Test Targets 2.0: A Collaborative effort exploring the use of scientific methods for color imaging and process control

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Authors
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A collection of digital test forms showcasing features, capabilities, and applications in printing and publishing.
Test Targets for Graphic Arts Imaging
R·T School of Print Media <2/2002>
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Preparing the files for output at the Digital Publishing Center; front row left: Ian and Mahadzir; back row left: Tanit, Arthur, Deepak, and Anir.
**Acknowledgments**

*Test Targets 2.0* was a class project in Test Targets for Graphic Art Imaging in the winter quarter of 2001-2 academic year. The objectives were to put together a collection of custom test forms, developed by Professors Robert Chung and Franz Sigg, and to coach students to showcase possible use of these test forms along with associated Microsoft Excel templates for device calibration and process control when implemented in a color managed digital workflow.

We wish to extend our sincere appreciation to the following individuals and organizations for their support and assistance. Without their supports, this publication could not have been completed.

**Cover design — Tom Chung**

Trained as a designer, Tom has worked in New York City as an art director in advertising, design and web. He launched creativeputty.com offering his 21 years of marketing communications experience on-line.

**Silver halide photography — Donna Crowe**

Enrolled in the graduate school at RIT and fond of nature photography, Donna made many of her beautiful photographic images available to fellow students to study color image reproduction.

**Digital photography — David Pankow**

As the curator of the RIT Melbert B. Cary, Jr. Graphic Arts Collection, a library on printing history, Dave provided digital images of the Kimberly-Clark Collection in this study.

**Imposition and layout — Mahadzir Mohamad**

Creative and accommodating, Mahadzir took on extra responsibilities in this class project. He provided the layout of *Test Targets 2.0*.

**Paper — Sappi Fine Paper North America**

A long-time supporter of RIT in research and materials testing, Sappi (also known as S. D. Warren Company) donated all digital grades paper for the reprint of this publication.

**Presswork — John Eldridge**

Familiar with both conventional printing and digital imaging, John provided the expertise and support in the Indigo UltraStream 2000 calibration and subsequent production runs.

**Finishing — Phil Bailey**

As a resident bindery and finishing master, Phil was instrumental in guiding us through the proper imposition and postpress to give the publication a finished touch.

**Digital press — Indigo America**

A recent equipment donation to RIT, we were pleased to be able to use the Indigo UltraStream 2000 to publish our publication.

**Color management technology — GretagMacbeth, Kodak, Monaco, X-Rite**

These companies were instrumental in providing us with color management software and hardware. We’re happy to recognize their long-time supports.

**Former RIT students**

The following individuals should be recognized for their efforts in the design and modification of early versions of the Print•RIT test forms and Excel templates: Joel Chan, Raul Gonzalez, Yoshikazu Shimamura, Yuth Chotipatoomwan, Stone Zhao, and Andres Santander.

**School of Print Media**

That’s right! This is our school’s new name. To stay current with the graphic media and digital imaging trends, we also offer a new curriculum. Please go to http://www.rit.edu/~spms to find out more about us.
Introduction

**Test Targets 2.0** is a collection of digital test forms and their applications showcasing features found in printer calibration software, pressroom color control devices, and color management systems. A test form consisting of pixel-based files as well as vector-based files, provides us with the tools to study how digital front-end moves data from pixels in a digital file to spots on paper. Test targets give us insight into the device addressability, tonal rendering, and gamut capabilities.

**Test Targets 2.0** was conceived, developed, and produced at RIT. It represents a synergy among faculty, staff, and students in School of Print Media. It also represents a learning continuum where we revised and updated these test forms as illustrated in the publication. When used in conjunction with color measurement tools and custom-designed Excel templates, these test forms provide us with insights into device characterization and process optimization.

Let me offer you a quick sketch of what’s included in this issue. The cover design idea came from the test targets. “By using different shades and contrasting colors,” explained by Tom, “Pixel-like letter forms are created with the test target elements. It is a demonstration of how informative test targets can be.”

A number of Print•RIT test forms are shown in the first section of the book. The byline of the test form indicates its purpose. Device specific data, e.g., press, paper, digital front-end, are also documented. To showcase how these test forms may be used, Mahadzir elaborated on the common section of the test form. My colleague, Franz, introduced various synthetic test elements for device addressability and for screening diagnosis.

To characterize a CMYK output device, Arthur measured an Indigo printed sheet by densitometry and analyzed the data with a custom Excel template. Anir did the same except that he measured the press sheet colorimetrically. Tanit explored the tonal rendering capabilities of the Indigo digital front-end. He was able to simulate three tone reproduction settings simultaneously.

To showcase the use of test forms for color management practices, I compared color image reproduction from digital photography to print with and without ICC-based color management. Deepak compared two rendering intents, perceptual and absolute colorimetric, using images captured by a film scanner. Ganesh compared color image reproduction using scans from two scanners. Together, these applications provide a link between test targets and solutions to real-world problems.

