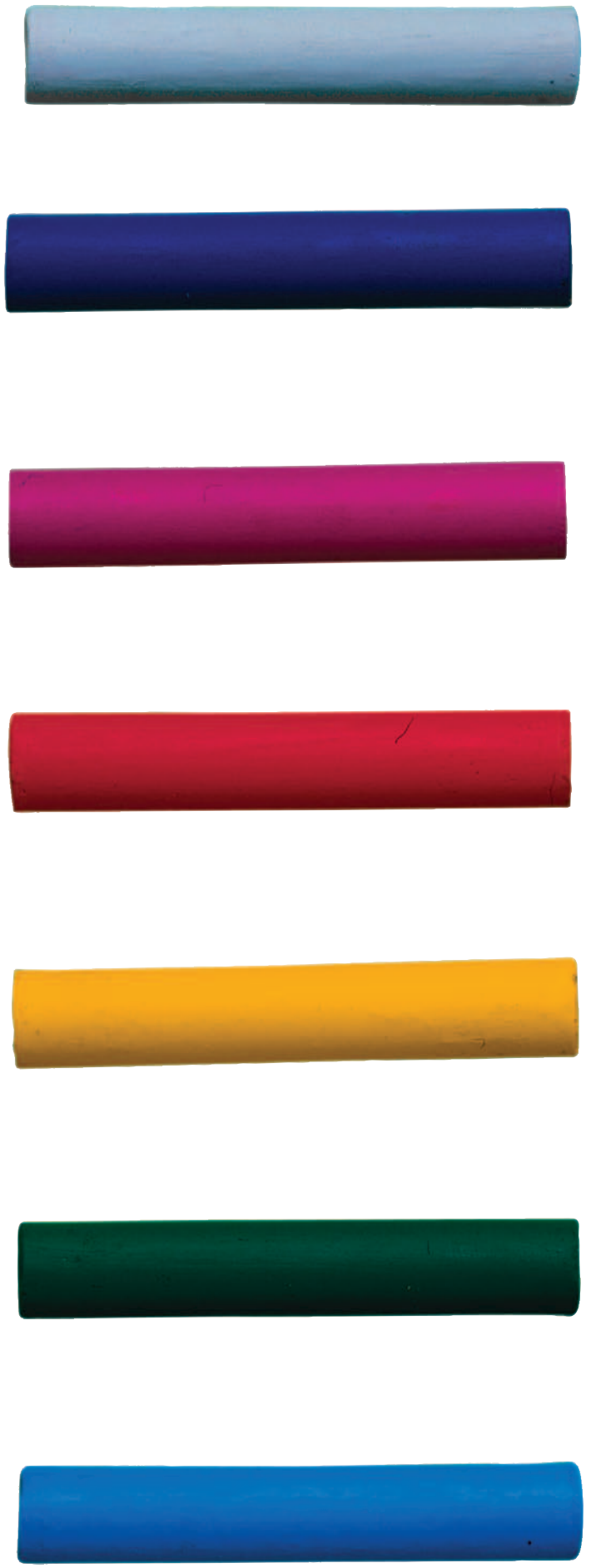

Color Management: What's New from the ICC?

by David McDowell, NPES/Eastman Kodak

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The ICC profile definition specification is currently undergoing a major revision. Once approved, the new version of the specification will be available for free download from the ICC Web site (www.color.org). This should be available early in 2002.

In spite of all that has been written about color management, there still seems to be a lot of confusion about the International Color Consortium (or the ICC as it is more familiarly known), its responsibilities, goals, accomplishments, and specifications.

We will come back to this new version of the ICC profile definition specification later, but let's first look at the ICC, its current status, and some of the issues with which they are currently struggling as they move forward. Although the ICC is neither a national- nor an international-accredited standard activity, but rather an industry consortium, it is nonetheless a key part of the larger standards effort within the imaging community.

What Is the ICC?

The ICC, formed in 1993, had eight founding members. These were Adobe Systems Inc.; Agfa-Gevaert N.V.; Apple Computer, Inc.; Eastman Kodak Company; FOGRA-Institute; Microsoft Corporation; Silicon Graphics, Inc.; and Sun Microsystems, Inc. The membership has now grown to include over 70 companies and/or organizations.

The scope or purpose of the ICC: To create, promote, and encourage an open, vendor-neutral, cross-platform color-management system architecture and components. Results of the ICC shall be made available to the public and shall be submitted to the appropriate international standards organizations.

