Test Targets 3.0: A Collaborative effort exploring the use of scientific methods for color imaging and process control

Robert Chung
rycppr@rit.edu

Franz Sigg

Fred Hsu

Gregory Firestone

Hemachand Kolli

See next page for additional authors

Follow this and additional works at: https://scholarworks.rit.edu/books

Recommended Citation

This Full-Length Book is brought to you for free and open access by RIT Scholar Works. It has been accepted for inclusion in Books by an authorized administrator of RIT Scholar Works. For more information, please contact ritscholarworks@rit.edu.
Digital Imaging

A collection of digital test forms showcasing features, capabilities, and applications in printing and publishing.
Table of Contents

Acknowledgements ................................................................. iv
Introduction ........................................................................... v

Part One: Test Forms and Images
TF_01 Device Characterization Target ........................................... 1
TF_02 Pictorial Reference Images ............................................... 2
TF_03 Synthetic Targets .......................................................... 3
TF_04 Screening Targets ........................................................ 4
TF_05 GretagMabeth Profiling Target ......................................... 5
TF_06 Monaco Profiling Target .................................................. 6
TF_07 Fujifilm Profiling Target ................................................... 7
TF_08 Kodak Profiling Target ..................................................... 8
TF_09 ECI Profiling Target ......................................................... 9
TF_10 TAC Chart ................................................................ 10
TF_11 Contrast Resolution Target ............................................ 11
TF_12 Kodak Press Aim Chart .................................................. 12

Part Two: Digital Imaging Applications
Effect of lighting on digital camera profiling ............................. 13
Colorimetric assessment of digital camera profile accuracy ........... 15
Appearance analysis of different digital cameras ....................... 17
Spot color matching between Pantone and icc press profiles ........... 19
Visual analysis of printer profiling software packages ................. 21
AM and FM screening .......................................................... 23
Studying contrast and resolution ............................................. 25
Color matching comparison between generic and custom press profiles ..... 27
Colorimetric analysis of color image reproduction ..................... 29
Test Targets 3.0 Cover — from design to print production ........... 31
CMS — from press run analysis to a color managed-workflow ........ 33
About the authors .................................................................. 35
Acknowledgments

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

Color management technology — ColorVision, Fujifilm, GretagMacbeth, Kodak, Monaco, X-Rite

These companies were instrumental in providing us with color management software and hardware. We calibrate our monitors in the lab with the use of ColorVision’s OptiCal and X-Rite’s DTP-92 monitor optimizes. GretagMacbeth’s ProfileMaker 4.1 and Monaco’s Profiler 4.0 are both upgraded to Mac OS X. Fujifilm’s ColourKit is a new profiling software addition. Kodak provided us with as many licenses of Colorflow ProfileEditor as needed for teaching and research at all SPM labs. We’re happy to recognize their long-time support.

Cover concept — Tom Chung

Tom has worked in New York City as an art director in advertising and design for web and print media. He did the cover design for Test Targets 2.0. The cover design in Test Targets 3.0 represents a continuation of the exploration of visual illusion.

Source images — Patti Russotti and Donna Crowe

Reproducing aesthetically pleasing images in a color-managed workflow makes the task fun and rewarding. Please check out fine details in the FM rendered flower scene, courtesy of Professor Patti Russotti, and images, by Donna Crowe, used in the colorimetric analysis of color image reproduction.

Design and layout — Gregory Firestone

Greg took on extra responsibilities in this project. He provided the class a Quark template with embedded style sheets. He also worked extensively on modifying the cover artwork to achieve the desired visual effect. Pay extra attention to the effect of spot varnishes and the spatial grouping of pixilated color patches. You can see one figure or the other, but not both at any given moment.

Prepress — Fred (Chao-Yi) Hsu

As Professor Chung’s research assistant, Fred was familiar with resources in the color management systems lab. He helped update master test forms, attended press run planning meetings, and followed through on countless details so that files were submitted to the Printing Applications Laboratory for computer-to-plate output on time.

Paper — International Paper Company (IP)

When we told Jerry Craig, Product Improvement Manager, Coated and SC Papers of International Paper, about Test Targets 3.0 and what we intended to accomplish, IP donated all the web rolls needed for all web press runs without hesitation.

Computer-to-Plate and Presswork — RIT Printing Applications Laboratory (PAL)

Under the leadership of Bill Garno, PAL was instrumental in implementing our color management tests. We wish to thank Bill Pope for his technical support, Barbara Giordano for her business support, and Fred White and his web press crew for the production of this publication.

RIT Sloan Printing Industry Center

RIT’s Sloan Center initiates research projects to forecast market and technology trends in the Printing Industry. The Center has been very supportive of our color management testing and the publication of Test Targets 3.0.

RIT School of Print Media

This is our homeroom. We’re proud to be a vital part of the curriculum. We encourage more students to take this course and join forces in the future editions of Test Targets. To learn more about the School of Print Media curriculum, please go to http://www.rit.edu/~spms.
Introduction

By Professor Robert Chung

Concepts and goals

Test Targets 3.0 is an RIT School of Print Media publication. It is a collection of test targets and their applications in color matching, color image reproduction, and process control in a color-managed print production environment. Test Targets 3.0 serves as a test bed for teaching and learning digital imaging technologies in the course, Test Targets for Graphic Arts Imaging, that Franz Sigg and I co-teach. It provides us with a platform to experiment and to realize new digital imaging paradigms. Contents, design, and pre-publishing of this publication were carried out as a group project in the class with print production support from RIT Printing Applications Laboratory.

We published Test Targets 2.0 in 2002 with the use of the Indigo UltraStream 2000 digital press at RIT. Test Targets 3.0 furthered our methodologies for process capability studies and extended the scope in ICC-based color management practices. Images in Test Targets 3.0 were color managed in Photoshop 7 using Macintosh G4 computers. Contents were paginated in Quark 5, imposed in Preps, and plated by Creo CTP using Harlequin RIP and KPG plates. The document was printed on 80 lb. IP Velocity #3 coated paper using Heidelberg M-1000B web offset press. Four press runs were scheduled: the first for press calibration and profiling, the second and third for color management testing without text and pagination, and the fourth for the publication.

In this issue

Test Targets 3.0 focuses on the integration and analysis of a number of input devices, color image renderings with the use of a robust CTP system and a full-fledged web offset press. The first section is a collection of test forms. Some test forms, e.g., IT8.7/3 basic data set and profiling targets, were used as building blocks in this publication; some test forms were included for exploratory purposes. The second section is a compilation of color management practices by the class. Starting from the input side, Michael Meyerhofer studied the effect of lighting on the image rendering aspect of digital camera profiles. Using Photoshop API, Gregory Firestone evaluated the colorimetric accuracy of digital camera profiles. Nilay Patel demonstrated how digital camera profiles enable tone and color rendering of digital cameras from consumer-level to professional-level.

On the output side, Vikaas Gupta compared color matching performance and Ryan Testa evaluated color image rendering of different profiling software packages. Tiago Costa examined the effect of AM and FM screening and the use of transfer curves for tonal rendering reconciliation. Because of differences in bit depths and addressability of many digital printers, Franz Sigg explained the use of the contrast resolution target to evaluate the tonal rendering ability of these output devices. Chao-yi Hsu examined color matching performance between a generic SWOP profile and a custom profile from the Heidelberg M-1000B calibrated press run.

Taking color reproduction as a system, Hemachand Kolli followed the work of Pearson, Pobboravsky, and Yule (ISCC, 1971) to compare the relationship between the source image and its ICC-based reproduction by means of colorimetry. Gregory Firestone described the use of color management from cover design to print production using a Heidelberg Speedmaster sheetfed press. I documented the importance of press run analysis, press profiling, and process control in a color-managed workflow.

