Using Virtual Pressrun to Implement Press Calibration

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Keywords: color, calibration, printing, standards, characterization, simulation

Abstract

Press calibration requires two pressruns. Run 1 determines outer color gamut and Run 2, printing with adjusted data in relation to a specified printing condition (Device 1), determines in-gamut colors. In this project, we define virtual pressrun as the application of a device-to-PCS colorimetric transform of a printer ICC profile in Run 2 to calibrate a press, Device 2. The goal is to compare the results of three methods of data adjustment suggested by ISO TS 10128, i.e., TVI adjustment, device link adjustment, and gray balance adjustment. A secondary goal is to compare the results of the virtual pressrun to actual printing with the adjusted data. Results show that virtual pressrun acts as Run 2 proxy in press calibration without run-to-run variation. Using virtual pressrun and visual simulation of pictorial color image reproduction, this research demonstrates that printing adjusted data to Device 2 can be used as a proof for production printing on Device 1.

Introduction

There is often a need to produce similar printing results (color matched) from two different devices. The most common example is the need to proof on one device and accomplish production printing on a second device.

Press calibration requires two pressruns. Outer gamut colors, e.g., solids of process color inks, are adjusted in Run 1. Process control data or characterization dataset are then adjusted and printed in Run 2. ISO TS 10128 suggests three approaches that are commonly used to accomplish these data adjustments, i.e., TVI adjustment, device link adjustment, and gray balance adjustment.

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A typical approach is to print the same test form on Device 1 and Device 2, measure the results, adjust the data for Device 2, repeat the test and compare the new results. A key problem in evaluating the results is that most output devices themselves have variability and this variability combined with measurement uncertainty clouds the results.

Virtual pressrun represents the ideal situation where both devices perform consistently over time by working with characterization data and ICC profiles. In this case, both devices print a test form and an ICC output profile is prepared that represents the color reproduction characteristics of each device. Using the device-to-PCS colorimetric (A-to-B) transform of the profile allows the expected color for any combination of CMYK data (for example, the altered data) to be determined for that specific device. Run 2 in effect becomes a virtual printing device with a repeatable printing condition which allows the performance of various data adjustment techniques to be evaluated numerically without printing variability and measurement uncertainty.

Objectives

The primary goal is to compare the results of different methods of data adjustments suggested by ISO TS 10128: TVI adjustment and device link adjustment. A secondary goal is to compare the results of the virtual pressrun to actual printing with the adjusted data.

Resources

In terms of hardware, the devices chosen for use are Presstek 52DI offset press and a Xerox iGen4 digital printer. The aim is to adjust the data sent to the iGen4 so that its output could be used as a proof for production printing on the Presstek 52DI using unadjusted data. In terms of software, Excel, Photoshop, i1 Profiler, ColorThink Pro, and Curve3 are used.

Test forms (12” x 18”) include IT8.7/4, P2P25x, RIT Test Block, 10-Patch target, and pictorial color reference images (Figure 1).

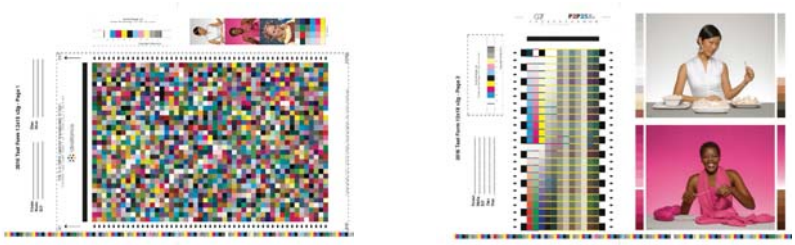

Figure 1. *Test form (Page 1, left, and Page 2, right)*

The IT8.7/4 target (Page 1) is used to build ICC profile and to analyze dataset conformance. RIT Test Block (Page 1), consisted of three pictorial images and a 4x6 synthetic target, is used to appraise color image reproduction and to extract process control data (gamut corners, gray balance, and TVI). The P2P25x target is used to calibrate a press according to the gray balance and the TVI method. In addition, a small 10-Patch target is placed in each of the two test forms and is used to verify press stability.

Methodology

1. Conduct Run 1, color measurement, and ICC profile generation

   a) Print the test forms by 52DI and iGen4. Document the printing conditions, including consumables, platemaking, process control settings, etc.

