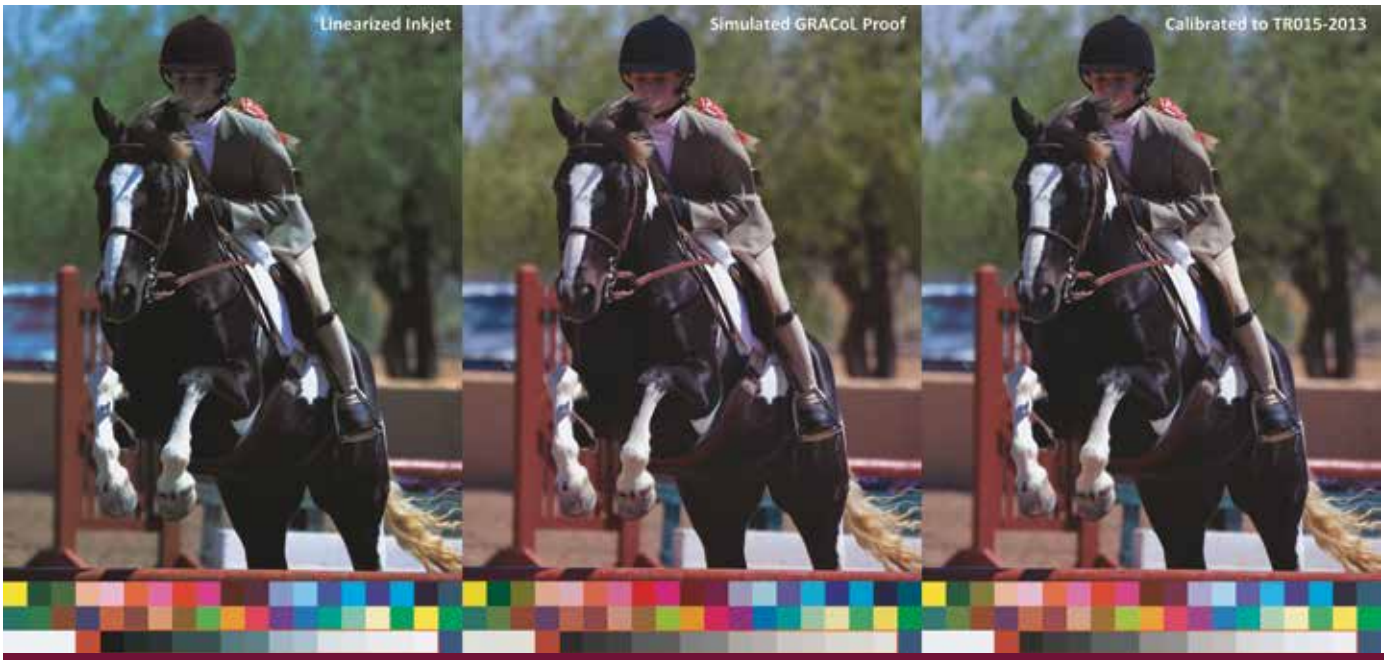

Fig. 1. A simulated GRACoL® proof (center) is shown next to two simulated print samples from the same inkjet device. The linearized print (left) shows an obvious green cast, a not uncommon problem with many commercial inkjet inks. The ANSI TR015 calibrated print (right) shows the green cast removed; the visual appearance of the print more closely matches the GRACoL proof. Calibration was performed in lieu of linearization; no extra step was added. Also, no color management was performed, save for an initial set of primary ink limits that were defined prior to calibration to avoid excess ink saturation at print time (the same limits were applied to the linearization sample). Photo credit: Desert Trails Horsemanship, Chandler, Arizona.

drift begin to occur, the calibration curves may simply be reiterated and reapplied; in most situations this avoids the need to regenerate the ICC profile.

The key difference between conventional linearization and G7 calibration is that G7 establishes a known good condition against which **any printer** may be calibrated and tested for conformity. Regardless of what happens during production — ink and media changes, printer maintenance, environmental variation — your known good condition is always available to calibrate back to. Linearization, on the other hand, calibrates only to a transient condition that can change over time. Without the ability to calibrate to a known good condition independent of any one printer, with traditional linearization there is no good way to ensure consistent color reproduction over time.