In closing

Test Targets 3.0 represents a voice from design, digital media, and print production communities. It reminds us of the importance of standard operating procedures and densitometry in press calibration. It speaks of the importance of graphic arts technology standards and colorimetry in device profiling. The voice tells many success stories how color-managed imaging workflows enable both design and print production. We also learned that results from our experiments may not necessarily be what we planned. Positioned in the middle of all these excitements, Test Targets 3.0 helps amplify these messages.
Test Targets 3.0
Print•RIT Pictorial Reference Images
ISO12640 Standard Color Image Data

ID  TF 02
Version  v2.1
Prod. Date  Feb. 17, 2003
Notes

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

Press  Heidelberg M-1000B
Paper  IP Velocity 80 lb #3 Text
Prepress  Quark / Preps / Creo
150 lpi / 2400 spi

ISO 300

ISO 300

Heidelberg M-1000B
IP Velocity 80 lb #3 Text
Quark / Preps / Creo
150 lpi / 2400 spi

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

Press  Heidelberg M-1000B
Paper  IP Velocity 80 lb #3 Text
Prepress  Quark / Preps / Creo
150 lpi / 2400 spi
Print-RIT Screening Targets
Testing different screening

ID: TF_04
Version: v2.1
Prod. Date: Feb. 17, 2003
Notes: 

RIP Information:
Press: Heidelberg M-1000B
Paper: IP Velocity 80 lb #3 Text
Prepress: Quark / Preps / Creo
150 lpi & 300 lpi / Ugra & CreoFM

TR4V03U.EPS

IP Version 3011.104
PS Language Level: 3

Press
Paper
Prepress

Note:
These are Photoshop EPS files with imbedded screening. Some RIP’s override these requests and default to their own screening. FM scales were produced using Ugra Velvet screening and Creo Staccato FM screening.
GretagMacbeth Profiling Target
For Printer ICC Profile Construction

ID | TF_05
Version | v2.1
Prod. Date | Feb. 17, 2003
Notes |  

RIP Information:
Mac Distiller
600 ppi, 42.3 μpixel
PS Version: 3011.104
PS Language Level: 3

Press | Heidelberg M-1000B
Paper | IP Velocity 80 lb #3 Text
Prepress | Quark / Preps / Creo

150 lpi / 2400 spi

Press Information:
Mac Distiller
600 ppi, 42.3 μpixel
PS Version: 3011.104
PS Language Level: 3

Press | Heidelberg M-1000B
Paper | IP Velocity 80 lb #3 Text
Prepress | Quark / Preps / Creo

150 lpi / 2400 spi

ID | TF_05
Version | v2.1
Prod. Date | Feb. 17, 2003
Notes |  

RIP Information:
Mac Distiller
600 ppi, 42.3 μpixel
PS Version: 3011.104
PS Language Level: 3

Press | Heidelberg M-1000B
Paper | IP Velocity 80 lb #3 Text
Prepress | Quark / Preps / Creo

150 lpi / 2400 spi

Press Information:
Mac Distiller
600 ppi, 42.3 μpixel
PS Version: 3011.104
PS Language Level: 3

Press | Heidelberg M-1000B
Paper | IP Velocity 80 lb #3 Text
Prepress | Quark / Preps / Creo

150 lpi / 2400 spi
Monaco Profiling Target
For Printer ICC Profile Construction

<table>
<thead>
<tr>
<th>ID</th>
<th>TF_06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>v2.1</td>
</tr>
<tr>
<td>Prod. Date</td>
<td>Feb. 17, 2003</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
</tr>
</tbody>
</table>

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

Press: Heidelberg M-1000B
Paper: IP Velocity 80 lb #3 Text
Prepress: Quark / Preps / Creo
- 150 lpi / 2400 spi

1x1 2x2 3x3 4x4
Zero

Monaco_4.0_530.tif
Heidelberg M-1000B
IP Velocity 80 lb #3 Text
Quark / Preps / Creo
150 lpi / 2400 spi

Test Targets 3.0
<table>
<thead>
<tr>
<th>ID</th>
<th>TF_07</th>
<th>RIP Information:</th>
<th>Press</th>
<th>Heidelberg M-1000B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>v2.1</td>
<td>Mac Distiller</td>
<td>Paper</td>
<td>IP Velocity 80 lb #3 Text</td>
</tr>
<tr>
<td>Prod. Date</td>
<td>Feb. 17, 2003</td>
<td>600 ppi, 42.3 μ/pixel</td>
<td>Prepress</td>
<td>Quark / Preps / Creo</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
<td>PS Version: 3011.104</td>
<td></td>
<td>150 lpi / 2400 spi</td>
</tr>
</tbody>
</table>

![FujiFilm Profiling Target](image)

<table>
<thead>
<tr>
<th>ID</th>
<th>TR4V03U.EPS</th>
<th>Print Information:</th>
<th>Press</th>
<th>Heidelberg M-1000B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes</td>
<td></td>
<td>Mac Distiller</td>
<td>Paper</td>
<td>IP Velocity 80 lb #3 Text</td>
</tr>
<tr>
<td></td>
<td></td>
<td>License expires Jan. 24, 2003</td>
<td>Prepress</td>
<td>Quark / Preps / Creo</td>
</tr>
</tbody>
</table>

![RIT Bar V 0.2](image)

<table>
<thead>
<tr>
<th>ID</th>
<th>TR4V03U.EPS</th>
<th>Print Information:</th>
<th>Press</th>
<th>Heidelberg M-1000B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes</td>
<td></td>
<td>Mac Distiller</td>
<td>Paper</td>
<td>IP Velocity 80 lb #3 Text</td>
</tr>
<tr>
<td></td>
<td></td>
<td>License expires Jan. 24, 2003</td>
<td>Prepress</td>
<td>Quark / Preps / Creo</td>
</tr>
</tbody>
</table>

![RIT Gray Bar V 0.1](image)
Print-RIT TAC Chart
For Total Area Coverage Determination of a CMYK Output Device

<table>
<thead>
<tr>
<th>ID</th>
<th>TF_10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>v2.1</td>
</tr>
<tr>
<td>Prod. Date</td>
<td>Feb. 17, 2003</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
</tr>
</tbody>
</table>

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

Press:
- Heidelberg M-1000B

Paper:
- IP Velocity 80 lb #3 Text
  - 150 lpi / 2400 spi

Prepress:
- Quark / Preps / Creo

Print-RIT Bar
© Franz Sigg. Switzerland 2002
Use only at Rochester Institute of Technology
Device: Mac Distiller
License expires Jan. 24, 2003
Addressability: 600 DPI

Print-RIT TAC Chart
For Total Area Coverage Determination of a CMYK Output Device

Print-RIT Gray Bar
© Franz Sigg. Switzerland 2002
Use only at Rochester Institute of Technology
Device: Mac Distiller
License expires Jan. 24, 2003
Addressability: 600 DPI

Print-RIT Doubling Grid

TAC Chart
v 1.2
RIT, 2001

<table>
<thead>
<tr>
<th>A1 paper</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>75</th>
<th>62</th>
<th>60</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>117</td>
<td>152</td>
<td>186</td>
<td>222</td>
<td>263</td>
<td>276</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 50 K</td>
<td>167</td>
<td>202</td>
<td>236</td>
<td>272</td>
<td>313</td>
<td>326</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 60 K</td>
<td>177</td>
<td>212</td>
<td>246</td>
<td>282</td>
<td>323</td>
<td>336</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 70 K</td>
<td>187</td>
<td>222</td>
<td>256</td>
<td>292</td>
<td>333</td>
<td>346</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 80 K</td>
<td>197</td>
<td>232</td>
<td>266</td>
<td>302</td>
<td>343</td>
<td>356</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 90 K</td>
<td>207</td>
<td>242</td>
<td>276</td>
<td>312</td>
<td>353</td>
<td>366</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 100 K</td>
<td>217</td>
<td>252</td>
<td>286</td>
<td>322</td>
<td>363</td>
<td>376</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Print-RIT Contrast Resolution Target
Testing for resolution as a function of contrast