**Test Targets 2.0** is a study of the hard copy output device. We were pleased to perform fingerprinting on the Indigo UltraStream 2000 digital press. We intend to include other output devices, e.g., sheetfed and web offset presses, in future editions of the Test Targets publication series.

It is my pleasure to provide the introduction for this publication. It reminded me of many people who were intimately involved in the design of the earlier version of the test forms and in the improvement of Excel templates for tone and color analysis. It also reminded me of how lucky I’ve been that I can work with Franz Sigg, my colleague, side by side to teach the Test Targets course at RIT. Together, we made teaching and learning fun.

Robert Chung, Professor
Feb. 15, 2002
Rochester, New York

Please send your comments to Robert Chung, Professor, RIT/SPM, rycpr@rit.edu. To learn more about the Test Targets course, go to the web site at http://www.rit.edu/~rycppr.
## Print-RIT Device Characterization Test Form

**IT8.7/3 Basic data set from ISO 12640 SCID**

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- 600 ppi, 42.3 \( \mu \)pixel
- PS Version: 3011.104
- PS Language Level: 3

### Test Targets 2.0

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  - Paper: 100# Sappi Lustro Text

- **Prepress** Information:

### Press Information:
- **Indigo UltraStream 2000**
- **100# Sappi Lustro Text**

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**IT8.7/3.TIFF**

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**DG4C11U.EPS**

**RIT Doubling Grid**

---

**DG4C11U.EPS**

**RIT Doubling Grid**

---

**IT8.7/3.TIFF**

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Print-RIT Synthetic Targets Test From
Testing for resolution, register, dot gain, gray balance, uniformity

ID: TF_02
Version: v2.0
Prod. Date: April 8, 2002
Notes: 

RIP Information:
Mac Distiller
600 dpi, 42.3 µ/pixel
PS Version: 3011.104
PS Language Level: 3

Paper: 100# Sappi Lustro Text

Prepress: 

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DG4C1U.EPS  RIT Doubling Grid
4Res07U.EPS

---

4REP07U.EPS

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FA109U.EPS

---

RA73T_U.EPS  Also a version with 73 rays

---

VREGH08inU.EPS  Comes in inch / metric and horizontal / vertical versions

---

SWGR03U.EPS

---

S6A.rev.tif

---

P4Bar01U.EPS

---

TR4V03U.EPS

---

GCRBar02U.eps

---

Notes: Use only at Rochester Institute of Technology
Screen Ruling: 150 lpi
Addressability 600 DPI
License expires Jan. 24, 2003

Franz Sigg, Switzerland 2000
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RIT Bar

PrintTargets 2.0
Print•RIT Pictorial Reference Images
ISO 12640 Standard Color Image Data

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ISO 300

Test Targets 2.0 | 03
Note:
These are Photoshop EPS files with imbedded screen ruling for Adobe Accurate Screening. Some RIP's override these requests and default to their own screening. FM scales were produced using Ugra Velvet screening.
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**RIP Information:**
- Mac Distiller
- 600 ppi, 42.3 μ/pixel
- PS Version: 3011.104
- PS Language Level: 3

**Press**
- Indigo UltraStream 2000

**Paper**
- 100# Sappi Lustro Text

**Prepress**
- 

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### CMYK-Testchart Version 3.5

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### TCR Bar Version 1.0
The Showcase

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Objectives

The R•I•T Print test forms have been built based on some common features. There is a header with a title and subtitle, a target and production information. In addition, there are color bars and registration targets. This article explains the common purpose of these targets and why they have been used in all test form. The main purpose is to analyze the factors influencing the printing process, a series of test elements is often printed along with the image. Each element is designed to analyze a particular aspect of the printing process. While some of these test targets can be evaluated by eye, others require the use of measuring equipment. The usual form of these test elements is a strip across the edge of the press sheet.

1. The Print R•I•T Color Bar

The R•I•T Color Bar enables the user to monitor ink density, tint density (total dot gain), directional dot gain, wet trapping and checker boards to test resolution. One important variable is the uniformity of inking within the press sheets. Solids are used to test the uniformity. Therefore several solids are needed for each color in X and Y direction. (figure 2)

Dot gain normally does not change very much across the press sheet, and therefore it is enough to have one or two locations for the 50% tint patches. Total dot gain is measured using the Murray-Davies equation which needs a solid density and tint density as parameters (figure 3).

Directional dot gain can be observed by using the circular slur and doubling patches. If there is no directional dot gain, the circular pattern has a uniform density (figure 4a). If there is doubling or slur, then there will be light and dark segments in the circular pattern (figure 4b).