      Endurance 100 lbs. gloss cover stock is used by 52DI and iGen4. Due to the experimental nature of the research, we accept 52DI and iGen4 RIP linearization and calibration settings.

   b) Use i1 iSis2 to measure 52DI and iGen4 printed IT8.7/4 target. Save measurement files in CGATS.txt format.

   c) Use i1 Profiler to generate the 52DI ICC profile and the iGen4 ICC profile. Figure 2 illustrates the selection of the IT8.7/4 target definition file before submitting the measurement file in the profile generation process.

Figure 2. *i1 Profiler user interface*

2. Measure or extract process control metrics from Run 1

   The virtual pressrun experiment begins with using the Presstek 52DI ICC profile and the iGen4 ICC profile. As shown in Figure 3, use ColorThink Pro and the A-to-B look-up table of the Run 1 ICC profile to extract CIELAB values from the 4x6 synthetic target.

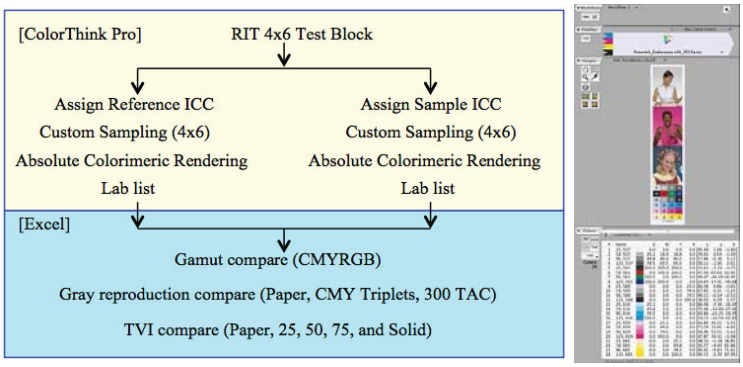

Figure 3. *Using virtual pressrun to print and assessing process control metrics*

Copy and paste the CIELAB lists into a custom Excel to compare process control metrics between 52DI and iGen4. Figure 4 compares the gamut corners between 52DI and iGen4 in a*-b* coordinates. The dotted line represents the 52DI. The solid line represents iGen4.

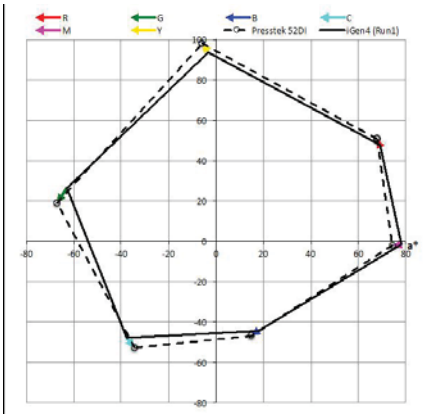

Figure 4. *Gamut comparison between Presstek 52DI (reference) and iGen4*

Figure 5 compares the gray reproduction between 52DI and iGen4 in a*-b* vs. %cyan dot coordinates. The three triplets are (C25M19Y19), (C50M40Y40), and (C75M66 Y66).

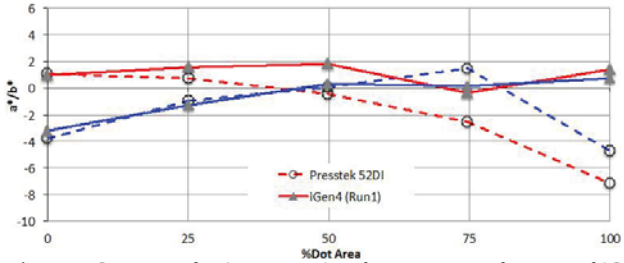

Figure 5. *Gray reproduction comparison between Presstek 52DI and iGen4*

Figure 6 compares the TVI between 52DI and iGen4 in TVI vs. %dot coordinates. Three tonal values (25%, 50%, and 75%) are used to construct the TVI curve between paper (0%) and solid (100%).

