Connecting the Dots

From print buyers, printed color and printing standards to conformity assessment.

By Robert Chung

INTRODUCTION

“Connecting the Dots” was a classroom exercise I used when I taught at the Rochester Institute of Technology (RIT). I’d ask my students to draw three rows of three dots each on a piece of paper. I then instructed them to connect all nine dots with straight lines with one caveat: the pencil could not be lifted off the paper. The exercise challenged students to connect all nine dots with the minimum number of lines.

Most students could connect the dots with five lines (Figure 1 is a typical example). Once in a while a student would connect them all using four lines (as Figure 2 shows). Notice that in this case the first line and the second line extended beyond the dots that, somehow, define the boundary.

The takeaways from this exercise might be that we tend to stay inside the boundary and follow existing rules, that following rules might not solve new problems and that finding new solutions requires thinking outside the box.

PRINTERS NEED PROCESS CONTROL STANDARDS

Printers want repeatable color, meaning the ability to consistently print customer-submitted files to process control aims. Achieving repeatable color requires a printer to calibrate the ink/paper/plate/press behavior according to printing aims and exercise process control for repeatable color during the press run. In addition, the printer needs to use a color-managed proofing system to produce standards-compliant proofs.

Figure 3 illustrates this concept when CMYK job data are prepared according to the Fogra 39 characterization dataset. The press was calibrated to ISO 12647-2 (solids and TVI) specifications. In addition, the ISO 12647-7 standard provides proofing aims and tolerances.

When paper has no optical brightening agent (OBA) and when printers print and proof to the numbers, printers are assured of quality printing and customers are happy with the proof-to-print match. This solution no longer suffices when customers make more demands, however.

PRINT BUYERS PREFER BLUER PAPER AND DEMAND COLOR PREDICTABILITY

Today’s print buyers are more global and supply chain management is more complex. In addition, print buyers prefer paper with a bluer shade. They demand high-quality printing and proofs that can predict the appearance of printed color. And they view
When paper mills accommodate print buyers’ paper needs by adding optical brightening agents in the papermaking process, it creates a misalignment in printing conformance according to the ISO 12647-2 standard. It also causes mismatches or color cast between the OBA prints and the non-OBA proof, according to the ISO 12647-7 standard.

**CONNECTING THE DOTS, A PRINTING INDUSTRY PERSPECTIVE**

For the printing industry, the takeaway from our connecting the dots exercise might be that existing standards may not apply in light of changing demands from print buyers, that new technologies continue to push the boundary and that new standards will evolve. In short, connecting the dots is all about setting strategies for the printing industry to embrace and managing change for survival, competitiveness and profit.

What can we do about the twin problems of printing conformance and proof-to-print matches that are difficult to reconcile with existing standards? Do we protest that print buyers should not change the rules in the middle of the game? Do we complain to paper makers that they have betrayed the printing industry? Or do we work to develop new standards and solutions to close the gap?

Three ISO standards are instrumental in solving these problems: ISO 3664 (2009), ISO 13655 (2009) and ISO/DIS 15339-1 (2011). ISO 3664 specifies the standard viewing conditions of D50 with defined UV energies. ISO 13655 specifies the measurement condition, M1, when printed colors are under the influence of OBA. And ISO/DIS 15339-1 specifies printing and proofing conformance according to substrate-corrected colorimetric aims (SCCA). Currently the US is developing CGATS.21 as a backup in case TC130 fails to move ISO 15339 forward. In this article we’ll discuss reference printing conditions (RPC) and how to use SCCA to solve the problems of printing conformance and proof-to-print color match.

**ISO 15339-1 AND RPC**

ISO 15339-1 (2011), which is currently at the second Draft International Standard (DIS2) stage, is a printing standard that uses color characterization data as the definition between input CMYK data and printed color for data exchange, proofing and production printing. Color characterization data, used as the aim for a particular printing task, is known as a characterized reference printing condition (CRPC). The seven CRPCs specified in this standard share the same gray balance characteristics but differ in their gamut volumes.

Designers use appropriate RPCs when preparing jobs for different printing conditions. For example, RPC1, which is similar to the dataset that generates the SNAP ICC profile, is for newspaper printing and RPC6, which is similar to the dataset that generates the GRACoL ICC profile, is for commercial printing. In other words, an RPC represents a printer’s target color space from which color images and content are prepared. Achieving accurate color image reproduction depends on the color management used in proofing and the actual printing condition, as shown in Figure 4.

![Figure 4. An example of a dataset conformity-based workflow.](image)
PROCESS CONTROL VS. PRODUCT CONFORMANCE

As shown in Figure 5, a prepress and printing workflow consists of three parts: job data as defined by RPC, color printing according to process control aims and product color conformance according to dataset conformance.