Wet trapping can be evaluated by measuring two color overprint patches (figure 5). Ink trapping is mainly affected by the tack of the inks and the degree of dryness of the first down ink layer.

Common Purpose Test Targets

All test forms have two sets of color bars placed in the X and Y direction (L shape). These color bars are specifically designed for these test forms using modular elements. They are not necessarily optimized for production press work. Other color bars are available for these applications.
Checkerboards are visual test target to evaluate resolution of the imaging device (figure 6). There are 1x1, 2x2, 3x3 and 4x4 spot checkers plus a 50% reference tint. This target is very sensitive to changes in exposure, and therefore is used to verify that the printing plate was made according to specifications. Even if these checkers can be resolved on a plate, they may not be resolved on the printed sheet.

2. The Gray Bar

The most immediate need for press color control is uniformity and accuracy of inking. If all inks are low or high then this is less of a problem than if only one ink is low or high. A gray bar shows color balance. There are two types of alternating patches: one patch which is only an 80% black tint, and the other patch which is a 3 color gray using 75% cyan, 62% magenta and 60% yellow. The dot areas of these patches were chosen because, when printed under standardized conditions, they will form a neutral gray of the same darkness. If the patches do not print gray, then the color imbalance can very easily be visually evaluated. Although its major use is visual, the gray bar can be measured to get quantitative data. If there is an imbalance, then it may be necessary to also verify directional dot gain.

3. Registration Target

Press operators need a quick way to verify registration. Normal registration crosses work well, but a magnifier is needed for evaluation. The RIT Traffic Light Registration Scale (figure 9a) can be visually evaluated. It indicates register of the colors relative to black. Because the black holes and the colored circles have the same size, the slightest misregister will cause a moon shaped white area on one side of the circle (figure 9b).

Summary

The common elements on these test forms make it possible to verify the conditions under which the test forms were printed. Evaluation can take place visually and/or densitometrically. Some of the characteristics that can be evaluated are:

- Hue and densities of printed inks
- Uniformity of inking across the sheet
- Dot gain or loss
- Directional dot gain such as doubling or slur
- Trapping
- Registration

Print-RIT Test Forms used in this study:
Test Targets Showcase: Using Synthetic Test Targets to Evaluate Output Devices

by Franz Sigg

Introduction
This test form contains targets for testing various aspects of output devices. Most of the EPS targets use handwritten PostScript code which has the advantage that the targets contain internal logic that allows them to automatically adapt themselves to the characteristics of the output device. For instance, they know device spot size and adjust to it. Some targets can be customized by the user by editing the header of the code of the file. More complete documentation is available at the location of the files. There are targets for the following parameters:

Registration
TR4V03U.EPS, Traffic Light Registration Scale. This target is more visually sensitive than a regular registration cross.

The following two targets should be place horizontally and vertically in a test layout.

PregH01U.EPS, Pixel Registration relative to black. This target indicates misregister in units of addressability squares and also millimeters.

VREGH08inU.EPS, R•I•T Visual Registration Scale. This target uses moiré to magnify registration errors and give a visually readable numeric readout.

Resolution
4Res07U.EPS, R•I•T 4 Color Resolution Target. This target shows 1x1, 2x2, 3x3 and 4x4 checkerboard patterns for all colors. If they all image with an area of 50% then the highest possible resolution of this digital system has been reached.

4REP07U.EPS, R•I•T 4 Color Resolution Patch. This target shows the same patterns as the 4Res07U.EPS target, but in a smaller format, to facilitate placement.

FanP10U.EPS, R•I•T 4 color Fan Target. This target shows aliasing and resolution, and whether the system can resolve down to one spot.

Addressability
ADIND04U.EPS, R•I•T Addressability Indicator. Sometimes output devices indicate a higher addressability than they mechanically produce. This target helps to determine true mechanical addressability.

Graybalance
SWGR03U.EPS, R•I•T Neutral Balance Target for SWOP. If an output device produces a gray balance as defined by SWOP, then the 4 fields appear to have a uniform gray color and do not show the circular center.

Smoothness of tonal reproduction
S6A.rev.tif, These vignettes have been published by ISO and indicate the smoothness of tonal rendering of a gradient, particularly at the highlight end of the scale.

Directional dot gain
DG4C11U.EPS, R•I•T Doubling Grid. Directional dot change is indicated when the horizontal and vertical lines are not reproduced at the same darkness. This is very useful for testing offset printing where doubling can be a major problem.

FanP10U.EPS, R•I•T 4 color Fan Target. This target shows aliasing and resolution, and whether the system can resolve down to one spot.

Production control
P4Bar01U.EPS

GCRBar02U.EPS

The color bars on this page were specially designed for these test forms from modular components. One shows inkling, dot gain, directional dot gain and resolution, the other shows color balance and can be used to visually test for uniformity of color.
Objective

The best way to obtain good color reproduction is by using color management. Color mapping with the use of profiles compensates for differences in tone reproduction and the color of the primaries. Although this is an elegant method, it requires considerable training and resources to make it work.