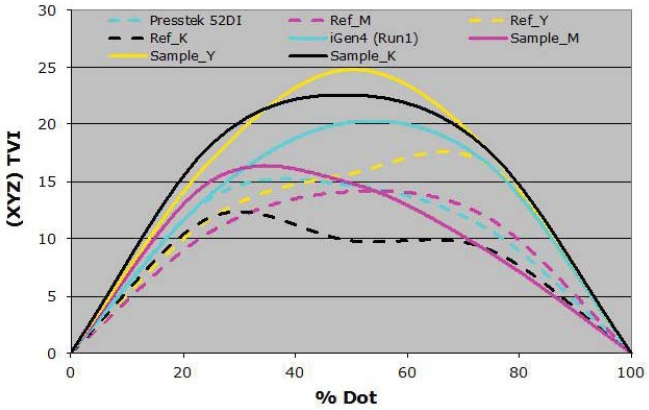

Figure 6. *TVI comparison between Presstek 52DI (reference) and iGen4*

3. Implement data adjustments

Press calibration is the adjustment of tonal values of the color characterization target according to one of the three process control metrics, i.e., TVI, gray balance, and device link (ISO/TS 10128, 2009). The following data adjustments procedures are used in the actual pressrun and the virtual pressrun experiment.

a) TVI adjustment

TVI adjustments, as illustrated in Figure 7, are carried out by (i) extracting CMYK ramps from the IT8.7/4 data between the reference (52DI) and the sample (iGen4), (ii) deriving four 1-D transfer curves in Excel, (iii) applying transfer curves to the IT8.7/4 target in Photoshop, (iv) assigning the iGen4 ICC profile of to the adjusted image.

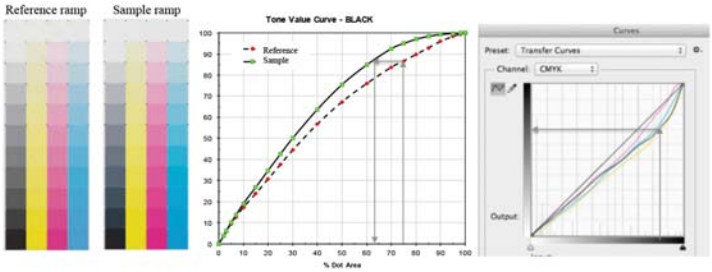

Figure 7. *TVI adjustments based on tonal ramps of two printing devices*

Note: The TVI adjustment can also be implemented by using Curve3 software and the P2P25x target. Both TVI adjustment methods were tested in this research.

b) Device link adjustment

A device link profile provides a dedicated transformation from one device encoding to another. In this project, device link adjustments are carried out by (i) using i1 Profiler to generate a device link ICC profile with 52DI ICC profile as the source and iGen4 ICC profile as the destination using colorimetric rendering, (ii) converting the digital file of interest using the device link profile in Photoshop, (iii) assigning the iGen4 ICC profile to the converted file to be printed by iGen4 (Figure 8).

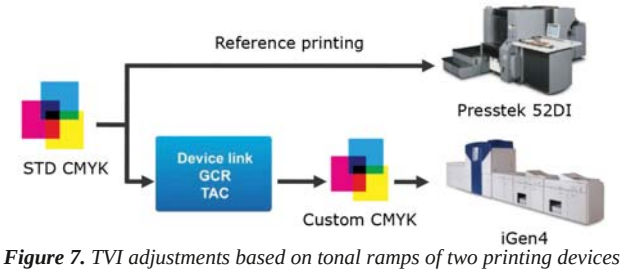

Figure 7. *TVI adjustments based on tonal ramps of two printing devices*

c) Gray balance adjustment

Gray balance adjustment can be carried out by (i) finding the gray balance characteristics of the reference (52DI), (ii) finding the gray balance characteristics of the sample (iGen4), (iii) deriving four 1-D transfer curves, (iv) applying transfer curves to the digital file of interest and saving it as the GB_adjusted file to be printed by the sample (iGen4) device.

Note: The gray balance method is not carried out due to the fact that (a) the gray balance characteristics of the reference (52DI) are arbitrary, and (b) HUB does not want to alter Presstek 52DI printing.

4. Conduct Run 2 using adjusted data

In the actual pressrun, iGen4 is used to print adjusted files. In the virtual pressrun (Run 2), the following procedures are used to extract CIELAB values from the A-to-B colorimetric transform as if the adjusted targets were printed and measured. There are two (TVI and device link) adjusted targets in the experiments.

a) Open the data adjusted IT8.7/4 target in ColorThink Pro 3.0.4b21. Sample the target (33x49) in absolute colorimetric rendering and save the list as IT8.7/4_adjusted file.