ID: TF_11
Version: v2.1
Prod. Date: Feb. 17, 2003
Notes:

RIP Information:
- Mac Distiller
- 600 ppi, 42.3 μpixel
- PS Version: 3011.104
- PS Language Level: 3

Press: Heidelberg M-1000B
Paper: IP Velocity 80 lb #3 Text
Prepress: Quark / Preps / Creo
- 150 lpi / 2400 spi

Resolution
Line width 1/pmm  Contrast  Range
1 1000 0.50 A 100.0 % 0.0 - 100.0 %
2 755 0.66 B 59.9 % 20.1 - 80.0 %
3 570 0.88 C 35.9 % 32.1 - 68.0 %
4 431 1.16 D 21.5 % 39.3 - 60.8 %
5 325 1.54 E 12.9 % 43.6 - 56.5 %
6 246 2.03 F 7.7 % 46.2 - 53.9 %
7 186 2.69 G 4.6 % 47.7 - 52.3 %
8 140 3.57 H 2.8 % 46.6 - 51.4 %
9 106 4.72 J 1.7 % 49.2 - 50.9 %
10 80 6.25 K 1.0 % 49.5 - 50.5 %

Spot Correction: 0

Licensed user: Use only at Rochester Institute of Technology
Kodak Press Aim Chart
For fingerprinting a press

ID TF 12
Version v2.1
Prod. Date Feb. 17, 2003
Notes

Press Heidelberg M-1000B
Paper IP Velocity 80 lb #3 Text
Prepress Quark / Preps / Creo

150 lpi / 2400 spi

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

Print ⋅ RIT Bar
V 0.2
© Franz Sigg. Switzerland 2002

Use only at Rochester Institute of Technology
Device  Mac Distiller
License expires Jan. 24, 2003
Addressability 600 DPI

PS Version 3011.104
C M K Y
50%
Double

1 1 2 2
3 3 4 4

Y K C+Y M+Y C+M C

Zero Zero Zero

75 62 60 80

K 75 62 60 80

Place this side towards tail edge of sheet

Background only black, circles only CMY tints

25% 50% 75% 100%

25% 16% 16% 50% 39% 39% 75% 63% 63% 100% 86% 86%

KPAIM22J.EPS

RIT Gray Bar V 0.1
© Franz Sigg, Switzerland 2002

Use only at Rochester Institute of Technology
Device  Mac Distiller
License expires Jan. 24, 2003
Addressability 600 DPI

Press
Paper
Prepress
ID V ersion Prod. Date Notes
TF_12 v2.1 Feb. 17, 2003

Registration line is 2 pixels wide = 85 µ

Place this side towards tail edge of sheet
Effect of lighting on digital camera profiling
By Michael Meyehofer

Objective
This study is intended to explore the appearance of various lighting conditions on digital camera profiles. It compares images taken with incandescent ambient lighting, flash lighting, and indirect studio strobes. The images are then reproduced with the correct custom ICC profile as well as the custom ICC profiles for the other two lighting conditions. This experiment provides an analysis for optimal color management settings for lighting conditions.

Procedures
1. Digital photography
   A scene is taken of a Macbeth ColorChecker surrounded by colorful household objects using an Olympus E-20N digital camera (Figure 1). The same image is taken at a distance of 4 feet using three lighting conditions: incandescent room lighting, incandescent room lighting with a flash, and using a portable indirect studio strobe lighting kit. Settings on the camera were set to automatic to accommodate for proper white point, shutter speed, and aperture.

2. Digital camera profiling
   In addition to photographing the still image, a picture was taken of just the Macbeth ColorChecker to create an ICC profile for each lighting condition using Kodak ColorFlow software.

3. Image manipulation
   The three images, shot with different lighting, were taken into Adobe Photoshop 7.0 and applied the default (sRGB) profile as source to the press CMYK profile (Figure 2). The three images were also rendered with correct and incorrect source profiles to the press CMYK profile (Figure 3). The images were then cropped to 2 inches wide with a resolution of 300 ppi for pagination.

4. Pagination
   The three default (sRGB) profiled images are shown in Figure 2. Color-managed reproductions with correct and incorrect camera profiles are placed in a 3 x 3 image grid (Figure 3) for visual analysis. Together, they show many possible outcomes in color image reproduction.

5. Hardcopy output
   Plates are made on the CREO CTP system and the page is printed on the Heidelberg M-1000B offset web press. Consistency and accuracy are very important to properly access the results.

6. Visual analysis
   When evaluating the photographs the images with proper profiles appear more pleasing that those with the incorrect ICC profiles. The images taken under the indirect studio strobe lighting produces the best results.

Discussion
The scene was setup to contain critical testing areas. Colorful objects were used such as the Macbeth ColorChecker along with common items easily recognized like paint, color pencils, and rubber bands. A paintbrush and pencil holder were placed in the image to display the results on metallic objects. This arrangement provided a good source of tone and color for visual analysis.

You can see that each image, shown in Figure 2, had a slight fault due to the fact that the sRGB profile did not account for the effect of lighting. The incandescent image has a yellow colorcast and appears dull. The photo taken with a flash was blown out in certain areas. The indirect strobe photo also had a slight yellow cast to it and was a little dark. When properly corrected with the appropriate profile, these problems are resolved and acceptable reproduction are produced for all lighting conditions.
Figure 3 shows the effect of color reproduction with correct and incorrect camera profiles. When applying the incorrect profile, it produces more harm than good. In this case all results of incorrect profiles made the image worse than that which it started. In the instance of the incandescent lighting, the image became even more yellow using the wrong profiles. The image taken with a flash was even more washed out and the strobe lit image was received a blue colorcast. Image detail was also lost.

The three diagonal images, shown in Figure 3, reproduced with correct camera profiles, should appear the same. But the results prove otherwise. The incandescent image (upper left) with the proper profile is darker than that of the other two correctly profiled images (middle and lower right). A proper camera profile should convert the image to adhere to the values of the ColorChecker. Further investigation and study may suggest why this inconsistency occurred.

Good reproduction begins with a good original. The lighting conditions must be accounted for in digital photography and camera profiling. This study concludes that still images are best produced with indirect strobe lighting and a specific ICC profile that is custom built for that lighting condition.

“Good Reproduction begins with a good original. The lighting conditions must be accounted for in digital photography and camera profiling.”
Introduction
The use of digital photography in the graphic arts industry is rapidly expanding. Digital camera prices are continuing to fall and image quality is improving with each and every new camera release. Digital photography provides a fast and inexpensive workflow compared to traditional photography. A photo can be taken and instantly transferred to the computer in a matter of seconds. There is no longer the need to wait for costly film developing and scanning. Digital photography has seen extended growth in product photography for catalogs where large numbers of products are now captured quickly and inexpensively compared to traditional film-based photography.

Objective
As with any type of reproduction process, color accuracy and precision are key. It is crucial that the reproduced image match the reference image. This is especially important in product photography where one is judging the color of a product, such as a sweater, solely by the picture. It is also important that accurate color reproduction be repeated consistently. The purpose of this experiment is to determine if ICC color management provides better color accuracy than using the digital camera’s default color space, e.g. sRGB.