A simpler method can be used in cases where we would like to match two printing systems that differ in dot gain but use similar inks. For instance, the inks for offset and flexo are similar, but dot gain is quite different. Or, using one printing system and set of inks but different screening, there will also be different dot gain. Figure 1 shows an example of this.

Generating an FM halftone

There are many ways to generate an FM halftone. Some RIP’s have special settings for FM screening. We are using Velvet Screen from Ugra that generates an FM bitmap from a Photoshop EPS file. With this method it is possible to apply the transfer curve in Photoshop when generating the EPS file. This has the advantage that it becomes possible to print an AM and FM image side by side on the same press sheet.

Using an Excel to calculate the transfer curve

It is possible to determine the transfer curve manually by plotting the graphs. However, to facilitate the process, an Excel workbook called Transfer Calc was developed. It has a worksheet with instructions to help the user. Figures 1 and 2 were copied out of this workbook. This workbook is flexible and can be adapted to data sets with different numbers of gray scale steps.

Print-RIT Test Form used in this study:
Test Targets Showcase: Device Characterization by Densitometry

by Arthur Summerville

Objectives

This is a study that illustrates how the IT8.7/3 test target is utilized for characterization. The IT8 target is very effective in obtaining the density values and amplitude response of an output device. The information from the IT8.7/3 target is also useful in analyzing the stability and consistency of an output device. In addition, this study demonstrates how to make the Indigo digital press simulate the output of the Xeikon digital press.

Procedures

1. Digital output
   The Print•RIT test form was printed on the Indigo digital press. The samples were measured with the use of color measurement instruments and computer-aided data entry software.

2. Data collection
   These measurements were obtained by using an X-Rite densitometer (Figure 1). The CMYK ramps and solids were the only values obtained. The density values were saved onto an Microsoft Excel spread sheet. The data from these measurements was first entered into Microsoft Excel template 3_Press_Sheet(v3.x).xls, which calculates density-derived values. The density derived values are dot gain, print contrast, ink trapping, hue error, grayness, and efficiency. This template also calculates the amplitude response of the output device. In other words, the wanted density against dot area.

3. Data analysis
   The information provided by the IT8 target is useful in two ways: calibrating an output device and characterizing an output device. While calibration is to adjust the device to known values, an output device can be characterized, in terms of %dot area vs. density, once it’s calibrated. (Figure 2).

4. Comparison of two output devices
   If we compare amplitude differences between two devices, e.g., Indigo and Xeikon, as shown in figure 3, we see that Indigo has a higher amplitude than Xeikon. The difference may be reconciled to make the Indigo simulate the Xeikon by means of the transfer curve (Figure 4).

Abode Photoshop was used to achieve the transfer with the use of the ISO 12640 SCID test image. The transfer curve uses relative density as opposed to absolute density. The channels were split into 4 separate b/w images, then the values were entered according to the values calculated from the Print•RIT Excel template.

5. Pagination and output
   The pagination was implemented in Quark 4.0. The ISO image before transfer curve is placed at left (Figure 5a). The images with the transfer curve applied is shown at right (Figure 5b). The page was printed to Indigo UltraStream 2000. It is important
to keep the conditions of the output device consistent. Without a consistent process, the transfer curve will not be effective.

Discussion

By means of densitometric analysis of the two Indigo press runs, we were able to verify that the first press run and the second press run were consistent. By means of densitometric analysis of an Indigo and a Xeikon press run, we found out that there were noticeable differences in the amplitude response curves of all four process inks. By means of visual assessment, we could see that the appearance of the Indigo printed IT8.7/3 target (Figure 5a) is warmer in color balance and richer in tonal range than that of the Xeikon printed target.

To reconcile the difference between the image printed on the Xeikon (reference) and the image printed on the Indigo (sample), four transfer curves were applied to the image printed on the Indigo. When comparing the source image (Figure 5a) and the image modified by the transfer curves (Figure 5b), we noticed that the modified image, printed on the Indigo, is similar to the image printed on the Xeikon.

Conclusion

Densitometry is a useful quality control tool. It is important in device calibration, e.g., adjusting solid ink density and dot gain to a reference printing condition. It provides data for conformance verification and corrective action. Another reason that densitometry is important is because it can be used, along with custom Excel templates, to alter the amplitude response of the imaging device in order to simulate the amplitude response of another device, as demonstrated in this study. Moreover, the use of a natural image, available from the ISO 12640, proved to be useful for visual assessment purpose. This is because of the abundance of neutral background and memory color, such as fleshtone, that we can easily associate with than the color patches.