Note: The data sequence must be the same as the target definition.

b) Open the IT8.7/4 TDF in Excel and replace the Lab values from step (4a).

c) Use i1 Profiler and the adjusted IT8.7/4 file to generate the Run 2 ICC profile.

Results

To find out the relationship between the conformance to process control aim (gamut and TVI) and the conformance to color characterization dataset, we will assess conformance to process control aims first, and conformance to dataset second.

1. Conformity assessment to process control aims

Figure 9 compares process control metrics between the TVI method (left) and the device link method (right). In the TVI method, the black TVI curve conforms nicely, but there are experimental errors in cyan, magenta, and yellow TVI curves. In the device link method, all CMYK TVI curves conform to the reference closer than the TVI method.

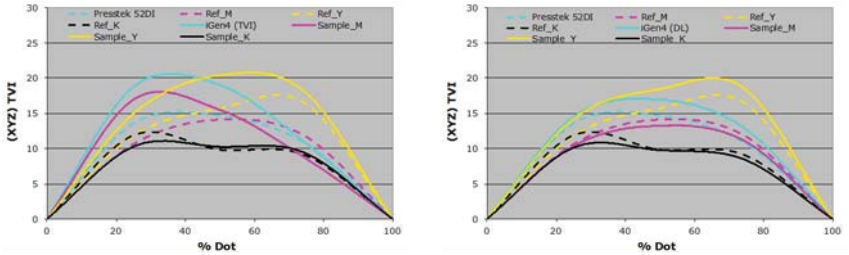

Figure 9. *TVI conformity between TVI method (left) and device link method (right)*

Figure 10 illustrates the gamut comparison between the TVI method (left) and the device link method (right). In the TVI method, solids cannot be adjusted. Thus, all gamut corners are not affected. In the device link method, gamut corners, e.g., magenta solid, are adjusted, but yellow solid did not due to gamut clipping.

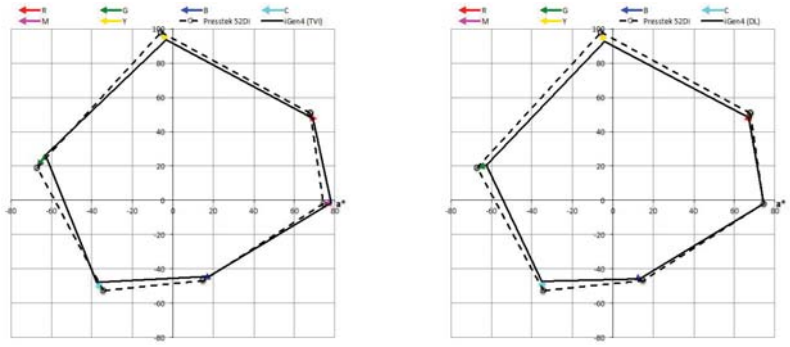

Figure 9. *TVI conformity between TVI method (left) and device link method (right)*

2. Conformity assessment to dataset aim

Figure 11 shows how to use virtual pressrun to assess dataset conformity between a reference and a sample printing condition. The procedure is the same as assessing process control conformity (Figure 3). The difference is in the use of the IT8.7/4 target and associated data analysis.

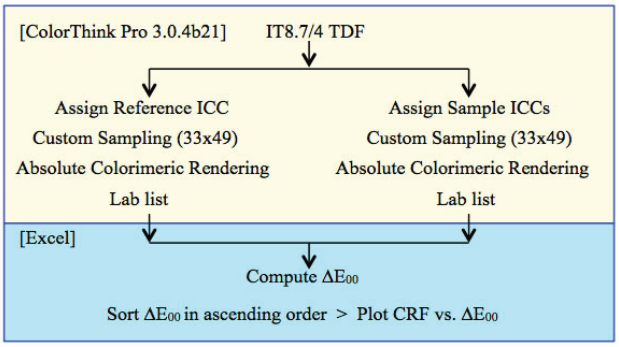

Figure 11. *Assessing color conformance to dataset*

A single number in ΔE_{00} unit is useful to describe the color difference between two colors. When we describe color difference between two printed IT8.7/4 targets, many ΔE_{00} values result. A convenient form of describing color match or difference between two printing conditions is to use CRF (cumulative relative frequency) vs. ΔE_{00} coordinates based on the IT8.7/4 target.