Resources
This experiment was performed using a Nikon Coolpix 5000 digital camera. GretagMacbeth ProfileMaker 4.1 software was utilized to create the ICC profile based on measurements obtained from the Macbeth ColorChecker DC color chart (Figure 1). The reference chart used to assess color accuracy was the Macbeth ColorChecker 24 patch color chart (see CMS workflow diagram). Assorted vegetables with memory colors were also incorporated as a source of reference for the human visual assessment.

Procedures
1. Image Capturing
   Setup the Nikon Coolpix 5000 by turning the flash off and manually setting the white point of the camera using the white backdrop as the reference. Place the Macbeth ColorChecker and vegetables in front of the white backdrop. Take a picture and name the file Scene_Raw.tif. Remove the ColorChecker and vegetables and place the Macbeth ColorChecker DC color chart in the exact same location as the previous chart. Take another picture. Name the file ColorCheckerDC.tif.

2. Digital Camera Profiling
   Using Macbeth ProfileMaker 4.1 and the picture of the ColorChecker DC (ColorCheckerDC.tif), create an ICC profile for the Nikon camera. Name the file CP5000_indoor.icc.

3. Color Management
   Set the Photoshop color conversion options to use the Adobe (ACE) CMM and absolute colorimetric rendering intent. Open the

Figure 1. Profile creation workflow
raw digital file Scene.tif without color managing. Assign the newly created ICC profile to the image and then convert the image to CIELAB using the predefined color settings. Save the file as Scene_CP5000.tif.

Open the raw digital file Scene.tif once more. Assign the camera default color space profile, otherwise known as sRGB. Using the same color settings as before, convert the file to CIELAB. Save the image as Scene_sRGB.tif.

4. Profile Accuracy Testing
Set the sample size of the eyedropper tool to 5x5 pixels. Inspect the CIELAB values for both images. Using the supplied CIELAB values for the MacBeth ColorChecker as the reference, calculate ΔE values and analyze the results.

<table>
<thead>
<tr>
<th>ColorChecker Patch</th>
<th>Default ΔE</th>
<th>CMS ΔE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 White</td>
<td>25.2</td>
<td>2.9</td>
</tr>
<tr>
<td>D2 Neutral 8</td>
<td>20.7</td>
<td>1.8</td>
</tr>
<tr>
<td>D3 Neutral 6.5</td>
<td>17.5</td>
<td>2.9</td>
</tr>
<tr>
<td>D4 Neutral 5</td>
<td>14.7</td>
<td>2.9</td>
</tr>
<tr>
<td>D5 Neutral 3.5</td>
<td>13.8</td>
<td>2.5</td>
</tr>
<tr>
<td>D6 Black</td>
<td>12.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Chart 1. Neutral color patch ΔE values from analysis

Discussion
The CIELAB inspection revealed a dramatic difference between the default and custom built profile. Lower ΔE values are indicate closer colorimetric reproduction. The average colorimetric difference of the default workflow was 18.2 ΔE. The CMS workflow yielded an average 5.4 ΔE. Clearly, the CMS workflow is much more accurate.

Most areas in the graphic arts aim for a ΔE of 3 or less. One may ask why the ICC color managed workflow did not produce more accurate results. The reason is that color management software for digital cameras does not necessarily aim to produce the most accurate colorimetric results; instead, they aim to simulate traditional photography. The following is a quote from Scott Gregory, former Director of Kodak Color Management Systems Group, “In building a digital camera profile the aim is typically not to capture scene colorimetry. The aim is typically to render a scene much the same way conventional photography renders a scene. Each film has its own unique mechanism for interpreting scene color and usually the goal of the digital camera profile is to do something similar like film.”
Introduction
This is a study to determine if there is a difference in color appearance between consumer and pro-level digital cameras in a color managed workflow.

Resources
1. Digital cameras:
   Kodak DC260 (consumer $900 MSRP)
   Nikon Coolpix 5000 (mid-level $1500 MSRP)
   Nikon D1X (pro-level $7000 MSRP)
2. Profiling software:
   Kodak Colorflow - digital camera profile
   GretagMacBeth 4.1 - printer profile
3. Scene: Macbeth ColorChecker & assorted fruits

Procedures
1. Image capturing
   Assemble pictorial image of fruits. Take pictures with each camera. Use automatic settings.

2. Digital camera profiling
   Using the MacBeth ColorChecker and Kodak ColorFlow, create 3 different ICC profiles, 1 for each camera.

3. Color management
   Open up the pictures in Adobe Photoshop with the default camera profile, sRGB. Convert the pictures to CMYK using the provided Heidelberg M-1000B profile (created by GretagMacBeth 4.1) and perceptual rendering intent. This is what was done for Figures 1, 3, and 5. In addition, for Figure 2, 4, and 6, the sRGB input profile was replaced with the custom camera input profile created by Kodak Color Flow.

Discussion
The image from the Nikon D1X camera (Figure 6) looks slightly warmer than the other two. As long as image size is 100% or less, the 3 images (Figures 2, 4, and 6) look very similar. If the images are enlarged to 300% (Figure 7, 8, and 9) then it becomes apparent that there are major differences in sharpness and detail.

Conclusion
There are many different types of digital cameras ranging from the consumer level to the professional level. Besides a large difference in price, professional cameras offer higher capturing resolutions, more memory, and extended features.

Color management enables color rendering abilities in all cameras. for consumer level or pro-level camera. However color management systems cannot compensate for lack of spatial resolution.
Figure 1. KodakDC260_neel_raw.tif
sRGB profile to Heidelberg profile
File size: 4.56 M, Bit depth: 8, Exposure time: 1/14 sec., F stop: 3.0, Focal length: 13.6 mm

Figure 2. KodakDC260_neel_CMS.tif
ColorFlow profile to Heidelberg profile

Figure 3. CP5000_neel_raw.tif
sRGB profile to Heidelberg profile
File size: 14.1 M, Bit depth: 8, Exposure time: 1/5 sec., F stop: 3.8, Focal length: 14.9 mm

Figure 4. CP5000_neel_CMS.tif
ColorFlow profile to Heidelberg profile

Figure 5. D1X_neel_raw.tif
sRGB profile to Heidelberg profile
File size: 16.9 M, Bit depth: 8, Exposure time: 1/45 sec., F stop: 3.3, Focal length: 42 mm

Figure 6. D1X_neel_CMS.tif
ColorFlow profile to Heidelberg profile
Spot color matching between Pantone and ICC press profiles

By Vikaas Gupta

Introduction
The prime objective of this study is to evaluate spot color matching performances between Pantone and custom ICC press profiles by simulation using the Adobe Photoshop 7.0 API.

In this particular methodology, the measured CIELAB values for the color swatches were taken as the reference and converted to their respective CMYK working spaces (B to A conversion, absolute). The Heidelberg output press profile was taken as the destination space and the CMYK values were converted to CIELAB (A to B conversion, absolute).

Procedure
1. Fifteen color patches from the Pantone Color Imaging Guide (1996) were selected and their measured CIELAB values specified as aim points. The patches were measured using a calibrated X-Rite 528 spectrodensitometer under D50 illuminant and 2 deg. observer.

2. Two profiling packages, Kodak Colorflow v2.1 and GretagMacbeth ProfileMaker v4.0 were used to build an ICC press profile. The output profiles were built for the Heidelberg M-1000B perfecting web offset press on which this publication is printed. The profiles were based on test targets printed earlier on the same equipment.(see the article on page 33 for details)

3. There is a Pantone profile for 150 lpi screen available in the ColorSync folder on Apple Macintosh workstations. Since the colors specified were those taken from Pantone, we wanted to see how the Pantone profile performs in matching its own set of colors using the Heidelberg M-1000B press. To ensure further accuracy and to avoid any gamut-clipping, all colors specified were those which can be reproduced using web-offset inks.

