The Manhattan Project

The story of how an ad-hoc group of New York / New Jersey ad agencies and printers who just wanted to improve their own printing efficiency, ended up revolutionizing printing standards.

Overview

The Manhattan Project (2003-2004) was an initiative by a group of Manhattan-area ad agencies and printers to define a common “reference appearance standard” for commercial offset printing.

Members included:

AGT (pre-press and printing)

Applied Printing Technologies (pre-press)

Foote-Cone-Belding (agency), now IPG Healthcare[1]

Hutcheson Consulting (leader) now HutchColor

Ogilvy & Mather (agency), now Ogilvy

Sandy Alexander Inc. (pre-press and printing)

TBWA\Chiat\Day (agency)

Also associated with the project were;

Dan Bowen (DuPont Imaging Systems)

Mike Rodriguez (R.R. Donnelley)

Larry Warter (Fujifilm)

The project’s initial tests were so successful that the Manhattan Project was soon absorbed by the Idealliance GRACoL® committee, which had a similar mandate, and the goals of both groups were ultimately fulfilled in 2006 with the release of the GRACoL2006 dataset.

Goals and motivation

The main goal of the Manhattan Project was to establish a single, precise definition of how a good offset press sheet should appear to the eye, and publish it as a colorimetric dataset to be used as a common target for all commercial printers and proofing systems to aim for.

The hope was to make all printing systems produce very similar results to each other and therefore reduce costs when preparing, printing and exchanging CMYK files.

At the time, offset printing was inherently unpredictable. Pre-press proofing systems differed

[1] Credit for kick-starting the project belongs to FCB’s Anthony Bellacicco (the squeaky wheel) and Ken Lantz, who provided some oil.

significantly from each other and from actual offset press sheets. One offset press run would typically not match another press or even a previous run on the same press, even though the same files, inks, substrate and calibration aims were used. Different CMYK files had to be produced for each machine and exchanging files between printers or locations, or re-printing a previous job, often involved custom trial-and-error pre-press or pressroom adjustments.

The International Standards Organization (ISO) had just published a 2004 update of its ISO 12647-2 standard, which defined basic variables like ink and substrate colors, but like earlier editions, it lacked direct control of two key pictorial appearance characteristics – neutral tonality and gray balance.

By defining a truly appearance-based standard that could be achieved easily on all presses, the Manhattan Project sought to answer some key questions raised by the new technologies of ICC (International Colour Consortium) color management and CtP (Computer-to-Plate) filmless platemaking, namely;

"If the whole world uses the same ISO-standard ink and substrate colors, why can't CMYK files produced in one country print the same in another?"

"If ICC color management can match virtually any printing system to any other, why don't all presses and proofs aim to match one ideal standard press condition?"

"How much can CtP calibration help different offset presses match each other?"

Initial testing

The initial challenge was to obtain printed samples of optimized offset printing, from which characterization data could be measured. Sandy Alexander (Mike Graff)[2] and AGT (John Sheehan) donated press runs while all members provided proofs on a variety of laminate halftone proofing systems including KPG Approval, Fuji FinalProof and DuPont WaterProof.

To minimize changes to existing workflows and standards, the solid ink Lab values in ISO 12647-2 were adopted, but the ISO-standard TVI (Tone Value Increase, a.k.a. "dot gain") curves were seen as a limitation, because practical experience showed they seldom resulted in predictable or accurate gray balance.

The P2P method

To solve the limitations of TVI, the Manhattan Project tested a new calibration method developed by Hutcheson, known as Proof2Press or P2P. Instead of measuring individual C, M, Y and K ink scales, P2P calibration measured just two gray scales, one printed with "balanced" CMY percentages and the other with black ink only. An additional "grayfinder" target was printed for CMY gray balance analysis.

The P2P method capitalized on the fact that the neutral tonality and gray balance of all CMY or CMYK printing systems can be completely controlled by simple curves, one for each ink, without limiting color gamut or the need for ICC color management.

A Proof2Press spreadsheet automatically calculated the CMYK adjustment curves necessary to force a printing system to match any other system's neutral tonality and gray balance characteristics. The big question was "what printing condition should P2P calibration aim to match?"

[2] If there's a Ground-Zero for G7, it's Sandy Alexander in Clifton, NJ, who hosted the world's first G7 press test and many subsequent G7 press runs and training courses.

First experiments – targeting SWOP®

The P2P system was first validated by trying to match the already existing TR001 dataset. TR001 was the world's first ICC-compatible CRPC (Characterized Reference Print Condition) consisting of characterization data from an IT8.7/3 target printed on an official SWOP press run in 1993. It was also the basis for Adobe's US Web Coated (SWOP) v2 ICC profile, by then the defacto standard for converting RGB images to CMYK.