Print-RIT Test Form used in this study:
Objectives
The reproducible range of colors which can be obtained from an output device depends on a variety of factors such as the type of reproduction process used, the consumables such as colorants and substrates. The aim of this study is to show the use of IT8.7/3 (ISO12642) to colorimetrically characterize an output device. In other words, to show how the IT8.7/3 can be used to find out the reproducible range of CMYK (device dependent) colors of a particular device. A plausible application of this device characterization target could be its use to compare the gamuts which can be obtained from two different output devices. Care should be taken that the materials such as substrate and measurement criteria are standardized in order to obtain a meaningful result.

Procedures
1. Print the IT8.7/3 on an Indigo UltraStream 2000 Sheetfed digital press using default conditions (145 lpi and 14% dot gain).

2. Measure the IT8.7/3 target using the Spectrolino Spectroscan (Figure 1).

3. Enter the data in to the Print•RIT template B_color_IT8(V3.2).xls (see Table1). To explain, Section 1 of Table 1 indicates the Patch ID on the IT8.7/3 target. Section 2 indicates the known CMYK values per IT8.7/3 (1993); section 3 indicates the measured CIELAB for the respective patches; and section 4 calculates the resulting C* value for the measured a*b* values.

4. Use section 3 of table 1 to plot the a*b*slice
The a*b*values can be used to show the color gamut of the printing device as shown in Fig 2. The a*b* slice is a means of visualizing the boundaries of the color gamut which can be reproduced by an output device. It acts as a tool to provide the first approximation of the colors which can be reproduced by the device.

5. Use section 3 and 4 to plot the L*C* slice.
It should be noted that color space is 3-D in nature. A major drawback of the a*b* slice is that all the colors represented, lie on a non constant L* plane. This means that even though a color may lie within the gamut boundaries of an a*b* diagram it may still not be reproducible by the output device. The L*C* slices help us to visualize the relationship between L*(Lightness) and C* (Chroma) for any given process color. Fig3 shows the L*C* slice for the blue (C+M) and yellow printers. It can be seen from the figure that the yellow which is reproducible by the device has very high chroma at very high lightness values (nearly paper white) however for low lightness values it shows a steady decrease in chroma. However in the case of blue it may be noted that the shape of L*C* slice is almost the opposite.

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Table1. Data table in Print•RIT templB_color_IT8(V3.2).xls.
6. Colorimetric comparison

The IT8.7/3 can be used for colorimetrically comparing different devices. The figure 4 and 5 show the colorometric comparison between the Indigo and the Xiekon. The a*b* slice and the L*C* slice clearly indicate that the reproducible range of colors. In other words the total gamut volume which can be obtained from the Indigo is much larger.

CIELAB values can be measured from the IT8.7/3 printed by using two different output devices (in this case the Indigo and Xeikon). The data is entered in to the Print•RIT template D_DeltaE_Plot(v2.3).xls. The Template can then be used to derive a ΔE plot between each patch of the IT8.7/3 target (see Fig. 6 and 7) indicating the total visual difference between the two output devices.

Discussion

Colorimetric characterization of an output device can be extremely useful. In addition to indicating the reproducible gamut of an output device, it can further be used as a tool to compare the gamuts of two different devices. The IT8.7/3 can also be used to find the ΔE difference between prints obtained from two different devices. The

ΔE provides an accurate quantification of the visual differences between a reference and sample. Test form TF_03 can be used to validate the findings which are derived from colorometric characterization of devices. The visual inspection of these standard pictorial images provides us with an accurate approximation of the reproducible color range of the output devices. In this case the print from the Indigo would have brighter and more saturated colors than those printed from the Xeikon.

References

www.rit.edu/~rycppr
www.color.org
www.gretagmacbeth.com
B_color_IT8(V3.2).xls
D_DeltaE_Plot(v2.3).xls

Print-RIT Test Forms used in this study:
Test Targets Showcase: Digital Front-end Simulation

by Tanit Viriyarungsarit

Objectives

This is a study to illustrate Indigo UltraStream 2000’ s capability to produce a number of tone reproduction, and to use the IT8/7.3 target to simulate printing conditions with midtone dot gain of the Indigo.

Procedures

1. Dot gain references
   In QuarkXPress 4.0, place the IT8.7/3 target and the pictorial target on a page, and output a file to the Indigo, then increase the amount of dot gain output by making an adjustment on RIP to vary dot gain on each printed sheet.

2. Measurement
   Select printed sheets at 0%, 14%, and 25% dot gain, use the X-Rite Spectrodensitometer to measure each CMYK color patch on the target to obtain density values required by the Microsoft Excel 3a_PressSheet (v3.4).xls template.

3. Plate/Press curves
   The 3a_PressSheet(v3.4).xls template calculates an amplitude response curve, which shows the relationship between percent dot area on the digital file and density value on the press sheet (See Figures 1, 2, 3).