Figure 5 also depicts a major difference between process control and product conformance. As shown in the bottom of Figure 5, a process control-based workflow focuses on a printer’s ability to print a color bar to conform to solids and TVIs regardless of whether the printed color meets a print buyer’s expectation. As shown on top of Figure 5, a product conformance-based workflow focuses on a printer’s ability to go beyond process control to ensure product color conformance as exemplified by dataset conformance and a print-to-proof match. As such, it requires a dedicated press run to print the characterization target.

ALIGNING PROCESS CONTROL AND PRODUCT CONFORMANCE

When a printer conforms to process control requirements, it also should conform to dataset aims and tolerances. There are difficulties in the harmonization of ISO 12647-2 and ISO 15339-1. The key issue is that ISO 12647-2 defines process control aims and then develops characterization data by printing to these aims on a typical press. ISO 15339 defines characterization data directly and extracts process control aims from this characterization data.

Four technical issues must be addressed from the standard development and implementation point of view:

- Define common RPCs and extract process control aims from the RPCs.
- Align process control and product conformance tolerances by studying the correlation between their respective parameters and maximizing the agreement between them.
- Align RPC and the actual printing condition. If a printer can calibrate its actual printing condition by TVI or gray balance to match the RPC, the alignment is complete. If not, the use of the color management or device links between the RPC and the actual printing condition is necessary.
- Adjust the white point of the RPC for the range of normal substrate color encountered in the actual printing condition (more explanation in the next section).

ISO 15339-1 AND PRINTING TO SCCA CONFORMANCE

Recognizing that paper color has an impact on printed color, ISO 15339-1 specifies the adjustment of the target dataset and process control aims for the paper color used in the actual printing condition. To establish a workflow that conforms to substrate-corrected dataset, a printer needs to:

- Decide on the RPC and the paper color.
- Calculate the substrate-corrected colorimetric aims (SCCA), i.e., CMYK solids, gray reproduction of near-neutrals (incidentally, there is no change in TVI values).

(Editors note: The SCCA calculator is a free download at the IDEAlliance website.)

- Calibrate the press to conform to substrate-corrected process control aims, i.e., solids, TVI or gray balance.
- Assess the OK sheet for dataset conformance according to ANSI CGATS TR 016. If the measurement data conforms to the substrate-corrected dataset, the dataset conformance is complete. If the measurement does not conform to the substrate-corrected dataset, the use of a device link between the RPC and the actual printing condition will be necessary.

When SCCA is applied to printing aims, the substrate bias is reduced and the printing conformance is enabled for a wider range of paper. In practice, G7 Gray and G7 Targeted are SCCA-based conformity schemes. RIT’s PSA certification is also an SCCA-based conformity scheme.

PROOFING TO SCCA CONFORMANCE AND PROOF-TO-PRINT MATCH

Due to the substrate color difference, ISO 12647-7 conformed color proofs and prints from paper containing OBA do not match when viewed side by side. To solve this
problem, the three areas to consider are: how the contract proof is defined, proofing to SCCA conformance, and communicating color between the printer and print buyer. Each of the three points is elaborated below.

- The two definitions of contract proof are: (1) a proof that conforms to a specified dataset to simulate an expectation before the paper has been chosen, and (2) a proof that uses a substrate-corrected dataset in the proofing process to predict the visual appearance of the actual printing condition.

- To apply SCCA to proofing, the reference data set is substrate-corrected, a source ICC profile is built from the substrate-corrected dataset and the source ICC profile is applied in the proofing color management workflow using absolute colorimetric rendering. RIT conducted a case study with the participation of four proofing solution providers (ISO/TC130/WG3 N1349, 2012). They were all able to use color management to match source datasets. The print-to-proof visual match was optimized based on the MI measurement of the printing paper. The proof best matches print containing OBA if gamut clipping between the two color spaces is minimized.

- Predictability of printed products requires clear communication between print buyers and printers. If the customer specifies the color proof according to a dataset without knowing the paper, a proof-to-OBA print match is outside the scope of the communication. If the customer specifies the substrate color and expects the proof-to-OBA print match, proofing to SCCA is required.

**PRINTING CERTIFICATION SCHEMES**

Continuing along the path to “connecting the dots” in the printing industry, the relationship among printing standards, certification schemes and conformity assessment has been ambiguous to many experts in the ISO TC130 community, as well as to printing industry practitioners. This article will demystify these terms and make sense of our paths forward.

As depicted in the top section of Figure 6, certification is needed throughout the printing industry. As stated earlier, print buyers consider certified printers that can achieve color predictably and repeatedly to be trustworthy.

<table>
<thead>
<tr>
<th>Print Buyers Predictable Color</th>
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<tr>
<td>Printers Repeatable Color</td>
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**Table 1** summarizes the differences in the applicable standards, press calibration, and operating procedures, which enable color repeatability from press to press and from time to time.