The current ICC product is its specification for the format for color profile data. The official title of the current version is Specification ICC.1:XXXX File Format for Color Profiles. It will soon be joined by additional specifications covering other color-management issues. However, the larger contribution of the ICC to the imaging community is the color-management architecture into which these profiles fit and its role as the forum through which the ongoing refinement and extension of an open color-management architecture can take place.

Who Is the ICC?

The leadership of the ICC is elected annually from within the membership. The current Chair is Lars Borg of Adobe and the Vice-Chair is Uwe Krabbenhoeft of Heidelberg. The work of the ICC is managed by a Steering Committee made up of the representatives of the founding members and representatives of seven additional company members elected annually. For 2001, these were Sony, Polaroid, Heidelberg, Hewlett Packard, Canon, Harlequin, R. R. Donnelley, and Xerox. (Members of the 2002 Steering Committee are currently being nominated and elected.)

In addition, the ICC has a series of working groups focused on specific areas. The current Working Groups are Specification Editing, Graphic Arts Special Interest, Architecture, Workflow, CMM Chromatic Adaptation, and Communications.

Application for membership in the ICC is open to any company or individual. There is a nominal annual fee involved to allow the ICC to be independent of any outside group or influence.

Administrative support is provided through an administrative secretary, Kip Smythe of NPES, and a technical secretary, Tony Johnson of the London College of Printing. Tony, who is familiar to many in the graphic arts, was appointed as the ICC technical secretary at the beginning of 2001.

What Is ICC Color Management?

For those not familiar with the ICC architecture, a brief description is in order. Normally, to convert values obtained from an input device—such as RGB from a scanner—into the device code values needed by an output (rendering) device—such as a CMYK printer—a transform is needed to appropriately modify the data. As input and/or output devices are added, such a transform is needed between every new pair of devices—this gives n^2 transforms if we require a transform from every device to every other device. These transforms are based on up to three components:

1. Characterization data for the individual devices (the relationship between device code values and the color—defined by an internationally accepted measurement procedure—either input to or produced by the device);
2. The gamut adjustments necessary to accomplish the desired appearance match between input and output; and
3. Any conversions (separations) between the working space of the input device and the output device.

The change in perspective introduced by the ICC was the concept that if transforms were provided between each input or output device and an intermediate or reference color space, then to move data between devices one would simply need to combine the appropriate transforms. Using this scheme, only one set of transforms would be required per device, and adding a device would only require the addition of one transform or a total of n transforms or sets of transforms versus the n^2 required without a reference space. We say sets of transforms because the ICC has made provision for three different types of transforms, called "rendering intents," which provide for different types of mapping of color into the available device gamut. These are colorimetric, perceptual, and saturation and allow the profile users to select the type of transform appropriate to their imaging application. Colorimetric transforms are typically used in proofing, perceptual transforms in cross-media reproduction where gamut mapping is an issue (e.g., transparency to print and display to print), and saturation in reproducing business graphics where it is important to keep bright, vivid colors.

The name given to this intermediate color space is "Profile Connection Space" (PCS), and the carrier for the transforms is called a profile. The computational engine that combines these profiles and then processes image data through the associated transforms is called the Color Management Module (CMM).

Simply put, the profile vendors use the device characterization data and their color science/reproduction knowledge to build the appropriate transforms between the device and PCS. The intelligence is in the profiles. The CMM is simply a processing engine that is typically built into an operating

system, application, or output device (and, therefore, provided by different vendors), and the color image that results should be independent of the CMM used.

The Profile Specification is currently undergoing a revision, which both clarifies existing features and adds new features. We will get to those shortly. However, there remain a number of issues—particularly for some workflows—that will require further refinement. Thus, the ICC also has several working groups looking at various remaining issues. Two of these are of particular significance to the future of the ICC and to the utilization of color management within the graphic arts industry. These are the Architecture and Workflow Working Groups and the Graphic Arts Special Interest Group (GASIG).

Some Working Groups

Architecture and Workflow Working Groups

The present ICC architecture was designed by the initial charter members and represents their best thinking based on the workflows they perceived at the time the ICC was created. However, a number of ICC members have identified a need to look at the architecture in the context of the workflows being commonly used, to see whether that would allow color management to be more transparent to the user and/or better suited to their needs—depending on the type of user.

The specification and architecture the ICC has defined ensure a portability of color images that was not achievable prior to its publication of the first edition of the profile specification.