4. Transfer curves
   The simulation of dot gain done by RIP can also be achieved by applying transfer curves to the original pictorial image. The Microsoft Excel 5_Transfer-

(v2.4).xls template does this by calculating different values between the reference and the sample. By using density values from both sources, the template derives a set of density steps from 0% to 100% dot area, which can be applied as a transfer curve in Photoshop (See Figures 4, 5, 6, 7).

5. Applying transfer curves
   In Photoshop 6.0, open the pictorial target and go to Page Setup > Adobe Photoshop > Transfer Functions to input transfer values of CMYK, then go to Layer > Split Channel to apply curves in each CMYK channel, finally merge all channels, place the target onto a Quark page, and output a file.

Discussion

By using transfer curves and a choice of paper, the Indigo can simulate tone reproduction of other output device in any given condition; e.g., coated stock with AM or FM screening. Also the Indigo can be used as a proofer for an offset press since the flexibility of its digital front-end enables the user to find out the best dot gain setting so that the Indigo can closely simulate the offset printing by quickly and effectively.

Print-RIT Test Forms used in this study:

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Figure 1. Amplitude response curves of the Indigo with DFE set at linearized mode.
Figure 2. Amplitude response curves of the Indigo with DFE set at 14% dot gain.
Figure 3. Amplitude response curves of the Indigo with DFE set at 25% dot gain.
Figure 4. Amplitude response curves of the Indigo with DFE set at linearized and at 14% dot gain.

Figure 6. Amplitude response curves of the Indigo with DFE set at 25% dot gain and at 14% dot gain.

Figure 5. An example of the tonal transfer curve for the black printer to be applied to the 14% dot gain image.

Figure 7. An example of the tonal transfer curve for the black printer to be applied to the 14% dot gain image.

Figure 8. The simulation done by using amplitude response curves to simulate tone reproduction of DFE set at linearized mode (A), 14% dot gain (B), and 25% dot gain (C).
Test Targets Showcase: Digital Photography to Print

by Robert Chung

Objectives

This is a study to illustrate how ICC color management can be applied from digital photography to print. It makes sense that we also compare the difference in image quality between an ICC-based workflow and a legacy-based workflow.

Procedures

1. Digital photography
   Two Kimberly-Clark paintings were captured by a Nikon D1X digital camera (figure 1) with indoor strobe lighting.

2. Digital camera profiling
   A Macbeth ColorChecker was photographed along with the paintings and the Nikon ICC profile was built with the use of Kodak ColorFlow ProfileEditor (v2.2.1).

3. Image cropping and resizing
   The raw image was opened in Photoshop 6.0 without color management. It was cropped and resized so that the image is 3.5” wide with a spatial resolution of 300 ppi.

4. Legacy-based color workflow
   The color settings in the legacy-based workflow is represented by the U.S. Prepress Defaults (figure 2). The cropped image was converted via mode change to SWOP CMYK. By doing so, neither the camera color space nor the printer color space were accounted for in the color conversion.

5. ICC-based color workflow
   The color settings in the ICC-based workflow is shown in figure 3. First, the cropped image was opened in Photoshop 6.0 by assigning the Nikon ICC profile to the raw data and converted to the ColorMatch RGB working space. This provided the appearance match between the original painting and the monitor display. The second step was to convert the image from the ColorMatch RGB space to the Indigo UltraStream CMYK space via the “Convert to Profile.” The Kodak CMM and perceptual rendering were used in the conversion.

6. Pagination
   The pagination was implemented in Quark 4.0. The paintings, rendered by the ICC method, are placed at left (Figure 4). The images, rendered by the legacy method, are shown at right (Figure 5).

7. Hardcopy output
   The page was printed to Indigo UltraStream 2000. It is important that the printing conditions, i.e., RIP, press, paper, and toners, all adhered to a known condition where the printer ICC profile was generated from.

8. Visual assessment
   When comparing against the original paintings, images rendered by the ICC method show better agreement than the legacy method.
Discussion

The Kimberly-Clark original paintings were used as subjects to study color image reproduction from digital photography to print. The original oil paintings were commissioned by Kimberly-Clark Corporation to depict “high points in man’s long history of developing methods for communicating written words” (Kimberly-Clark Corp., 1971.) Two paintings, Papermaking at Fabriano and The Roman Alphabet, by the same artist, Douglas M. Parrish, portray a wide range of tonality and color. They are excellent sources of images for reproduction quality assessment.

In digital imaging workflow, it's strategic that we account for device-dependent variables prior to addressing image-dependent adjustments. In this case study, both the color sensitivity of the Nikon DX1 digital camera and the color rendering capabilities of the Indigo UltraStream 2000 digital press were accounted for in the ICC-based workflow. The color managed reproduction agree very well with the original paintings whereby the legacy-based workflow did not.