4. The color settings were set to the output working space of the three profiles (namely Pantone, Kodak and GretagMacbeth). The rendering intent was set to Absolute Colorimetric for maximum color accuracy. Black point compensation and dither boxes were left unchecked. The colors specified were converted to their CMYK values using the Adobe Photoshop 7.0 API.

5. The recorded CMYK values for the three test conditions were converted back to CIELAB (A to B conversion, absolute) using the press profile as the output working space. Pantone and GretagMacbeth color patches were rendered using the output press profile created by GretagMacbeth ProfileMaker v4.0. The Kodak color patch was rendered using the output profile created using Kodak Colorflow v2.1.

6. Color matching accuracy is judged by the average $\Delta E$ between the 15 color samples produced and their original color specifications. Table 1 shows the three different conversion methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>B to A (Abs)</th>
<th>A to B (Abs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pantone</td>
<td>Pantone 150 lpi</td>
<td>ProfileMaker</td>
</tr>
<tr>
<td>Custom 1</td>
<td>ProfileMaker</td>
<td>ProfileMaker</td>
</tr>
<tr>
<td>Custom 2</td>
<td>Colorflow</td>
<td>Colorflow</td>
</tr>
</tbody>
</table>

Table 1. The three color matching methods used

Results
A summary of the minimum, maximum and average $L^*$, $a^*$ and $b^*$ differences are given below in tables 2a, 2b and 2c.

<table>
<thead>
<tr>
<th>$n=15$</th>
<th>$\Delta L^*$</th>
<th>$\Delta a^*$</th>
<th>$\Delta b^*$</th>
<th>$\Delta E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>-1.27</td>
<td>-2.24</td>
<td>-0.54</td>
<td>0.24</td>
</tr>
<tr>
<td>Max.</td>
<td>0.49</td>
<td>1.03</td>
<td>2.98</td>
<td>3.76</td>
</tr>
<tr>
<td>Ave.</td>
<td>0.09</td>
<td>0.00</td>
<td>0.62</td>
<td>1.06</td>
</tr>
</tbody>
</table>

Table 2a. Results for GretagMacbeth ProfileMaker v4.0
Visual differences perceived between the Pantone and ICC color patches are indicative of quantitatively measured color differences. To enable perceived differences in color, the specified colors reproduced using the Pantone and custom ICC (Kodak Colorflow v.2.1 and GretagMacbeth ProfileMaker) methods are shown in figure 3.

**Discussion**

For this study no physical printed output was used. The analysis was done using the Photoshop API. Hence, any variations due to random errors present in measuring instruments and the printing process itself were eliminated. In theory $\Delta E$ should be zero. In practice however this is not the case and we notice small $\Delta E$ differences which are due to rounding and interpolation errors of the profiling package and CMM used.

The $\Delta E$ was calculated using this CIELAB value as the sample and the CIELAB values of the specified color patches as the reference. Since $\Delta E$ as a total color difference is used as a major parameter to judge the degree of a color match, we can conclude that the custom ICC profile does indeed provide a closer match to the specified color than the Pantone profile.
Objective
This is a study on how different ICC profiling software packages compare to each other, and the default SWOP profile. We compared the difference between Kodak, GretagMacbeth, Monaco, and SWOP ICC profiles when applied to an RGB test image. The visual differences and pleasingness of color were compared.

Procedure
1. Scanning
   A color photograph was scanned on a Scitex Eversmart Pro scanner and assigned the Eversmart ICC input profile created with Kodak Colorflow. The file was then saved as glove_RGB.tif.

2. Press Profiling
   Using the three different print profiles from their subsequent companies, three profiles were created for comparison to the SWOP ICC profile. Kodak ColorFlow (TF_08), GretagMacbeth Profile Maker 4.1 (TF_05), and Monaco Profiler 4 (TF_06) ICC profiles were created through their various software packages. Measurements were made on the GretagMacbeth Spectrolino Spectroscan. Identical settings were used for all three profiling packages using the RIT TAC chart (TF_10): TAC/UCR: 300, Max Black: 66%, Black Start: 25%.

3. Image Preparation
   The glove_RGB.tif image was opened in Adobe Photoshop 7.0 using the embedded Eversmart ICC profile. It was cropped and resized so that the image was 3” wide with a spatial resolution of 300 ppi and saved as an RGB file, glove_cropRGB.tif.

4. ICC-based color workflow
   The color settings were standardized in Photoshop for all CMYK conversions. Black Point Compensation was activated and the conversion engine was set to Adobe with relative colorimetric and perceptual intent. Using the glove_cropRGB.tif image as a starting point, four copies of the image were made, then opened and converted from the RGB Eversmart working space to the subsequent Heidelberg CMYK working space using relative colorimetric and perceptual rendering intents. The eight images were then saved as ICC tagged TIFF file per profiling software package, including SWOP.

5. Output
   The images with the same ICC profile, with different rendering intents were placed diagonally to each other in a QuarkXPress document giving the observer the ability to see perceptual and relative intents side by side. Figures 1-8 show all four profiles, along with each relative and perceptual intents.

Observations
Before observing the visual pleasingness of the images, the TAC was confirmed at 300%, and the max black at 66% using the Show Info palette in Photoshop. Overall, the three profiling software packages tested created similar appearance. There were no significant differences when looking at the visual pleasingness of the images in either relative colorimetric or perceptual rending intent. The profiled images were slightly lighter than those converted using the SWOP profile. In general, all the software performed extremely well.

Inspection of ICC profiles made with different profiling software packages displayed no problems when reproducing pictorial images. All three packages performed equally. No colorimetric analysis was performed so color matching of critical colors may be a different story than reproducing pictorial color images.
AM and FM screening
By Tiago Costa

Introduction
FM screening is becoming a trend in computer-to-plate workflow. The problem when using these fine screen rulings is that there is more dot gain. The solution is to apply transfer curves to the images, which compensates dot gain by reducing the frequency of microdot. It is understood that, to obtain good results, we must have a repeatable process which stays calibrated. For this experiment, different screening methods are compared. AM 150 lpi is used as reference and compared to AM 300 lpi, FM Staccato from Creo, and FM Velvet from Ugra. Both FM screens have a microdot size of 21µ.

Procedures
1. Calibration, Measurement, and Calculation
   The TF_04 Screening targets test form used was printed on the first calibration press run to SWOP standards. That test form has a series of step wedges for each screening, which were measured using an X-Rite densitometer. The data was collected and pasted into the “Transfer_Plot (v2.4)” Excel template that calculates a transfer curve from a reference to a sample (Figure 1).

2. Preparing the Images
   The pictorial reference image used in this study, courtesy of Professor Patricia Russotti, contains fine detail, and it is a good resolution test. In order to be able to compare tone reproduction between the images, simple 4-color scales were added to the original image in Photoshop. To obtain different screenings on a single printing plate, screen rulings are embedded in the EPS images via PhotoShop. Transfer curves were implemented by altering the tone values in Photoshop by using Image > Adjustments > Curves.

3. FM Screening
   Velvet screening was implemented by first applying the needed curves to the Photoshop EPS file, which was saved without embedded screen ruling, and then processing this file using Velvet screening software set at 1200 dpi to create a bitmap of 2x2 microdots. The default noise factor of 25 was used. Staccato screening is part of the Creo RIP and is activated by embedding the screening called Staccato 20.

<table>
<thead>
<tr>
<th>Screening</th>
<th>Embedded Screen Ruling</th>
<th>Applied Curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM 150 lpi</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>AM 300 lpi</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>FM Velvet</td>
<td>none</td>
<td>yes</td>
</tr>
<tr>
<td>FM Staccato</td>
<td>Staccato 20</td>
<td>yes</td>
</tr>
</tbody>
</table>

   Table 1. Settings for Images

Discussion
By analyzing the images in the next page we can observe that there is a difference between the images with and without transfer curves. Overall, it is quite easy to see that the images without curves are darker, due to dot gain. The transfer curves applied to the images on the right-hand column does not affect resolution, but it brings the images closer to the reference image (Figure 2). A transfer curve lowers tone gradation to account for dot gain. The transfer curves from the different screenings are not much different from each other. However, the AM 300 lpi required more correction in the highlights than the FM to match the reference tone values.