The first round of prints were carefully calibrated by the P2P method to match the gray balance and neutral print density curves of TR001. Simultaneously, comparison test prints were made with the same systems calibrated to the standard TVI curves in ISO 12647-2.

When the results were viewed in FCB's D50 viewing booth, the committee unanimously agreed that all five P2P samples exhibited a very close visual match to each other and to a certified SWOP press sheet from the original 1993 press run. Unlike the P2P method, the TVI samples differed unacceptably from each other and from the certified SWOP press sheet.

Based on these initial tests, the Manhattan Project approved TR001 as their interim standard for publication (SWOP) color separation, proofing and printing.

Seeking a commercial offset target

Having demonstrated that the P2P method worked, the next task was to produce an equivalent standard for commercial printing on brighter, grade 1 coated paper.

The Idealliance GRACoL committee had already released a provisional dataset known as DTR004 for testing. The Manhattan Project simply replaced the TR001 dataset with DTR004 as a target in the Proof2Press spreadsheet and a similar round of press and proofing tests were conducted.

Although the P2P method again produced an excellent match between all five systems, the results were too dark and did not represent good commercial printing. DTR004 was therefore rejected as unsuitable for a commercial printing standard.

Merging with GRACoL

Because the Manhattan Project and the GRACoL committee shared common members and goals, the two groups merged. At Idealliance's request, Hutcheson donated the P2P method to Idealliance who renamed it "G7®" and published a free "G7 How-To" booklet that evolved from the Manhattan Project working document, "Matching Standards".

Although a US committee, GRACoL hoped to produce a commercial offset definition that could be used internationally, not just in the United States, so they worked to change as little of the existing ISO 12647-2 standard as possible.

However, the recent trend away from film-based platemaking to Computer-to-Plate (CtP) had changed the natural TVI (dot gain) characteristics of offset presses since the standard was written. This, along with the success of the P2P method, argued strongly for replacing the legacy ISO 12647-2 TVI curves with a new definition of tonality.

Defining G7 tonality

ISO 12647-2 provided two sets of TVI curves, one reflecting the higher TVI caused by plate exposure through a halftone negative (prevalent in the USA), and one based on the lower TVI caused by exposure through a halftone positive (prevalent in Europe and Asia). This meant

that CMYK data prepared for positive plates would be too dark if printed with negative plates, and vice-versa. The ISO 12647-2 TVI curves were therefore not a good basis for a single, universal definition of print appearance, because these lightness variations conflicted with the goal of a constant printed appearance and made the exchange of image files between regions needlessly difficult and expensive.

Because CtP plates produced TVI curves roughly between the positive and negative curves in ISO 12647-2, the GRACoL committee could have defined new TVI curves based on the natural performance of a CtP-based press run, however TVI is not a colorimetric unit and TVI curves cannot (on their own) control gray balance, so instead GRACoL defined tonality in the new NPDC (Neutral Print Density Curve) metric used by the P2P method.[3]

Two NPDC curves, one for a CMY-only gray scale and one for a K-only scale, were produced by averaging neutral density (ND)[4] measurements from nine carefully controlled GRACoL test runs versus original file percentage.

G7 press testing

GRACoL press testing involved at least two press runs each, at the following nine sites;

Sandy Alexander, NJ	July 7-8, 2004
AGT, NJ	July 22-23, 2004
Fidelity, CT	January 31-Feb 1, 2005
Manroland, IL	March 30-31, 2005
LaGraphico, CA	April 28-29, 2005
Komori, IL	June 2-3, 2005
Heidelberg, GA	July 7-8, 2005
LP Thebault, NJ	July 18-19, 2005
CRW, Pennsauken, NJ	September 15-16, 2005

The first run was made with no plate curves, followed by a second run with correction curves to match the average of that and all preceding first runs. ISO-standard paper and solid ink CIELAB values were targeted, using 175 lpi and 200 lpi euclidean dot screening.

Raw data from all first runs were averaged and smoothed to produce the G7 NPDC curves.

The GRACoL press tests closely replicated typical commercial CtP printing in the US, which explains the rapid adoption of GRACoL and G7. As a bonus, the average TVI curves roughly averaged the positive and negative TVI curves of ISO 12647-2, making GRACoL and G7 ideal candidates for addition to the ISO 12647-2 standard.

G7 Tonality adaptation function

If a press or proofing system had a different dynamic range (DR) than GRACoL, a non-linear compression/expansion function built into the P2P algorithm altered the CMY and K NPDC target curves to fit the new system's DR. To maintain constant highlight-to-mid-tone contrast

[3] This decision caused the final GRACoL dataset to deviate slightly from the ISO 12647-2 TVI curves while remaining within ISO tolerances, except for the K curve.

