Digital Color Process Control in the Graphic Arts

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Abstract

This paper provides an overview to the world-wide accredited standards development program that has resulted in providing the fundamental tools needed by the graphic arts industry for *open* digital color process control.

Introduction

Start at the beginning, and end at the end. That is the fundamental imperative of process control. Printing is a process (Figure 1).

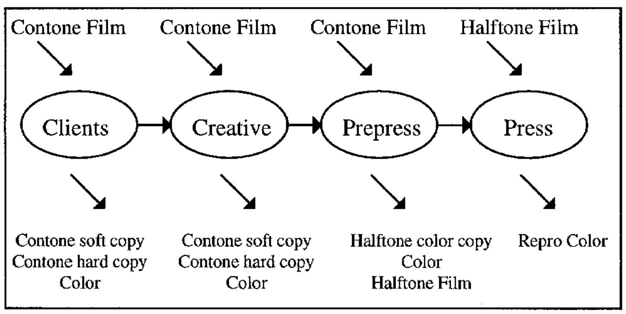

Figure 1. Digital Color Control Process Flow in an Open Environment

It is a custom manufacturing process that begins with concept creation (e.g., pre-prototyping), proceeds through prepress (e.g., prototyping), and through to printing (e.g., reproduction or manufacturing). It is classified as a "custom" manufacturing process because each page is different from all of the other pages reproduced. This process is also characterized by comparatively rapid turn-around-times and a fairly high degree of customer required iteration throughout the process. In addition it is common to have several different companies—with quite a mix of technological components—all involved with the pre-prototyping, prototyping, and manufacture of any one given printed page.

Given all of these variables, how does one achieve the critical requirement for an exacting degree of digital color process control? (*Note*: An exacting degree of digital color process control within the graphic arts is necessary because achieving this is a significant part of what the customer pays for.)

Start at the beginning, and end at the end. How is this done? Approximately 92% of the color imagery that appears in print was first captured on some sort of continuous tone color film. Obviously one might assume from this that film is a logical start point for digital color process control in the graphic arts. The logical end point is, of course, print itself.

However, computers—being what they are—need numbers, or values, in order to provide *digital* color process control. And, of course, the more precise the numbers are the more effective the resulting process control.

The graphic arts industry has accomplished this definition in the form of a series of accredited national and international standards that serve as the technical underpinnings for open process digital color control. *(Figure 2).*

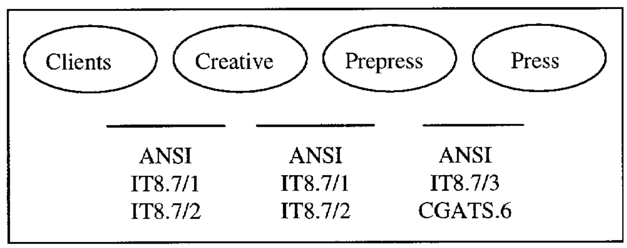

Figure 2. Accredited Standards for Open Process Digital Color Control

In providing open process digital color control we start at the beginning of our process either continuous tone color transparencies or print film. We want to then control this color throughout our digital process. Computers, of course, use numbers. So the first question to be addressed and answered is:

What are all of the colors that can appear on all of the respective continuous tone (contone) films that are used in the process?

A color scientist would ask this question a little differently. They would ask what colorimetric values comprise the various color gamuts of the respective contone films.

Until recently we, as an industry, did not know the answer to that question. We do today.

This new knowledge is embodied in a suite of accredited standards that are collectively known as the standard color tool kit.

It was ascertained that the most logical method of achieving true device independent color would be to develop and use colorimetric targets for both the widely used input materials (i.e., color transparency and reflection films) as well as the target final output conditions.

It was acknowledged that both the red, green, blue (RGB) and cyan, magenta, yellow, and black (CMYK) color spaces are basically device dependent color spaces—that is, the characterization and representation of these two color spaces are highly dependent upon the capabilities of the respective devices employed in the manufacturing process.

