Origin of The Optimal Method

REFRAMING COLOR CALIBRATION; MATCHING A REFERENCE PROFILE

"We realized that standard datasets were more important than their associated press calibration technique."

William B. Birkett

Our quest began in the summer of 2003. An important advertising client called to tell us their printer was having trouble matching our proofs.

As the technically oriented owner of Precision Color Inc, it was my job to investigate the problem. Our prepress company was supplying files and proofs to this printer, who had recently installed a CTP system. It was the time of color anarchy, as film and matchprint gave way to digital replacements, and each printer had its own ideas on color calibration.

This printer was cooperative and showed us the problem. Its presswork was sharper than our proofs. It seemed like an easy thing to fix, using tone reproduction curves. So:

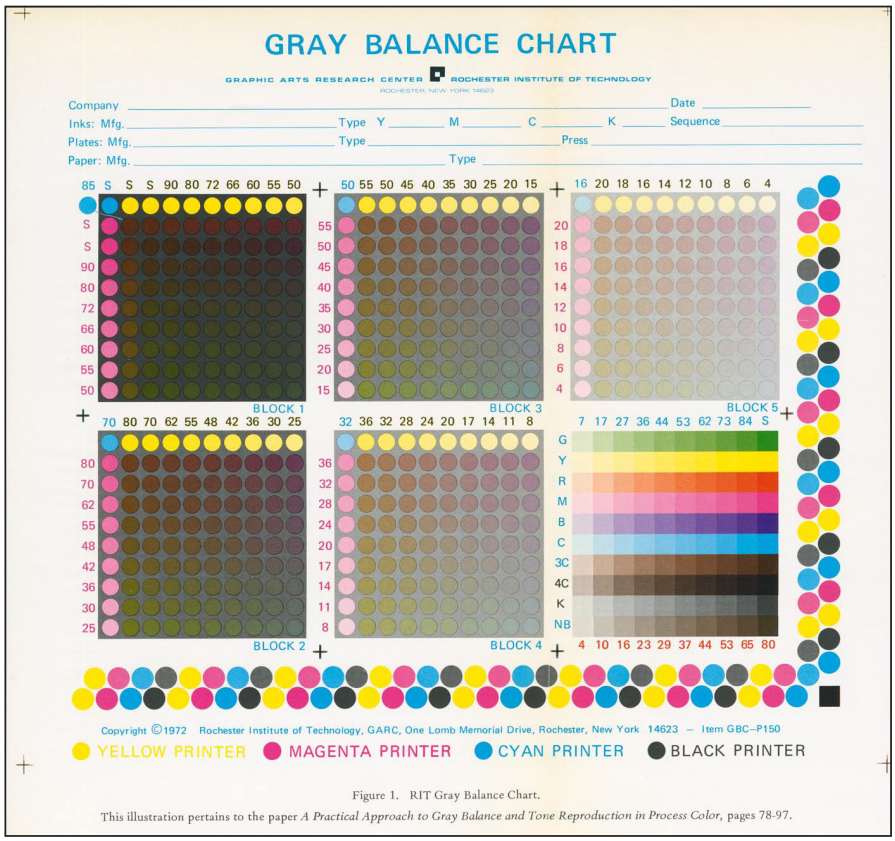

Figure 1: 1972 TRAND test chart

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Chuck Spontelli cuts a press sheet.

» It printed our test form, which we measured, then built tone curves using a tool from Scitex

» As a check, we made a new proof, which should have matched the press sheet. To our dismay, it did not

» We double-checked our work and measured the new proof. The TVI values were very close to the press sheet, but the color didn't match

I showed this to my friend, Chuck Spontelli, who was visiting from Bowling Green State University (BGSU), where he taught printing and color to students in the department of Visual Communications and Technologies (VCT). The prepress proof was a Kodak Approval with real halftone dots, transferred to the same paper as the press sheet—not a color-managed inkjet proof. Our prepress business was heavily invested in the Kodak equipment. We touted the advantages of real halftone dots, and the option to use the actual printing paper. So, it was important to find out why our proofs didn't match this presswork. Meanwhile, Chuck was looking for a research topic, and found this intriguing.