The dotted line in Figure 12 represents the color difference between 52DI and iGen4 initially. The gray line represents the color difference between 52DI and the TVI adjusted iGen4. The solid line represents the color difference between 52DI and the device link adjusted iGen4. The 95th percentile of the CRF_ΔE distribution is an indication of color image match between the two reproduction conditions.

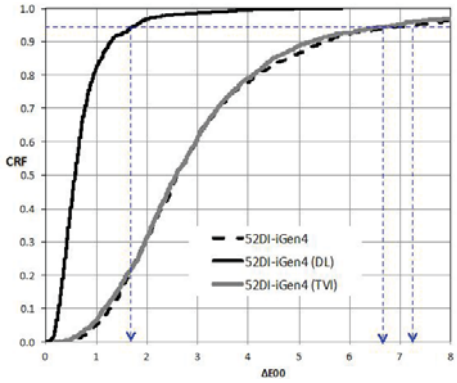

Figure 12. *Color difference assessment by TVI method and device link method*

3. Dataset conformity of the virtual pressrun and the actual pressrun Table 1 compares the 95th percentile of the CRF_ΔE, based on the IT8.7/4 target (1,617 color patches), between the virtual pressrun and the actual pressrun.

ΔE_{00} (95%tile)	Virtual Pressrun	Actual Pressrun
52DI-iGen4	7.1	
52DI-iGen4(TVI)	6.8	6.4
52DI-iGen4(DL)	1.7	3.9

Table 1. *95th percentile of the CRF_ΔE_{00}*

The 95th percentile of CRF_ΔE of Run 1 (7.1 ΔE00) is the largest. The CRF_ΔE of the TVI adjustments (6.8/6.4) improve color match slightly. The CRF_ΔE of the device link adjustment (1.7/3.9) improves color match significantly. The device link method by virtual pressrun shows better results (1.7) than the actual pressrun (3.9) because the elimination of run-to-run color error.

Discussions

1. Using Curve3 to implement the TVI adjustment

In contrast to the Excel method, resulted in Figure 9 (left), Figure 13 illustrates the improved TVI conformance using the Curve3 derived TVI adjustment curves. Curve3 is commercial press calibration software capable of deriving the gray balance based transfer curves as well as the TVI based transfer curves.

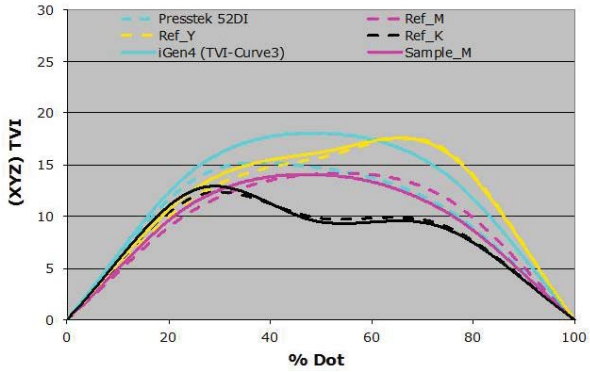

Figure 13. *Using Curve3 to implement the TVI adjustment method*

Figure 14 shows the improved dataset conformance using Curve3. The 95th percentile ΔE_{00} improves is reduced to 5.3.

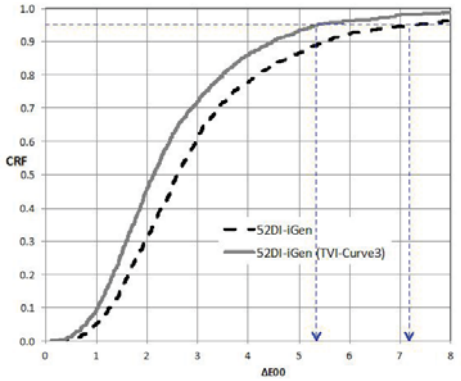

Figure 14. *Using Curve3 to implement the TVI adjustment method*

2. Visual simulation of pictorial color reproduction

Color image match between the adjusted images and the reference in the actual experiments was not evident due to run-to-run variation. Figure 15 illustrates visual simulation of pictorial color image reproduction using the procedures below:

a) Open the Test Block in Photoshop. Assign the reference ICC profile (52DI) and save as a reference embedded file.

b) Repeat the above step by assigning the ICC profile (iGen4_bef), the ICC profile (iGen4_DL), the ICC profile (iGen4_TVI), and the ICC profile, iGen4_TVI (Curve3).

c) Convert all five files to LAB color space using the relative colorimetric rendering.

d) Place the five LAB images side by side in PowerPoint and add captions.