Common Misconceptions

A common misconception regarding G7 calibration is that it restricts the color gamut of the printer. This stems from confusion over visual appearance and color gamut; the notion that two printers calibrated to produce prints with a common visual appearance must likewise produce a common color gamut. But G7 defines only a standard visual grayscale relative to the native white and black points of the printer. It does not restrict the native process solid densities of the printer, nor does it restrict its gamut. Regardless of gamuts, G7 calibration will cause two printers to produce images with very similar visual appearance; a printer with a larger gamut may produce images more vibrant and saturated, but still visually similar to one with a smaller gamut. In G7 parlance, such a printer could be called G7 Extreme.

Another common misconception is that G7 calibration prior to profiling is unnecessary since the ICC profile should correct for neutral density. While technically true, this approach can be problematic for several reasons. First, achieving G7 compliance is not the same as maintaining it. For inkjet printing in particular, G7 calibration is an excellent basis for process control. With few exceptions, there is no way to 'dial in' color on an inkjet printer. All control over color reproduction resides in software, and in most cases relies on an ICC profile, but generating an optimum ICC profile is nontrivial. ICC profiling software from different vendors, or even different versions from the same vendor can offer different parameters and produce different results. Sometimes the selection of parameter values can be ambiguous or subjective, and very often different operators using the same software will generate profiles that produce somewhat different output.

Correcting for day-to-day color drift with frequent reprofiling can be time consuming, and can introduce errors and inconsistencies of its own. On the other hand, G7 calibration is quick, with virtually no parameters to configure, and yields a simple pass/fail outcome. When an ICC profile is built for a printer **already calibrated** to G7 aims, the calibration acts as a foundation for the profile. Except for some extreme cases, color drift can be corrected for by simply reiterating the calibration curves, which is fast, requires minimal operator skill and avoids the need for reprofiling. For the print shop owner, that is most often the ROI justification for adopting G7.

Real World Application

There are several G7-based solutions available, both standalone and system-integrated. A list of certified G7 solutions is available on the IDEAlliance website under the heading of G7. Working in partnership with ColorMetrix Technologies (makers of ProofPass®), Mutoh has developed an enhanced version of its ColorVerify® inkjet process control software, incorporating several common neutral density calibration methods, including ANSI TR015 to provide its users with an advanced set of tools to better ensure consistent color reproduction over

time and across multiple devices. It works directly with Mutoh's SpectroVue® VM-10 spectrophotometer, a compact instrument that mounts directly on the printhead of any of Mutoh's current line of ValueJet® printers. With it, calibration and control strips can be measured mid-production, on-printer without the need for sheeting off or measuring by hand.

With ColorVerify, operators can define a known good condition that the printer can be calibrated back to should color drift be detected in a control strip. Calibration replaces traditional linearization, allowing the printer to be calibrated to independent aim points prior to building the ICC profile. In this way, the ICC profile is built on top of the calibration. This becomes the baseline condition used by ColorVerify to check and correct for color drift during production, keeping the printer calibrated to standard aims even if ink, media, machine or environmental conditions change. In addition, the backend ColorVerify cloud server can analyze and archive this data to provide a 'big picture' of the production workflow over time, providing end-to-end process control for any large format inkjet workflow.

Christopher Brown is the Engineering Manager in charge of Mutoh's Advanced Engineering Group at Mutoh America's US headquarters in Phoenix, Arizona, a position he has held for the past 17 years. Part of Mutoh's global research and development network, AEG focuses on development of color management and digital image processing technologies, coordinated through Mutoh's Research & Development Center located in Shimosuwa, Nagano, Japan. Mr. Brown led the team that developed the VM-10 spectrophotometer, and designed Mutoh's Calibrator software. His primary work is with micro spectrometers and spectral sensing devices, sensor arrays and embedded instrumentation. He is a software developer with a background in image processing, color management and digital halftoning; an IDEAlliance Certified G7 Expert; and, holds multiple patents related to spectrophotometer methods, spectral deconvolution and inkjet printing.

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