CALIBRATION TOOLS

I recalled the Tone Reproduction and Neutral Determination (TRAND) technique we used to calibrate our drum scanners (see *Figure 1*). It was developed by Zenon Elyjiw and H. Brent Archer of Rochester Institute of Technology (RIT), who described it in a 1972 Technical Association of the Graphic Arts (TAGA) paper. It involves printing a test chart with many near-neutral patches, identifying the gray ones visually, and using the density and CMY coordinates of those patches to build a scanner gradation. Using color management, I adapted this technique to make tone reproduction curves. I made a new approval proof using these curves, and it matched the press sheet very nicely.

The idea was simple. By building curves from a gray CMY ramp, we achieved a good reproduction of the gray axis. Anyone who's made color separations with a camera or scanner (there's still a few of us around) will tell you: That is the essence of good color. We had to make an International Color Consortium (ICC) profile of both proof and press sheet to build the curves. So, I

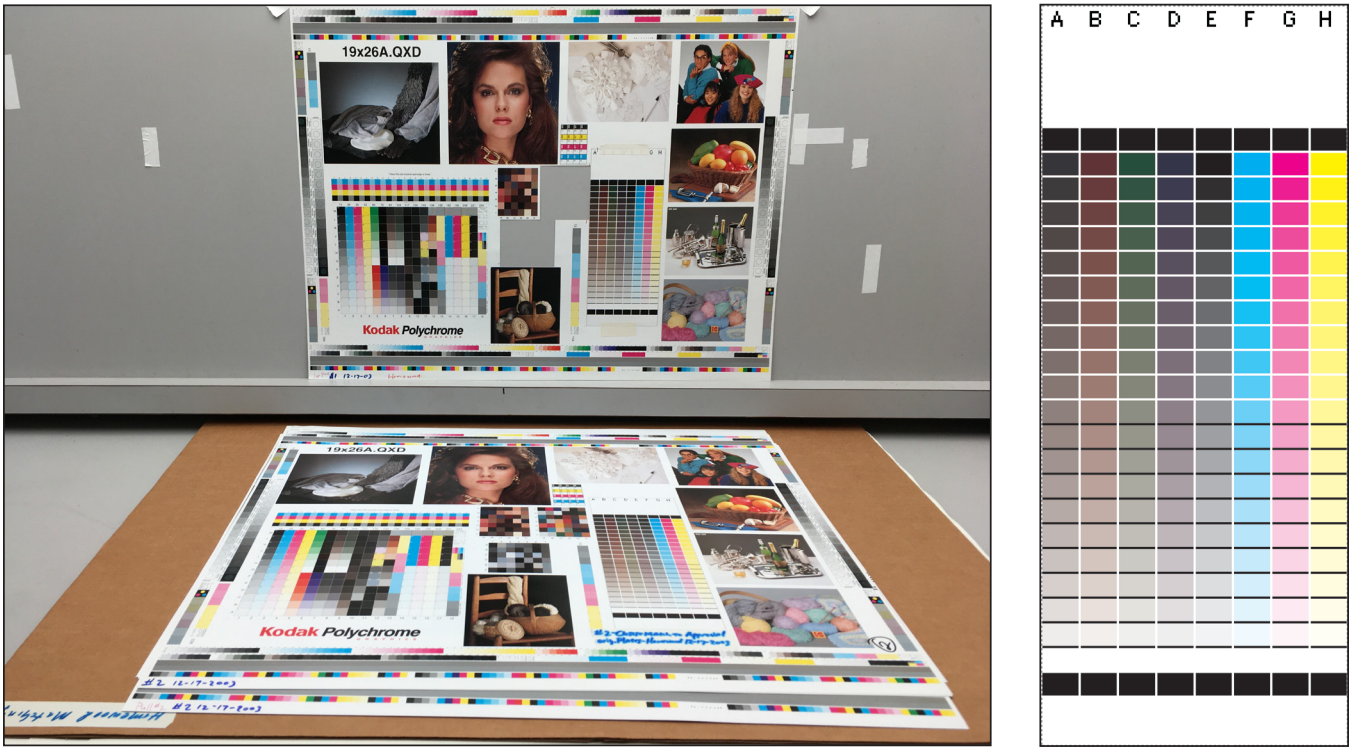

Figure 2: PressCal test chart and the original Homewood Press test sheets from 2003

refined the technique by using a tone ramp, where each sample contained equal amounts of CMY, rather than gray.

Curves built this way were nearly identical to those made with actual gray patches. Chuck and I tested this improved technique in December 2003 at Homewood Press, a small print shop in northern Ohio. The owner, Scott Dubuc, generously donated time and materials to help us (see *Figure 2*).

The results of this work were very encouraging, and we wanted to make them public. So we contacted TAGA and submitted an abstract for a paper. It was accepted and we got to work. We presented our paper at the 2004 annual meeting in San Antonio, TX. View the paper at optimalmethod.org.

This paper explained our technique from the standpoint of print standards, which were then based on density and dot gain. It was one thing to match a proof to printing, but that wouldn't help someone set up a printing process from scratch. We felt improved standards were needed.

STANDARDS & DATA SETS

My interest in standards grew from the realization that our prepress business depended on them. It was not feasible to have a unique color setup for each client. Matchprint proofs were our standard for many years, but CTP put an end to that. We were desperate to find a commercial print standard with authority.

Author William Birkett, making curves.