[4] Note that colored density values are not colorimetric, but neutral density (ND) is derived from L* without regard to a* and b* and is thus indirectly a colorimetric unit.

across all printing system, this function altered darker tones more than lighter tones.[5]

Standardizing G7 gray balance

In printing, as in photography, the consistent production of neutral gray tones from primary CMY colorants is one of the most important control requirements. However, ISO 12647-2 had no direct gray balance definition, so GRACoL had to develop one from scratch.

Gray balance is actually a two-part definition; part one is the ratio of CMY percentages that should produce gray, part two is the colorimetric value a gray area should measure when printed.

Gray balance part one: CMY ratios

In the absence of an existing gray balance standard, GRACoL defined a scale of constant CMY "triplets" from "white" (0 C, 0 M, 0 Y) to "black" (100 C, 100 M, 100 Y) that should always print neutral gray on all printing systems, regardless of ink colors or other variables. It was tempting to define these triplets with equal CMY values, e.g. 50 C, 50 M, 50 Y[6], but for legacy compatibility reasons, they were based on the traditional mid-tone imbalance of 50 C, 40 M, 40 Y[7].

That was the easy part.

Gray balance part two: colorimetry

Part two required that the printed color of these standard CMY triplets be defined in unambiguous colorimetric terms.

This part was not so easy.

At first, a constant gray balance definition was tried which required each triplet to print with theoretical neutral CIELAB values of 0 a* and 0 b*. This was effective for nearly neutral substrates but if the substrate had a noticeable color bias, grays tended to appear the opposite color, due to the visual system's chromatic adaptation function, which subconsciously uses the unprinted substrate as a "neutral white" reference.

A second definition was tried that required the whole gray scale to have the same a* and b* values as the substrate, but this caused the opposite problem. As the grayscale became darker, grays seemed to magnify the substrate color.

Finally, a simple compromise was chosen that was easy to implement, replicated tradition[8] and produced a convincing neutral appearance throughout the whole CMY gray scale. In this final definition, printed grays are defined as the substrate a* and b* values, multiplied by the inverse fraction of the cyan percentage.[9]

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[5] The compression / expansion function (tonality adaptation algorithm) is detailed in ANSI CGATS TR015.

[6] The author wants his gravestone to read "It should have been 50, 50, 50".

[7] The traditional gray ratio of 50 C, 40 M, 40 Y has little scientific basis. It dates from the 1940s when "blue", "red" and "yellow" inks were weaker than today's CMY inks. Blue was weakest, requiring larger dot values to balance red and yellow. Modern inks can easily produce neutral grays with equal CMY percentages, either by increasing pigment load or ink film thickness, but breaking tradition would have made GRACoL incompatible with millions of existing CMYK files and support technologies.

[8] The traditional 50, 40, 40 CMY ratio could always make a neutral gray, regardless of paper color.

[9] For details, see ANSI CGATS TR015.

SWOP joins the G7 party

When the SWOP committee[10] saw the success of G7, it adopted the same principles and merged with Idealliance. Rather than hosting more live press tests, the TR001 dataset was tweaked slightly, to precisely match G7 tonality and gray balance, producing two versions, SWOP2006_3 and SWOP2006_5, for use on grades three and five publication stock.

G7 vs. P2P

Once gray balance was decided, Idealliance locked the G7 formulae and published them in ANSI CGATS TR015, where they have not changed in over fifteen years.

So how is G7 different from P2P? In fact they are almost identical, except for two key differences;

First, whereas the P2P method can match any printer to the tonality of any other printer, all G7 tools (graph paper, spreadsheets or software like Curve4) are hard-wired to match only the original GRACoL NPDC curves, modified as needed by the adaptation function.

These fixed target NPDC curves mean that anyone using G7 (properly) should get the same visual contrast or tonality in neutral areas as any other G7 user, subject only to differences in substrate brightness and/or maximum neutral density.

Secondly, while P2P can theoretically match the gray balance (or imbalance) of any target system, G7 uses a fixed formula that ensures the whole CMY gray scale always appears neutral or colorless (relative to substrate) from white to maximum CMY density. It also guarantees that grays produced by any two G7 printers, regardless of inks or technologies, should match each other, subject only to differences in substrate color.

Taking G7 to ISO

Because of the unexpected popularity and rapid adoption of G7 in the Americas and Asia, the US delegation to the ISO TC130 committee (which writes the ISO 12647-2 standard) proposed in 2006 that ISO 12647-2 should be modernized by replacing legacy film-based TVI curves with a G7-like system that precisely defined neutral tonality and gray balance.