A certification scheme is a set of requirements defined by a scheme owner. ISO states that certification schemes are outside its scope and that those choices should be made by the market. There are differences in scope and in technical rigor among certification schemes such as G7, PSO (Process Standard Offset) and PSA (Printing Standards Audit).

- G7 is a press-calibration method and qualification scheme developed by IDEAlliance in 2006. More than 900 printing companies worldwide are G7-qualified. It involves sample submission, which is assessed per G7 pass/fail criteria. There is no onsite audit of the product workflow and no production variation assessment.

- PSO is a certification scheme developed by Fogra and the German Printing and Media Industries Federation (bvdm) in 2004. More than 400 printing companies worldwide are PSO-certified. PSO involves a press run during an onsite audit in which approved sheets and production samples are assessed according to ISO 12647-2 for offset and ISO 12647-7 for proofing.

- PSA, a certification scheme developed by RIT, has been available since September. PSA involves a press run during an onsite audit in which approved sheets and production samples are assessed according to a specified RPC in ISO 15339-1 and tolerances in ANSI/CGATS TR 016.

The first PSA certified printer, Hung Hing Printing (China) Co Ltd, is located in Shenzhen, China. Because Hung Hing is a G7 Master Printer, IDEAlliance will award Hung Hing Printing the world’s first certification as a “G7 GRACoL Certified Printer” based on its recognition of RIT’s audit results.
substrate color and conformity requirements between PSO and PSA. PSO certifies a printer’s ability to conform to process control aims and tolerances, while PSA certifies a printer’s ability to conform to substrate-corrected dataset aims and tolerances. Ultimately, the difference is about addressing the printer’s need and satisfying the print buyer’s color printing requirements.

RIT has developed two certification schemes: PSA Certified and PSA with Honors. PSA Certified focuses on technical compliance in tone and color reproduction quality as defined by ISO/DIS 15339-1, and PSA with Honors focuses on sustained performance through the support of a quality management system to be defined by ISO 16761. Graphic technology—Conformance assessment and management system requirements for color reproduction quality.

**TECHNICAL STANDARDS AND CONFORMITY ASSESSMENT STANDARDS**

ISO/IEC Directives, part 2, has strict rules about how standards should be written. First, a standard must adhere to the neutrality principle so that “conformity can be assessed by a manufacturer or supplier (first party), a user or purchaser (second party) or an independent body (third party).”

ISO also states that a certifiable standard must contain requirements that can be implemented and that the level of implementation must be assessed by a third party. In addition, technical standards must be silent on conformity assessment matters. The separation between technical standards and conformity assessment standards is depicted in the bottom section of Figure 6. For example, TC130/WG3 is responsible for developing technical standards and TC130/WG13 is responsible for developing conformity assessment requirements.

**CONCLUSION**

Connecting the dots involves creating new paradigms to solve new problems. An immediate challenge is to meet the printer’s process control needs and the print buyer’s product conformance needs at the same time.

The print buyer is the key driver for printing certification. When operating on ISO 15339-1-compliant workflows, a certified printer benefits from having aims and tolerances that are quantitative, measurable and achievable over a range of substrate color. This in turn helps build trust and enables color repeatability and predictability.

When seeking certification, the printer needs to think about where his customers are and what their requirements are, decide on a certification scheme and contact the certification body, find out if the in-house operating procedures are in line with the applicable standards, conduct internal studies, identify technical gaps and close these gaps through teamwork and training, and participate in the onsite audit, achieve certification and celebrate the success.

**REFERENCES**


ISO 3664 (2009) Graphic technology and photography – Viewing conditions

ISO 13655 (2009) Graphic technology – Spectral measurement and colorimetric computation for graphic arts images

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<table>
<thead>
<tr>
<th>Scheme</th>
<th>PSO</th>
<th>PSA</th>
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<tbody>
<tr>
<td>Applicable standards</td>
<td>ISO 12647-2&lt;br&gt;ISO 12647-7&lt;br&gt;ISO 2846</td>
<td>ISO/DIS 15339-1&lt;br&gt;ANSI/CGATS TR 016&lt;br&gt;ISO/TS 10128</td>
</tr>
<tr>
<td>Calibration &amp; control</td>
<td>TVI adjustment</td>
<td>Printer’s choice (TVI, gray balance, device link)</td>
</tr>
<tr>
<td>White point</td>
<td>Proofing and printing substrates adhere to specified aims</td>
<td>Proofing and printing aims are adjusted based on the white point of the substrate being printed</td>
</tr>
<tr>
<td>Printing conformance requirements</td>
<td>4 solids ($\Delta E_{ab}$), 4 midtone TVIs, 1 midtone spread</td>
<td>Dataset ($\Delta E_{00}$), 4 solids ($\Delta E_{00}$), 4 midtone ($\Delta E_{00}$), 1 midtone triplet ($\Delta E_{00}$)</td>
</tr>
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Table 1. A comparison between PSO and PSA certification scheme