When we talked to clients about print standards, the one they knew of was Specifications for Web Offset Publications (SWOP). In 1995, the Committee on Graphic Arts Technology Standards (CGATS) ran a press test to characterize SWOP printing. It published the measurements as the TR 001 data set. If only we had an equivalent data set for commercial printing.

Fortunately, this work was already underway. In March 2004, we purchased a reference press sheet from the Association of Graphic Solutions Providers (IPA), which was printed to General Requirements for Applications in Commercial Offset Lithography (GRACoL) specifications. CGATS published the measurements of this pressrun as DTR 004. We planned to use this as our commercial color standard. But the pooh-bahs of standards giveth and then taketh away. Because of technical errors, the DTR 004 data was flawed, and eventually withdrawn by CGATS.

The people doing this work regrouped and decided that future pressruns would have smooth tonal characteristics, based on linear CTP plates. Because of our TAGA paper, I was invited to comment on these matters. I attended the Leyda Brain Trust meeting in San Diego, CA in January 2005, where I shared ideas on how to create a set of press characterizations that would have a common appearance. These ideas, combined with our color matching technique, were adopted by Idealliance and eventually became the G7 method.

Meanwhile, Chuck and I wrote a follow-up TAGA paper, which was presented at the 2005 annual meeting in Toronto, Canada. View the paper at optimalmethod.org.

This paper introduced two key elements of The Optimal Method. We fitted measurements of color tone ramps to cubic spline curves using a simple computer algorithm. We were unaware that cubic spline curves are Bernstein polynomials, a class of functions used in computer modeling, and that far better methods existed for fitting curves to data. Despite our lack of technical polish, we had some good ideas for improving print standards and laid groundwork for The Optimal Method.

We received inquiries about our work and began using our calibration technique with consulting clients. The results were generally good, but not always. Sometimes, the color match was off in the shadows, due to oddly shaped curves in that region. We came up with a quick remedy, which was to build two sets of curves: one using the near-neutral technique and the other using TVI. These curves were combined, favoring the near-neutral curves in the highlights and the TVI curves in the shadows (see *Figure 3*).