Therefore, the work involved with the development of the accredited standards tool kit—undertaken by the American National Standards Institute's Imaging Technology Committee 8 (i.e., IT8) and the ANSI Committee for Graphic Arts Technologies Standards (CGATS)—is based on the colorimetric color space defined by the Commission International De L'Eclairage (CIE).[1]

The basic work of CIE defines a color space system which is inherently "device independent" as it defines colors based on human perception rather than on the nature, or characteristic, of various electro-mechanical devices.

The underlying work of the ANSI IT8 and ANSI CGATS committees—U.S.A.'s subset of the ISO/TC130 committee—is based in CIE XYZ. This was done in recognition of the variety of different devices employed within the graphic arts process. CIE L*a*b* and CIE LUV are two uniform color space definitions which evolved out of the CIE XYZ non-uniform color space. CIE LUV is well suited to, and is often used, in conjunction with color monitors. CIE L*a*b* is suited to, and is often used, in conjunction with a variety of output devices. Both CIE LUV and CIE L*a*b* (as well as the innumerable number of their respective permutations) can be calculated into and out of CIE XYZ.

Thus the arguments over standardizing on either CIE LUV or CIE L*a*b* are rendered somewhat irrelevant.

The Mechanics of Characterizing Color Input Data

The ANSI IT8 committee began the development of providing tools to characterize and calibrate color input data by defining the characteristics of a standard input target for color transparency materials.

The group started with color transparency, or transmissive, materials because the results of a survey that it conducted revealed about 75% to 80% of all color data handled in the graphic arts industry started out as—or was input from—color transparency materials. The group subsequently moved to defining the colorimetric values for reflective, or print, film.

The technical specification for the standard color transmission (i.e., transparency) target is contained in the ANSI IT8.7/1 standard.[2]

The technical specification for the standard color reflection target is contained in the ANSI IT8.7/2 standard.[3] These standards have been implemented on 35mm and 4 × 5 inch transparency films and 5 × 7 inch print film, by Fuji Photo Film, Eastman Kodak, and Agfa.

A schematic diagram, which shows the basic characteristics of the 4 × 5 inch standard transmission input target is shown in Figure 3.

The manufacture of these targets requires a very precise process owing to the nature of the color information presented:

The complete color gamut of each respective film is represented in regions A and B. The pure yellow, magenta, cyan, and neutral dyes of the respective films are presented in region C. The material specific dye pair scales (i.e., red, green, blue) are presented in region D. Columns 20, 21, and 22 (i.e., region E) are available for the respective target vendors to include whatever material they wish to include. Both the Fuji Photo Film and Agfa targets include a variety of patches within these columns. The Kodak target contains a small image as well as color patches in these three columns.

Colorimetric data on these various targets were then defined through a series of controlled measurements.

Thus the industry now has characterized data, colorimetrically defined by the color gamut characteristics, of the various input film materials.

This provides the underlying tools that the industry needs to characterize and calibrate color data on input. Step one in achieving true device independent color.

Displaying Calibrated Data

The basic mechanism by which to display color calibrated data on a monitor is defined in the ANSI IT8.7/4 standard.[4]

The basic philosophy of color standards is to use calibrated data to drive the display—rather than to use the display to calibrate the data. This was done in recognition of the fact that using the display device to calibrate the data was an inherently device dependent approach to data calibration.