It is highly desirable that color managed RGB images are converted to other output devices via Photoshop 6.0 API where the consistency of color image rendering can be witnessed. This would be an important objective as the Test Targets project continues.

Reference

Graphic Communications Through the Ages, Kimberly-Clark Corp., 1971.

Print-RIT Test Forms used in this study:
Test Targets Showcase: Color Rendering from Scan to Print

by Deepak Dubey

Objectives

This is a study to illustrate how ICC color management can be applied from scan to print. We compared the difference between image quality using different rendering intents namely perceptual and absolute rendering intents.

Procedures

1. Scanning
   A number of 35mm transparencies shot by Donna Crowe were scanned on a Nikon Coolscan Scanner.

2. Scanner Profiling
   A IT8.7/1 Target. by Fuji was scanned along with the images and scanner ICC profile was built with the use of GretagMacbeth ProfileMaker software*.

3. Press Profiling
   The profile of the Indigo UltraStream 2000 device was created by printing GretagMacbeth Profiling Target on the device. The printed target was measured on the GretagMacbeth Spectrolino Spectroscan and a printer ICC profile was created using GretagMacbeth ProfileMaker software*.

4. Image Cropping and resizing
   The raw image was opened in Photoshop 6.0 without color management. It was cropped and resized so that the image is 3.5” wide with a spatial resolution of 300 ppi.

5. ICC based color workflow
   The color settings in the ICC-based workflow is shown in figure 2. First, the cropped image was opened in Photoshop 6.0 by assigning the Nikon Scanner ICC profile to the raw data and converted to the ColorMatch RGB working space. This provided the appearance match between the original painting and the monitor display. The second step was to convert the image from the ColorMatch RGB space to the Indigo UltraStream CMYK space via the “Convert to Profile.” The Kodak CMM with perceptual and absolute colorimetric rendering were used in the conversion.

6. Pagination and Hardcopy output
   The pagination was implemented in Quark 4.0. The images rendered by the ICC method with perceptual rendering intent are placed at left, figure 3a and 4a and the images with absolute colorimetric rendering are shown at right, figure 3b and 4b. The page was printed to Indigo UltraStream 2000 under known printing conditions.

7. Visual assesment
   When comparing between Images with perceptual and absolute rendering intent, images with perceptual rendering intent show rich and bright colors with good contrast while the images with absolute rendering are a bit darker.

Discussion

To understand the cause of visual difference between two intents we must first understand the apporach taken by the rendering intents during the conversion of colors from source to destination color space. Converting colors to a different color space which in our case is from ColorMatch RGB working space to Indigo UltraStream CMYK space, usually involves an adjustment of the colors to accommodate the gamut of
the destination color space. Different translation methods use different rules to determine how the source colors are adjusted; for example, colors that fall inside the destination gamut may render accurately or they may be adjusted to preserve the original range of visual relationships during translation to a smaller destination gamut. These translation methods are known as rendering intents because each technique is optimized for a different intended use of color graphics. The translation methods used by perceptual and absolute rendering intents are as follows:

Perceptual rendering
Perceptual aims to preserve the visual relationship between colors in a way that is perceived as natural to the human eye, although the color values themselves may alter. This intent is most suitable for pictorial image rendering.

Absolute Colorimetric rendering
Absolute colorimetric leaves colors that fall inside the destination gamut unaltered. This intent aims to achieve color accuracy at the expense of preserving relationships between colors. Absolute Colorimetric can be more accurate if the image’s color profile contains correct white point (extreme highlight) information.

With perceptual rendering, tonal values in figure 3a & 4a are lightened such that the chroma of the image preserved. With absolute colorimetric rendering, tonal values in figure 3b and 4b are darkened and the images appear less colorful suggesting that the preservation of tonal values at the expense of preserving chroma.

Print-RIT Test Forms used in this study:

* ProfileMaker Professional 3.1 is a color management software by GretagMacbeth. It has a suite of software applications to build profiles for scanners, digital cameras, monitors, printers, and presses.
Objectives

This study focuses on the role of scanner and printer profiling and its impact on color image reproduction. To test the importance of device profiling, two scanners were profiled and two output device profiles were tested. We learned that there are noticeable color differences in color reproduction between two scanned images when scanner profiles and printer profiles were incorrectly applied. And color differences were reconciled when the correct profiles were applied.

Procedures

1. Scanning
   The scanners used in the study were Nikon CoolScan and Scitex EverSmart. Two images, the IT8.7/1 and a nature photographic transparency, were scanned.

2. Scanner profiling
   A 35 mm profiling target was used to characterize the two scanners with the use of Kodak ColorFlow ProfileEditor (v2.2.1).