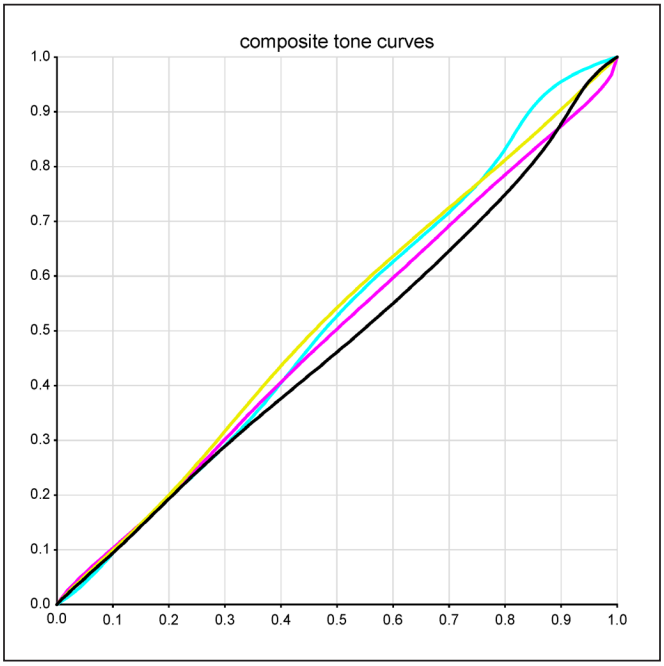

Figure 3: Composite Tone Curves

CTV TO SCTV

This blending technique needed an alternative to TVI, computed from colorimetry rather than density. That led us to develop a metric called CTV, or "colorimetric tone value." We thought this would be generally useful, and proposed it as a standard at the CGATS meeting in July 2005. View the briefing at optimalmethod.org.

There were a few comments after this meeting, then the idea sat dormant for nine years. With the help of Steve Smiley, it was resurrected as SCTV, or "spot color tone value." In 2015, ISO 20654 was approved, making SCTV a standard for spot colors only. Today, a revision of ISO 12647-2 is under development that includes CTV for process colors, as an alternative to TVI, which was our original concept. Now, back to the main story.

At the ISO TC-130 standards meeting in San Diego, in April 2006, the US delegation proposed standard datasets adjusted to a common appearance using the G7 method. This was not well-received by the German delegation, which had just introduced a certification program built around TVI calibration. Idealliance was planning a similar program using their G7 method. A serious rift opened in international print standards, which continues to this day.

In the aftermath of that fateful TC-130 meeting, CGATS wanted to prove the near-neutral technique was superior. We volunteered to work on that. At the CGATS meeting in Mesa, AZ in November 2006, we presented our findings. View the presentation at optimalmethod.org.

"PressCal can calibrate your press for re-runs or calibrate multiple presses in different locations to print identically, using your characterization profile."

NO FAVORITE

Using data from a highly touted G7 pressrun, we showed that neither calibration technique was superior. The near-neutral technique achieved better gray balance; the TVI technique produced better shadow rendition. We proposed a cooperative effort with Europe to develop an improved technique both factions could embrace. But by then, the G7 method was being heavily marketed, and our technical concerns were unwelcome, to put it mildly.

Both Idealliance and FOGRA (Germany's Graphic Research Technology Foundation) had a financial stake in their preferred calibration technique, and there would be no compromise. We attended CGATS meetings for a few more years, but it became clear Idealliance was in control of US print standards. One of our last contributions to CGATS involved the definition of gray, which underpins the G7 method. At the CGATS meeting in Grand Rapids, MI in July 2009, we gave a presentation. View the presentation at optimalmethod.org.

But once again, sound technical thinking was unwelcome. It was time for us to move on.

OPPORTUNITY KNOCKS

"One door closes; another opens," as they say. By giving up on standards work, we were able to focus on finding a better solution to the calibration problem. We realized that standard datasets were more important than their associated press calibration technique.