AM 150 lpi screening is limited in showing as much fine detail as the others. For the fine screen rulings, the details are all there, and it does not matter if it is an image with or without transfer curves. The AM 300 lpi screen shows almost as much detail as the FM screens. However, the previous observation assumes that print to print registration is obtained. In addition, the gray scale patches for Staccato appear more uniform than Velvet. Velvet might be improved by choosing a different noise factor.

In conclusion, the FM screening is capable of reproducing more detail, but speculations say that it can bring problems with paper dust piling, which is due to an ink emulsification for these extremely fine screen rulings.
Figure 1. Black transfer curves

Figure 2. 150lpi AM - Reference image

Before (without curve)

After (with curve)
Introduction

How could we measure the differences in resolution between AM and FM screening? How could we measure differences in resolution between a plate setter having an addressability of 2400 spots per inch (spi) and a laser printer that has only 600 spi or a monitor that has only 72 spi?

Addressability and resolution are not the same. Addressability is a measure of the number of spots an output device can place. Resolution is the visual ability to perceive fine structures at various tonal differences between them. There is no single number to specify the resolution of an output device, because resolution is a function of tonal difference (contrast). Moreover, resolution is related to the way that gray levels are produced, in other words, with the type of screening.

Halftones and Gray levels

There are two fundamental ways that gray levels can be produced: 1) Spots can be arranged in variable area clusters (halftone dots); or 2) Each spot can be imaged at variable density (bit depth). Both methods can be combined.

Offset printing can only print either full ink film or none. In this sense it is a binary system, where gray levels are produced by the use of halftone dots that are too small to be seen individually, but cover more or less area to produce different gray levels for the eye. In turn, each halftone cell is made up of the spots from the output device (imagesetter). Many spots are needed to form a halftone cell. This means that spots have to be very small indeed (about 10 microns wide, about 256 per halftone cell).

The spots on a monitor are about 35 times bigger; there are only ca. 72 per inch. Yet, images on a monitor can be very good, because each spot can be imaged at many (256) color intensities for each color channel. The number of gray levels that any spot can have is called bit depth and is expressed as a binary number. Offset printing has a bit depth of 1, a monitor has a bit depth of 8. Systems like laser or ink jet printers have an intermediate addressability of some 400 to 800 spi and they use a mix of halftone and bit depth modulation to obtain the gray levels.

Resolution and Contrast

The resolution obtainable by these output devices is affected by three kinds of frequencies that interact with one another: 1) Small image detail (pixels), 2) The addressability grid of the output device (spots) and 3) The halftone pattern (dots). To print an image pattern with very high contrast (black and white) does not require a halftone. The image is just formed by turning on or off the spots of the output device. This means that only two frequencies are involved and therefore better resolution is obtainable. This is one example of how resolution depends on contrast.

It is not easy to get quantitative data about resolution from pictorial images. It is much better to reproduce a test pattern that systematically samples different image resolutions at different contrasts. The RIT ConRes test target can be used for the purpose.

Description of Contrast target

The RIT Contrast Resolution Test Target, shown on page 11, consists of 6 panels, two each for cyan, magenta and black. For each color, one is vertical, the other is horizontal. Each panel consists of 10 rows with different line widths (representing image detail), and 10 columns with different contrasts between these lines. In other words, the line and the space between the lines have a different tone value for each column. Contrast is the difference in tone value. The lines and the contrasts vary stepwise over a logarithmic range, which can be defined in the header of the EPS file. The target works for devices with any bit depth or addressability.
Evaluation of Target

This target can be visually evaluated by reporting the lowest contrast at which a given line width still can be seen for the different colors and directions. A curve plotted from this data gives an indication of modulation transfer. See Figures 1 and 2.

CRV is a descriptive number for a given system.

The decision of what is and what is not resolved is somewhat subjective. It was found that it helps to train observers to get agreement between them. It was also found, that although different observers may use slightly different criteria for their decisions, they are very consistent within themselves. Therefore, they all agree on which system has higher or lower CRV.

Discussion

There is a clear difference of contrast-resolution between various printing systems. High addressability is not necessarily better. Using different types of screening on the same output device results in different CRV’s as shown for the three Approval screenings. The good low contrast performance of the 150 lpi Approval print shown here (green line for X direction) was only average in the Y direction.

The lower addressability of the xerographic printer limited high resolution at high contrast, but did not affect low contrast performance. The 6 colors of Epson do give good performance of low contrast resolution. Its addressability of 720 dpi was enough to also give good results at high contrast and fine detail.

Epson reports 1440 dpi for the Y direction (not shown here) and 720 dpi for the X direction. The CRV analysis did not show a significant difference between the two. It would be interesting to study the relation between the CRV results from the ConRes target and subjective evaluation of perceived quality of pictorial images.

Reference

Color matching comparison between generic and custom press profiles
By Chao-Yi Hsu

Objectives
It is not clear whether or not there is an advantage for using custom-built press profiles over generic press profiles. If there is no significant difference in color matching performances between a generic and custom-built profile, then a custom profile is not worth the effort to build. For determining the value of creating a custom profile, this study evaluated color gamut (A-to-B) differences between the generic profile (U.S. Web Coated SWOP) and the custom-built profile (Heidelberg M-1000B). Furthermore, the accuracy of color-matching (B-to-A) performance of the generic and custom-built profiles was compared on three a*b* slices, L*30, L*50 and L*70.

Resource
1. Press profiles: generic press profile (U.S. Web Coated SWOP) and custom press profile (Heidelberg_Oct_18_02.icc)
2. Test targets: a*b* slice test targets (L*30, L*50 and L*70). The color charts are defined by CIELab color space. The range of the color swatches goes from a* -100 to 100, and b* -100 to 100.
3. API: Adobe Photoshop 7.0.1
4. Profiling software: GretagMacbeth ProfileMaker 4.1.1
5. Data analysis: Gretag SpectroScan and Excel template “F_ab_slice(v1.0).xls.” CIE ΔE76 was calculated to show color differences between source data and the press output.

Procedures
1. Press profiles
Use USWebCoatedSWOP.icc as a generic profile. Using GretagMacbeth ProfileMaker 4.1.1, create a custom profile for Heidelberg M-1000B web press from the Oct. 18, 2002 press run. The press run was adjusted to SWOP specifications.

2. Color gamut evaluation
ProfileEditor 4.1.1 was used to evaluate the difference of color gamut between the generic profile and the custom profile.

3. Color-matching performance evaluation
Generic and custom profiles were used in Photoshop 7.0.1 to convert the original a*b* slice files to CMYK files. All the targets were printed on the Heidelberg M-1000B web press. Gretag SpectroScan was used to measure L*a*b* values of each printed a*b* slice target. The “F_ab_slice(v1.0).xls” Excel template was used to evaluate color matching performance between generic profile and custom profile images.

Discussion
1. Color gamut comparison
The colors defined in the a*b* slices cover the whole range of CIELab space (Figures 1, 2 and 3). However, those colors, lying outside of the press gamut, would be either clipped or rendered faithfully under absolute colorimetric intent.