3. Printer profiling
   Monaco Profiler (v3.2) was used to characterize the Indigo UltraStream 2000. The software offered choices in Look-Up-Table (LUT) size and bit depth for profile creation. (figure. 1)

4. Color conversion using correct ICC profiles
   The image was assigned with the scanner profile, and then converted to the ColorMatch RGB working space. The image was, then, converted to the Indigo color space via “Convert to Profile” in Photoshop 6.0 using perceptual rendering intent.

5. Color conversion using incorrect profiles
   The scanned image was converted from the ColorMatch RGB working space to the US Web coated v2(SWOP) profile in Photoshop.

5. Output
   The pagination was implemented in Quark 4.0. The images with correct profiles applied are placed at left (Fig. 1a-4a). The images with incorrect profiles applied are placed at right (Fig. 1b-4b). The page was printed to the Indigo digital press under calibrated printing conditions.

Discussion

In the color conversion using ICC profiles, the images scanned by different scanners had similar (Figure 1a-4a) tone and color reproduction. The images also had good gray balance appearance indicated by the gray scale in the IT8.7/1 target (Figure 1a and 2a).

The images looked different in the conversion using incorrect profiles. Because differences in the scanners color sensitivity were not accounted for in the color conversion. By applying the correct ICC profiles, the quality of image reproduction was improved.

Print-RIT Test Forms used in this study:
Figure 1a. Nikon ICC to Indigo ICC.

Figure 1b. ColorMatch RGB to SWOP.

Figure 2a. Scitex ICC to Indigo ICC.

Figure 2b. ColorMatch RGB to SWOP.

Figure 3a. Nikon ICC to Indigo ICC.

Figure 3b. ColorMatch RGB to SWOP.

Figure 4a. Scitex ICC to Indigo ICC.

Figure 4b. ColorMatch RGB to SWOP.
Lessons Learned

by Robert Chung

Test Target 2.0 began as an idea. We worked relentlessly for six weeks, and have transformed the idea into a reality. We learned that efforts required to put a publication together is much more than writing or grading a term paper. In addition, the amount of learning is proportional to the efforts made. Below is a summary of what we did well, and what we should avoid in the future.

Layout and imposition—We learned that a successful publication begins with good planning. The planning begins with how the publication is to be folded, stitched, and finished. We did not have the expertise in imposition and finishing when starting out the project. We created reader spreads in Quark, and had to adjust for creep after we proofed the job on the Indigo digital press. In addition, we had to output the page at 95% of its original size to account for the space for the footer. We plan to address these issues early, including the use of an imposition software, in the future editions of Test Targets.

File management—All files that we worked on resided on a multi-gigabyte disk, and were accessible by all networked stations. The shared disk was automatically backed up daily. The centralized file management structure allowed us to work simultaneously on various parts of the publication. When we performed a “Collect for Output” from the CMS lab (located at the main floor of the Gannett building), the entire Quark file could be made available at the Digital Publishing Center’s server (located in the basement of the same building) within minutes.

Press runs—In order to describe tone and color rendering of an output device quantitatively, multiple press runs were necessary. The objective of the first press run was to determine the calibration of the Indigo digital press with paper, toner, settings in the digital front-end, and the marking engine all taken into consideration. By including press profiling targets in the first press run, we were able to build press ICC profiles with the use of different profiling software packages. A second press run was to verify contents in the Test Targets 2.0. Another press run was to verify the page layout and imposition. For verification of color image rendering or verification of proper creep compensation, we only needed one copy from the press run. We appreciate the short cycle time and very short run capability of digital printing.

Color management—Test Targets 2.0 successfully illustrates how test forms are used for device calibration, characterization, and color management practices for printing and publishing. In this issue, a number of ICC-based color management applications showcased how digital images were reproduced accurately and consistently. A spot color match using ICC-based CMS was also demonstrated in the cover of this publication. The ΔE between the color specified and the color produced was 5.8. The major discrepancy was believed to be the gamut limitation in achieving a more saturated blue. The visual difference between the Pantone process swatch and the printed cover was small, but noticeable.

Class projects—There are vast differences between how individual lab assignments and how group projects are conducted and evaluated. In an individual lab assignment, the experimental procedures are given. Similar to a guided tour, a student would go through the hands-on portion of the lab and report back his/her lab findings. The instructor, then, evaluates the completeness, correctness, and the quality of the lab documentation. In a group project, both the success of the project and the evaluation of students’ performance become more complicated. We realized that the quality of the project, in this case—Test Targets 2.0, depends on how the class performs as a whole. It also depends on how a student carries out a specific part of the project, and how that student can contribute above and beyond his/her part in the area of problem solving and quality assurance. As far as the performance of the instructors, they are evaluated by the class. But the final evaluation comes from printing and publishing industries who hire our graduates to help them solve real-world problems.