ICC profiles built from these datasets were used to make color-managed proofs, and that is what printers wanted to match. It didn't matter how these profiles were created, so long as they defined a realistic color space.

- In 2006, CGATS released a GRACoL dataset and two SWOP datasets, supposedly created using the G7 method
- FOGRA already had numerous dataset created with TVI curves, per ISO 12647-2
- In 2013, CGATS.21 was released, which included seven datasets for different papers, with similar appearance

By reframing the calibration problem as matching a reference profile, we could work with believers of either faith. Calibration is the adjustment of a device or process to produce accurate results. The Optimal Method is a general solution to the print calibration problem that works with any set of measurement samples. By using near-neutral samples, it makes G7 curves. By using process color ramps as samples, it makes TVI-like curves.

Better yet, by using a full gamut of realistic color samples, it makes optimal curves. The Optimal Method works by reducing color errors to their minimum. This idea was inspired by the work of Robert Chung of RIT, who first used error statistics (CRF) as an indicator of color matching accuracy (see *Figure 4*). We presented The Optimal Method in yet another TAGA paper, at the 2018 annual meeting in Baltimore. For details, visit optimalmethod.org.

RESIDUAL ERROR

Some engineering problems have no perfect solution. Building tone curves is that kind of problem. Ideally, tone curves would eliminate all color errors between actual printing and the reference profile. But this is generally impossible, and there will always be some residual error. The best one can do is reduce the residual error to a minimum, focusing on the errors that matter most. We call this the optimal solution, and that is what The Optimal Method finds.

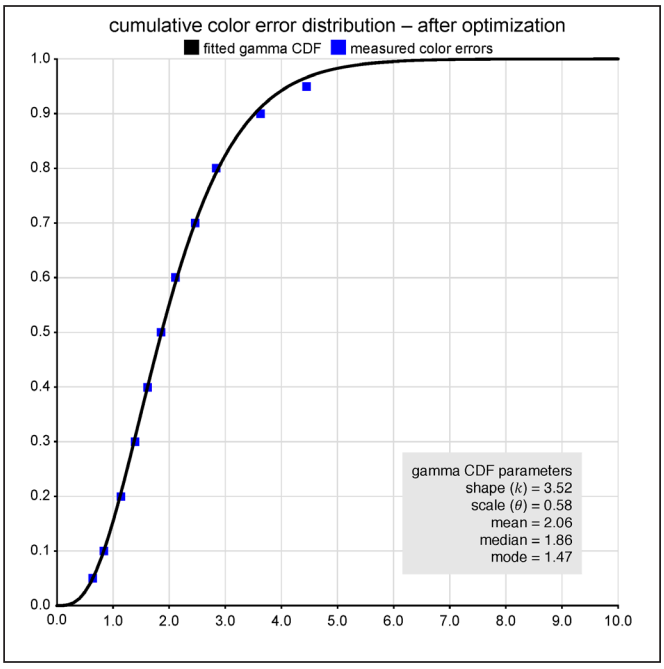

Figure 4: A PressCal CED graph, showing the cumulative error distribution, or CRF

We realize it may be difficult for those familiar with the TVI or G7 methods to accept this way of thinking. Both of those methods yield an exact solution for the sample sets they use. There is some comfort in thinking you've computed perfect curves down to the nth decimal place. But most of the possible colors are not even considered, relying on faith that if a few colors are correct, the rest will follow.

Those of us with experience running a color scanner will probably have a strong belief in the gray scale. And those with experience running a press may believe in TVI. But regardless of your faith, if you spend a little time using The Optimal Method (see *Figure 5*), you will see its advantages.

The Optimal Method, although simple in concept, is quite difficult to implement. So, we've created a free software tool called PressCal. Actually, we created a tool by that name in 2004, to compute curves for our TAGA paper. That tool gained acceptance over several years. In March 2010, I met with Dave Pauley, the CEO of Neyenesch Printers, in San Diego. We had a good conversation, where he encouraged me to turn PressCal into an open-source project. Today, the "color toolkit" is a library of 49 modules containing more than 50,000 lines of code. View it at optimalmethod.org.