Because the G7 NPDC curves were based on CtP press runs whose TVI curves roughly averaged positive and negative printing, it seemed a logical basis for a more universal standard that would eliminate the regional differences that limited the usefulness of ISO 12647-2.

This suggestion was repeatedly opposed by a few conservative TC130 members and it took more than fifteen years before the G7 concept would finally be added to ISO 12647-2 as an optional alternative to TVI curves, under the name “near-neutral”.

Did the Manhattan Project succeed?

The Manhattan Project started as a group of print buyers and printers who simply wanted to improve the economics and quality of their own print production. GRACoL2006, which can be traced back directly to the Manhattan Project, more than achieved that goal. But more

[10] Formed in 1977 by Joel Rubin, George Leyda et al, SWOP (Specifications for Web Offset Publications) was a set of specifications based on solid ink densities and dot gain. Although not a true standard, SWOP pioneered the idea of standardized printing and was still the official target for publication printing in 2005.

than that, it introduced a new approach to print standardization that exceeded the practical value and efficiency of existing standards.

What nobody could have predicted in 2006 was that G7, the calibration method on which GRACoL was based, would become even more important than GRACoL itself and eventually be standardized under the generic term, “near-neutral”. So as the current edition of ISO 12647-2 prepares to add the near neutral specification as an alternative to TVI curves, it’s worth remembering that GRACoL, G7 and the new near neutral standard can be traced back directly to, and would not exist without, the Manhattan Project.

About the author

A keen photographer since age ten, Don Hutcheson’s three favorite sayings are “printing is photography”, “laziness is the mother of invention” and “question everything.”

In 1973, he completed a five-year photoengraving apprenticeship in his hometown of Auckland, where in 1969 he operated New Zealand’s second drum scanner, a Hell C296. Seeking a little adventure, he left New Zealand in 1975 and soon learned to be more careful what he wished for. While teaching color printing at Mosul University Press, he was nearly eaten alive by wild dogs in the ruins of ancient Nineveh. Facing hanging or life in prison without parole for visiting Kuwait without an exit visa, his life was saved by Donna Summer of “love to love you” fame and he was personally pardoned by Saddam Hussein.

How he invented G7

Don came to the USA in 1979 to demonstrate drum scanners. The studio had two proofing systems from DuPont and 3M, but when he calibrated them to identical TVI curves, the resulting proofs looked very different. Worse still, a press sheet with the same TVI curves looked much lighter than either proof! This meant he would have to program the scanner differently for each system by trial-and-error – a slow, inefficient solution.

Then he had an epiphany; printing is just a branch of photography and the key color in photography is gray! So, he measured gray scales on both systems and plotted graphs of neutral density vs dot percent. Looking up the percentages needed on one proof to match the same densities on the other, he applied the resulting calibration curves via scanner gradation controls and made two new proofs from different films. Both proofs now matched very closely after just one test. Science triumphed over trial-and-error!

Using the same method, he could easily adjust each customer's scanner to match their proof to their press or vice-versa. RIP curves and ICC didn't exist yet, so in 1979, this was bleeding edge. But when Don showed his discovery to experts from Kodak, DuPont, Agfa, 3M and GATF, they all said he was doing it wrong. "TVI is the standard and that's what you should match" they said, so he kept his technique to himself.

In 1995, Don became one of the first ICC color management consultants. CtP was quickly replacing film but traditional linearization didn't seem to work for CtP, so he dusted off his old technique and, calling it "Proof2Press", travelled from printer to printer, making their proofing system match their press, or vice-versa, using a custom P2P spreadsheet. But setting up closed-loop systems that didn't match each other seemed a lost opportunity. Why not calibrate all presses and proofing systems to match one "master standard?", he thought.

In 2003, three New York ad agencies, tired of paying duplicate pre-press costs when moving files between printers, asked him basically the same question; "how should an ideal commercial press sheet look?" There was no standard, so Don suggested they make their own and, with the help of a couple of local printers, the "Manhattan Project" was born.

Because the Manhattan Project duplicated the GRACoL project, the two were merged under Don's leadership to create the new "GRACoL 7" specification. A key tool was P2P calibration, which became known as "GRACoL7 calibration" and abbreviated to "G7".

One of the most revolutionary moments in the history of printing came in 2006, with the release of two almost identical "official" CMYK color spaces, GRACoL2006 from the USA and fogra 39 from Germany. These suddenly wiped away the uncertainty of how a press sheet should appear and made pre-press, printing and print buying radically easier, faster and better.

In over fifty years, Don has seen a lot of changes in photography and printing. Sometimes he wonders what changes will happen in the next fifty years. You young'uns should feel free to drop by his grave now and then and let him know.

Bring IPA, or a good single malt.

Spill a little.