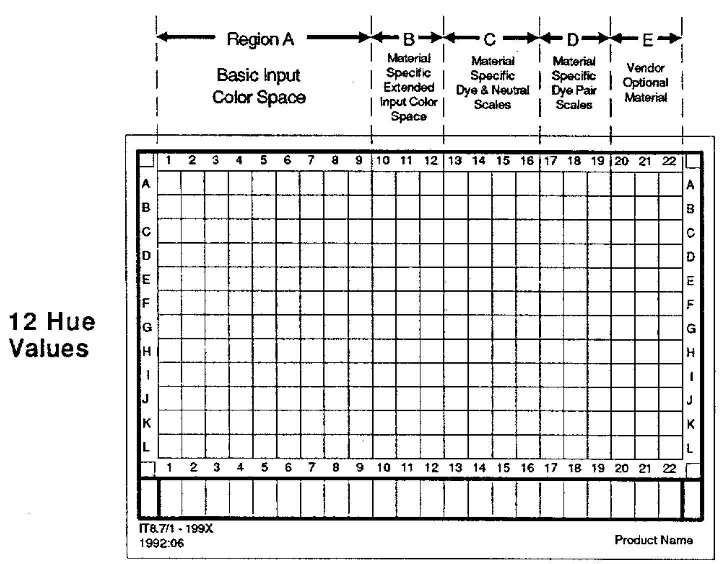

Figure 3. Layout, color transmission input calibration target.

Instead, the standard device independent color approach delivers data to the monitor that was calibrated upon its original input. The monitor is then used, to the best of this device's capability, as a window on the calibrated data.

Calibrating Color Output to Target Print Conditions

The process of developing colorimetric output targets was conceptually similar to that employed with developing the color input targets.

The necessary attributes of such a target was identified and subsequently defined in the ANSI IT8.7/3 standard.[5]

The primary purpose of this standard is to enable a user to define a color characterization data file consisting of CMYK ink values and their associated colorimetric tristimulus values (i.e., CIE XYZ), which can be used to characterize a printing process. A different file may be produced for each process, if necessary. The objective is that every CMYK image will have the appropriate file transmitted with it when sent to another system. In the event that a transformation is required for a different printing process or substrate this file may be used to enable that transformation. It should be noted that for this application, the color conversion need only be from CMYK to XYZ (or a derivative) or CMYK to C'M'Y'K'.

The basic work embodied in the ANSI IT8.7/3 standard has been extended to provide a colorimetric definition for lithographic printing processes specifically for the U.S.A.

This work, which is known as the CGATS[6] standard for "Type 1 Printing" evolved through the combined efforts of SWOP, Inc.—the industry group responsible for the development of Specifications for Web Offset Publications (SWOP)[6]—the ANSI IT8 committee, and the ANSI CGATS committee.

Today, this standard colorimetric definition for target U.S.A. printing conditions is defined in the CGATS.6 standard.[7]

Specific target printing conditions standards are being developed for both the Japanese and European printing communities which are also based on the colorimetric characterization work initiated by the ANSI IT8 committee.

True Device Independent Color

Taken together, these various standards provide a tool kit for implementors who are interested in developing responsive mechanisms for industry's need to have true device independent color.

Footnotes

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   a, *Colorimetric Observers*, standard CIE S 002, publication no. CIE S 002, 1986
   b, *Colorimetric Illuminations*, standard CIE S 001, publication no. CIE S 001, 1986.
2. American National Standards Institute (ANSI), ANSI standard IT8.7/1 1993, Graphic Technology, *Color Transmission Target for Input Scanner Calibration*, ASC/IT8/SC4 N 092.
3. American National Standards Institute (ANSI), ANSI standard IT8.7/2 1993, Graphic Technology, *Color Reflection Target for Input Scanner Calibration*, ASC/IT8/SC4 N093.
4. American National Standards Institute (ANSI), ANSI standard IT8.7/4 1993, Graphic Technology, *Default Three Component Color Data Definition*, IT8/SC4 N 079.
5. American National Standards Institute (ANSI), ANSI standard IT8.7/3 1993, Graphic Technology, *Input data for characterization of 4-color process printing*, IT8/SC4 N 094.
6. SWOP, Inc., Specifications for Web Offset Publications (SWOP), 1993 edition.
7. American National Standards Institute (ANSI), ANSI standard CGATS.6, *Graphics Technology Specifications for graphic arts printing - Type 1*, CGATS/WG4 N 052.

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5. *Spectrometric Colorimetry of Various RIP Testing Output,* published by DTI's Color Lab, October 1992.
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