PressCal builds on the color toolkit and provides a full suite of calibration functions, including TVI, G7 and SCTV curves. It supports spot colors and expanded gamut processes. View the sell sheet at optimalmethod.org.

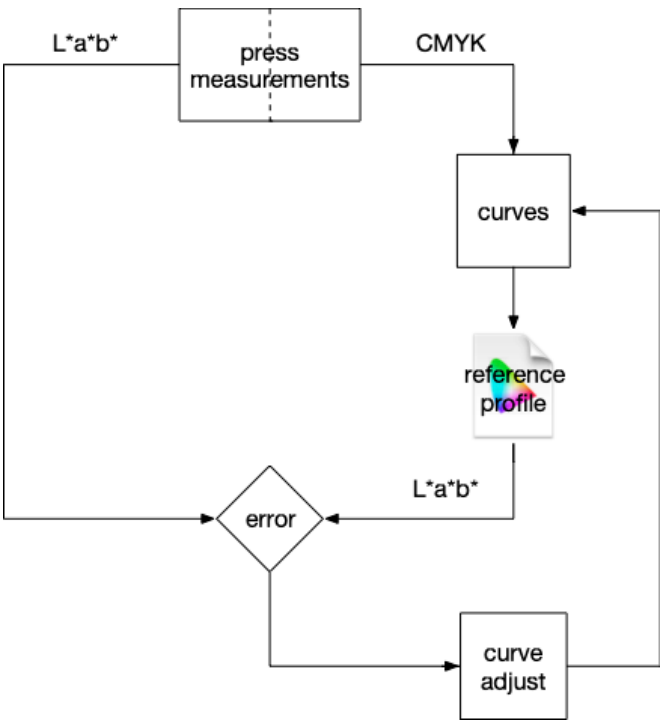

Figure 5: Optimal method flow chart

We believe The Optimal Method has many benefits for flexographic printers. Unlike other calibration techniques, the color reference is an ICC profile. This could be a CGATS profile, a FOGRA profile or your own custom profile. If you use *Flexographic Image Reproduction Specifications & Tolerances* (*FIRST*) methodology, PressCal could save you pressruns. It can produce tone curves from the fingerprinting pressrun to match your target color space, process control aim points and characterization data of the calibrated process. PressCal can calibrate your press for re-runs or calibrate multiple presses in different locations to print identically, using your characterization profile. The latest version of PressCal has many new features to support flexographic users. Best of all, it's free.

We believe print standards should be free, technically sound, and beneficial to both the industry and its customers. We're not in the standards or software business. We won't sell you a medallion for your website. But we are available as consultants to work with you on pressroom calibration. ■

ABOUT THE AUTHOR: *William Birkett has engineering degrees from the University of Michigan. After a short stint in the automotive business, he started a prepress company, Precision Color Inc, which prospered for many years. He and a colleague, Charles Spontelli—a graduate of Rochester Institute of Technology with a Master of Science from the School of Printing and an Associate Professor Emeritus at Bowling Green State University who taught courses in printing technology and color applications—got involved with print standards in 2003.*

Together, they developed a press calibration technique based on measurements of near-neutral colors. Bill and Chuck created the Colorimetric Tone Value (CTV) which is now Spot Color Tone Value (SCTV)—an ISO standard.

At the TAGA annual meeting in 2018, William and Charles introduced an improved calibration technique known as The Optimal Method, where curves generated direct a printing process to optimally match any ICC or proprietary color reference. Since then, they've developed an open-source software tool, PressCal, to implement this improved technique. William is glad for the opportunity to apply his math and engineering skills to help the printing industry. Since 2005, William has worked as a print quality consultant. His company is Doppelganger LLC. Contact him at wbirkett@doplganger.com.