Figure 1. L*30 a*b* slice target embedded with the custom profile, Heidelberg M-1000B_Oct_18_02

Figure 2. L*50 a*b* slice target embedded with the custom profile, Heidelberg M-1000B_Oct_18_02

Figure 3. L*70 a*b* slice target embedded with the custom profile, Heidelberg M-1000B_Oct_18_02
The gamut boundaries of the custom and generic profiles are showed in Figures 4, 5 and 6. There is not much difference between each other because both profiles were calculated for SWOP condition. Therefore, we do not expect much difference between them.

2. Color-matching performance comparison

The color difference observed in tables 1 and 2 shows the difference between two printing conditions, Heidelberg M-1000B press and SWOP press. The SWOP generic profile was calculated from an average of several carefully controlled SWOP runs. Custom profile was calculated from our condition and it compensates for the fact that our process was within SWOP tolerance but not exactly at SWOP aim. (Figure 7)

In table 1, only reproducible colors were used for color matching evaluation. In table 2, pairs of neutral color (a*=0 and b*=0) swatches were compared. Generally, the generic profile resulted in less reproducible color samples, higher ∆E values and higher a* values. By applying the custom profile, ∆E values dramatically decreased and color accuracy improved.

In conclusions, a precise printing system can achieve better color matching performance via correct custom device profiles.
Introduction
Color image reproduction, as shown in Figure 1, is typically analyzed by means of visual judgment, and not by quantitative means. With the use of test targets, this lab is designed to analyze color image reproduction colorimetrically and to correlate such findings with visual perception.

Objective
This is a study to illustrate how ICC color management can be applied from scan to print using perceptual rendering. Colorimetric analysis of IT8.7/1 reproduction is used for grayscale and hue reproduction.

Resources
1. Scanner profiling software: GretagMacbeth ProfileMaker
2. Test image: IT8.7/1 target and photographs by Donna Crowe

Procedures
1. Preparation
   An IT8.7/1 target by Fujifilm is scanned along with the pictorial images on a Nikon Coolscan slide scanner. Scanner ICC profile is built using GretagMacbeth ProfileMaker 4.0.

2. Press Profiling
   The output profile was created by printing the GretagMacbeth profiling target on the Heidelberg M-1000B press. The printed target is then measured on the GretagMacbeth Spectrolino Spectroscan. The printer ICC profile is created using GretagMacbeth ProfileMaker using perceptual rendering.

3. Application of Profiles
   After opening the raw RGB files in Photoshop 7.0, the image was assigned Nikon Scanner ICC profile. The second step is to convert the image from the assigned RGB space to Heidelberg M-1000B CMYK space via “Convert to Profile”. Adobe CMM with perceptual rendering was used in the conversion.

Analysis of tone and color reproduction
The colorimetric analysis procedures used were first published in a paper by Irving Pobboravsky and others (ISCC Proceedings, 1971) of which three different methods of tone and color analysis were performed as shown in Figures 3, 4, and 5.

Figure 3. (a) Tone reproduction of L*(orig.) vs. L*(repro.)
(b) Tone reproduction of Darkness (orig.) vs. Darkness (repro.)

Tone reproduction can be studied by plotting L* of the gray scale in the Fujichrome original against L* of the gray scale in the press sheet. Alternatively, it can also be studied by plotting the darkness of the original against the darkness of the reproduction. The latter is similar to using a density scale: the highlights of the tonal scale are in the lower left corner, the shadows are in the upper right corner (figure 3b).

Figure 3 shows that the dark steps were clipped in the reproduction. All other steps were reproduced at the correct lightness.
Figure 4. Colorimetric analysis of neutrality

Figure 4 shows that the gray scale steps remain the same as the original, they did not change hue or chroma in the reproduction.

Figure 5. Hue reproduction

Using the data of column 8 of the IT8 7/1 target (fig. 2), the graph in Figure 5 shows that the hue angles were preserved and there was some gamut compression indicating a reduction of chroma.

Discussion

Visual and colorimetric analysis agree that there was no hue shift and that the dark colors were clipped. In theory perceptual rendering should not clip. To find out what happened, colorimetric rendering was also tried but it gave the same results. Therefore there is a question whether the profiling software really differentiates between perceptual and absolute colorimetry rendering.

Reference

Objective
The cover was created with both a design and print production perspective in mind. The goal was to create an eye-catching cover for the publication that would attract the reader’s eye and reproduce well from a printing standpoint. The cover was color managed using new color profiles created by European Color Initiative (ECI). The measurement data used to create the profiles was recorded by FOGRA in the fall of 2002. The profiles were designed for offset printing, which is defined by ISO 12647-2.

Design Methodologies
Tom Chung, an art director from creativeputty.com, created the cover artwork concept. The purpose of the artwork design is to excite the viewers visual system by combining several different information elements into a single image. The artwork consists of an eye abstracted down to 342 square boxes and placed within a pseudo test target frame. The eye has been rendered to the point of extreme pixilation. The closer the viewer is to the artwork, the more abstract it becomes. As the viewer moves farther away, the optical system is less sensitive to resolution and the image of the eye becomes more visible. This is very similar in the way that halftone dots work. When viewed up close, the image is unrecognizable. As the viewing distance increases, the image becomes more visible.

The phrase “Test Targets” is superimposed onto the abstracted image of the eye. This is achieved by modifying lightness levels of certain color blocks and by applying a spot varnish to the cover during printing. The effect is subtle so that the viewer will see the abstracted design, recognize the eye image, and then notice “Test Targets” overlayed onto it. This was experimental and a very difficult task to accomplish due to limitations within the optical perception of the artwork. The “Test Targets” phrase and the resolved eye image are in direct competition with each other. If the image of the eye becomes too well defined, the words “Test Targets” become indistinguishable. If the words are accented too much, the image of the eye becomes irresolvable. Quite a bit of tweaking was required to bring both elements to a similar level. The spot varnish was added as a unique way to emphasize the “Test Targets” wording but not detract from the image of the eye.

Figure 1. Cover art without spot varnish

The color scheme for the cover and inside of the publication is based on the cover artwork. The purple color chosen for the outside cover was selected because it complements the colors within the artwork. A bright color would have caused too much visual tension with the artwork. The darker color helps focus the viewer’s attention on the artwork and bring a sense of uniformity to the cover. By selecting colors from the artwork for the inside of the publication, the relationship between the cover and text become part of a design system.

Production Procedures
The cover was printed on the Heidelberg Speedmaster 74 at RIT, a 6 color sheetfed press with a maximum paper size of 20x28 inches. All 6 printing units were utilized in the production of the cover, which was printed 4 color process plus 1 spot color and a glossy spot varnish.
The cover artwork concept was supplied in CMYK. Because design is a creative process and not based on a reference point, the image was converted to ECI's RGB profile (ECI-RGB.V1.0.icc) for editing in Adobe Photoshop. The ECI profiles promise an exact match between the RGB and the CMYK versions. The image was then modified to the desired appearance in RGB. Once the artwork modifications were complete, the image was converted to the ECI’s CMYK profile (ISOcoatedsb.icc). This ICC profile was optimized for offset printing on paper that is: grade 1 or 2, gloss or matte coated, 150lpi, and self backing (sb). The color settings in Adobe Photoshop used the Adobe ACE color engine, relative colorimetric rendering, and no black point compensation or dithering.

To successfully create the spot varnish, an extra channel had to be added to the CMYK file. First the blocks used to create the phrase “Test Targets” were selected. Then a new spot channel was added in the channels palette. The channel was named “varnish”. The cover artwork was then saved as a Photoshop DCS 2.0 EPS file as a single file DCS with no composite. This allows the preservation of the 5th channel. The file was placed into QuarkXPress for page layout.