The far left image in Figure 15 shows the color appearance of the unadjusted iGen4 image. This is followed by the 52DI reference. The middle image is the device link adjusted iGen4 image. The right two images are TVI adjusted iGen4 images. We can see that Curve3 derived TVI adjustment (far right) improves the color image match than the Excel-derived TVI adjustment.

Figure 15. *Visual simulation of pictorial color image match*

3. Analysis of experimental errors associated with virtual pressrun

Virtual pressrun has its own share of experimental errors associated with using the look-up tables in ICC profiles. In this experiment, the error between the A-to-B LUT of iGen4 ICC profile and the initial color measurement is 0.6 ΔE_{00} at the 95th percentile. The B-to-A-to-B (round trip) error of iGen4 ICC profile is 3.3 ΔE_{00} at the 95th percentile (Figure 16). It is not clear how much of the VPR device link error (1.7 ΔE_{00}) is contributed by the round trip error (3.3 ΔE_{00}).

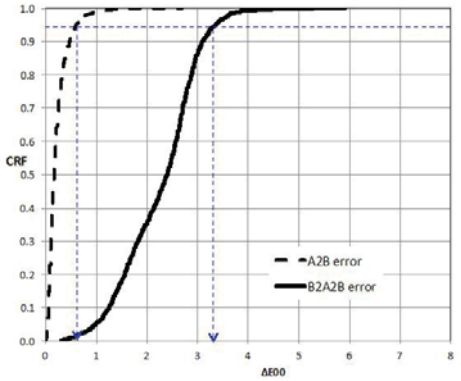

Figure 16. *A-to-B and B-to-A-to-B (round trip) errors*

4. Process control metrics vs. datasets as printing aims

   There were debates in many ISO TC130 meetings regarding whether process control metrics or datasets are printing aims since 2011. ISO 12647-2 (2013), first developed in 1996, specifies solid and TVI as printing aims. Different printing aims are specified for different printing processes and different substrates. In addition, ISO 12647-2 treats datasets, e.g., Fogra39, Fogre51, and ICC profiles as the result of printing to solid and TVI aims.

   Assuming that printing aims are printing process agnostic, ISO/PAS 15339 (2014) specifies seven datasets, having the same gray reproduction and highlight-to-midtone contrast, as printing aims. ISO/PAS 15339 considers press calibration and process control a responsibility of the print provider.

   Despite the chicken-egg (process-product) dilemma, we tested two press calibration methods in this project and learned that achieving process control aims is a means for achieving dataset conformance. But achieving process control aims does not guarantee dataset conformance. This points out the use of virtual pressrun to examine the performance of different calibration methods in press calibration is valuable to stakeholders.

Conclusions and Further Research

Virtual pressrun acts as Run 2 proxy in press calibration without run-to-run variation. Using VPR and visual simulation of pictorial color image reproduction, this research demonstrates that printing adjusted data to Device 2 (iGen4) can be used as a proof for production printing on Device 1 (Presstek 52DI).

It will be useful to streamline and automate the virtual pressrun and visual simulation techniques. It will be also useful to conduct more use cases to study press calibration methods under different sample-reference conditions.

Literature Cited

ISO/TS 10128 (2009) Graphic technology — Methods of adjustment of the colour reproduction of a printing system to match a set of characterization data

ISO 12647-2 (2013) Graphic technology — Process control for the production of half-tone color separations, proof and production prints — Part 2: Offset lithographic processes

ISO/PAS 15339 (2014) Graphic technology — Printing from digital data across multiple technologies — Part 1: Principles

Acknowledgments

We wish to recognize the following organizations and individuals for their supports and encouragement during the course of the study: RIT HUB (Mary Ellen Gauntlett, Mark Soman, and Christian Argentieri), RIT PAL (Jeffrey Wang and Margaret Hyman). We also wish to recognize the donation of ColorThink Pro and Curve3 software to RIT School of Media Sciences by ChroMIX and HutchColor. In addition, we wish to thank David McDowell, Standards Consultant, for reviewing the manuscript.