The purple background on the cover is PMS 518C. There were several reasons behind the decision for selecting a spot color. Initially, the purple background was a 4 color process purple. However, a large solid area composed of 4 different inks can cause many problems relating to color evenness and knockout text trapping. A spot color is ideal because there are fewer problems to worry about regarding registration, trapping, and color consistency. This particular spot color was also picked for its ability to be reproduced as a 4 color process color. The text portion of the Test Target 3.0 publication was printed on a 4-color web offset press and uses the process values of the spot color used on the cover. It was important to find a color that would reproduce consistently on both presses.

Discussion

The cover design of this year’s Test Targets publication was more complex than last year’s (Figure 3) from both a design and print production viewpoint. All 6 printing units on the Heidelberg press were put to work. In many ways, this cover opened the doors to many new aspects of designing and printing. It was impossible to accurately proof the cover because no digital proofers are able to simulate spot varnishes. It was also the first time that ECI color profiles were used on an RIT publication. These profiles were not characterized to the Speedmaster 74 specifically but to general ISO 12647 standards. The cover for will pave the way for future experimentation in design and print production.
Introduction
A single press run is required to produce a publication. But knowledge about the press is necessary to produce a color-managed publication. This article explains the approaches we took to produce Test Targets 3.0.

Calibrating the web offset press
A color-managed print production works if the press condition is repeatable. We identified the prepress, ink, paper, and press conditions and chose SWOP as the printing specification (Table 1).

Table 1. Press run organizer

<table>
<thead>
<tr>
<th>PREPRESS</th>
<th>Digital test forms: 1-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNATURE</td>
<td>See the attached layout</td>
</tr>
<tr>
<td>PRESS</td>
<td>Digital</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>Agfa Sherpa</td>
</tr>
<tr>
<td>PLATE</td>
<td>Coated CTP 5400 spig.</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>KODAK (375m): thermal</td>
</tr>
<tr>
<td>PRESS</td>
<td>Heidelberg SM-1000S</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>30C with offset press</td>
</tr>
<tr>
<td>FOUNTAIN BOWL</td>
<td>Anchor</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>XEROX 18 Emerald Premium</td>
</tr>
<tr>
<td>BLANKET</td>
<td>Day International 5400</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>Compressible</td>
</tr>
<tr>
<td>INK</td>
<td>Process</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>SUN CHEMICAL</td>
</tr>
<tr>
<td>PAPER</td>
<td>IP Vellum 45 #1000</td>
</tr>
<tr>
<td>BRNCH</td>
<td>35% M.O.B. Tex., 35% m.w.</td>
</tr>
<tr>
<td>PRINTING</td>
<td>Reference: SWOP</td>
</tr>
<tr>
<td>INK AROMA</td>
<td>RCMY</td>
</tr>
<tr>
<td>Solid ink density:</td>
<td>K. 1.60</td>
</tr>
<tr>
<td>(A10)</td>
<td>M. 1.40</td>
</tr>
<tr>
<td>(A10)</td>
<td>C. 1.30</td>
</tr>
<tr>
<td>Dot gain K:</td>
<td>22% Black</td>
</tr>
<tr>
<td>(A10) C.</td>
<td>20% Yellow</td>
</tr>
<tr>
<td>Color control bar:</td>
<td>RIT Color Control Bar</td>
</tr>
</tbody>
</table>

The first press run took place on Oct. 14, 2002. We asked the press crew to print solid ink patches to SWOP densities. We then measured the dot gain of 50% tint patches and adjusted the dot gain to SWOP aim points with the use of transfer curves in the CTP operation. Here, we added 1% dot gain to the cyan printer, 3% dot gain to the yellow printer, and 4% dot gain to the black printer while the magenta printer needed no adjustment.

With the help of dot gain adjustments in the CTP operation, the second (Oct. 18, 2002) press run conformed to SWOP density and dot gain specifications. The second press run lasted about 25 minutes. Press sheets samples were collected at 30 seconds interval.

Process variation and deviation
Process variation refers to how close the measurements compare to one another. Process deviation is a measure of the difference between the average of measurements and the aim or center points. A precise process exhibits small variation. An accurate process exhibits small deviation. While we strive for a precise and accurate process, we don’t always achieve it. Upon density measurement and analysis, Figure 1 shows solid ink density (SID) variation and deviation of process inks from their respective aim points over time for the Oct. 18, 2002 press run.

Figure 1. SID variation and deviation

While cyan, yellow and black printers showed solid ink density variations, their averages were close to the center point of SWOP aims. Only the magenta printer exhibits high SID deviation throughout the press run.

Figure 2 shows dot gain variation and deviation of CMYK printing units. We can see that the black printer exhibits a large dot gain deviation by consistently printing too sharp. More dot gain compensation would have been necessary for dot gain conformance of black printer.
Another interesting observation was the unusual high dot gain of the magenta printer found in press sheet #31. Upon close examination of the press sheet with a magnifier, the cause of the large dot gain was due to dot doubling. The doubling effect was also seen vividly from the concentric circles patch and the RIT doubling grid target.

**Profiling from the best sheet**

At 1200 ft/min press speed, a web offset press can print 20,000 impressions from a roll of paper in 30 minutes. But we need only one or no more than three press sheets to build a press profile. Thus, it is important that we pick the press sheet with no visual flaws while conforming to specifications the closest among all measured samples. From the second (Oct. 18, 2002) press run, press sheet #37 was the choice and we called this sample the best sheet. Plate/press curves of the best sheet (Figure 3) were measured from the TF_01 Device Characterization Target along with an Excel template. Profiling targets, e.g., TF_05 GretagMacbeth Profiling Target, from the best sheet were then used for press profiling.

**Color-managed workflow**

Variability exists everywhere. While no two snow flakes are identical, no two press runs are the same. We’ve developed a methodology in assessing process capability of a press run (GATF, 2001). Ultimately, it’s the temporal consistency within a press run and the run-to-run consistency that determines the color rendering performance of a color-managed imaging workflow.

You will see the effect of generic and custom press profiles when converting pictorial color images from source RGB profiles to the press CMYK profile. You will also find color matching comparison between generic and custom press profiles in Test Targets 3.0. Whatever the results which might be concluded, a color-managed imaging workflow will only excel in producing and matching color when profiled devices stay calibrated and are consistent.

**Reference**

Gregory Firestone - Greg is the only designer in the group. He enjoyed sending out countless design modifications that drove everybody crazy.

Robert Chung - Keeping his cool while everybody was losing theirs, the good professor ensured quality and timely production of the publication.

Michael Meyerhofer - Mike learned the hard way that digital cameras and strobe lights do not always mix. Fortunately his resourcefulness came through.

Nilay Patel - “Neel” thought Test Targets 3.0 was going to be the end of him. We are proud to report that he is alive and doing well.

Vikaas Gupta - Vikaas accepted nothing less than perfection and spent the whole entire night re-doing his report the day before everything was due.

Ryan Testa - Ryan encountered every possible setback in a color-managed workflow but rised above it all to produce a technically sound document.

Hemachand Kolli - “Hem” managed to keep a smile throughout the entire project. We still can’t figure out how he did it.

Chao-Yi Hsu - “Fred” essentially lived in the CMS lab for the last several weeks. He’s very grateful that RIT did not start charging him rent.

Tiago Costa - Tiago is now the guru of screening and transfer curves. Name a time and place and he can make a curve.

Franz Sigg - Franz questioned EVERYTHING we wrote in our reports. His insightful and inquisitive mind created new avenues of learning for all of us.
Test Targets v3.0
An R•I•T School of Print Media Publication
Rochester, New York, USA

Cover printed at R•I•T’s Printing Applications Laboratory on the Heidelberg Speedmaster 74 Sheetfed Press
80# Stora Enso Frostbrite Matte Cover

Text printed at R•I•T’s Printing Applications Laboratory on the Heidelberg M-1000B Web Press
80# IP Velocity #3 Coated Text

Copyright © 2003