An alternative architecture that has been studied by the ICC has sometimes been referred to as an "intelligent CMM" or pipeline approach. Rather than simply combining the transforms provided within profiles, this new architecture would use specially prepared characterization data and both color-appearance and gamut-mapping models to dynamically create the optimum transform between devices and then process the image data through this transform. However, such a change—while having theoretical benefits—may not meet the main needs of users and may make some of the problems they see worse in the short term as bugs get ironed out.

So, it was decided that in parallel to looking at new architectures, the ICC should also find out what users need so that any new architecture proposals can be evaluated against what they perceive as problems with the current architecture. User surveys have been carried out in Europe and the United States to understand the problems that users identified working with the existing system. Following this, it has become apparent that different problems arise in different workflows, and so the ICC is now identifying the requirements of these workflows as a model against which to test any architecture and the way it is implemented. By constantly challenging the current models from within, the ICC should be a stronger, more forward-looking organization.

The ICC is always looking for user feedback and anyone who wishes to submit problems they feel are due to the use of the current ICC color management architecture is invited to send them to Tony Johnson at tony@colouruk.demon.co.uk.

Graphic Arts Special Interest Group (GASIG)

The GASIG was created to allow those members of the ICC that had significant involvement with the printing and publishing industry to work together to ensure that the ICC architecture and implementation scheme meets the needs of that industry.

A key focus for current discussions is the question of mechanisms to allow the sender or generator of data to also define the preferred output. Within the present ICC Architecture, the input profile is typically associated with the input image data. However, the choice of output profile is typically left to the recipient of the data who will have knowledge of the output device and the desired reproduction. Within the ICC architecture, it was expected that the output device should render the original image as faithfully as possible as allowed by its capabilities (color gamut).

Unfortunately, this is not the workflow used by a large segment of the printing and publishing industry. In this industry, the preparer of the image data—the sender—anticipates (specifies) a particular reproduction capability and prepares a proof that is used to secure customer approval. The receiver of the data is expected to reproduce the image data to provide the best match to the proof prepared by the sender and used to get customer approval. This requires knowledge of selections made by the initial preparer of the data.

Currently, the graphic arts accomplish this by sending CMYK data. However, sending CMYK data defeats much of the flexibility that color management is intended to provide and eliminates many of the possibilities for repurposing (adjusting the image data for optimum rendering on an output device that has a different color gamut) or retargeting (adjusting the image data for optimum rendering on a different output device that has the same gamut) of the image data.

One possibility is to simply send along the output profile used to render the image for customer approval. However, this runs counter to the goal of an open color-managed data flow. Looking at the perceptual transform of an output profile typically used for graphic arts reproduction suggests it includes three separate functions—gamut mapping, tone-scale mapping (often considered part of gamut mapping), and color separation including black printer generation.

At the last meeting of the ICC, a key part of the GASIG discussions focused on alternate ways that this information could be conveyed with the image, yet still retain independence from the output device.

A number of options are being studied by the ICC. The GASIG (and the ICC as a whole) is committed to finding ways to meet the needs of both the graphic arts and other application areas within the ICC framework.

Future Work

In some ways, the ICC has largely met its initial objective. The specification and architecture they have defined has ensured a portability of color images that was not achievable prior to its publication of the first edition of the profile specification. However, as the preceding discussion shows, refinement of the ICC architecture—particularly for specific workflows—is still desirable and necessary. It represents a fundamental aspect of the current discussions within the consortium.

Thus, the decisions made over the next few years should be of great significance to any group that finds that the current system is too limiting in some way. To ensure that all views are fully represented within the discussions, it is important that the consortium has as wide a membership as possible. For details, contact Kip Smythe.

So What's New?

As we said earlier, the ICC specification has recently undergone a major revision. The main driving force behind this revision has been to improve interoperability. Certain ambiguities in the previous versions of the specification have permitted ICC-compliant profiles to be produced that were interpreted slightly different when used with different CMMs. This meant that different CMMs could produce slightly different results to each other, even when using the same pair of profiles. Much of this comes from the way different profile builders have interpreted the way some of the data are specified and what the PCS reference really is. This means that profiles could be built that work well with their CMM—or when both input and output profile come from the same vendor—but not when profiles are used with those from other vendors, used with other CMMs.

Although for many applications these problems were often small enough not to be an issue, there are other situations where high levels of consistency are particularly important. It was therefore necessary for the ICC to identify the major areas where ambiguities could permit poor interoperability and attempt to resolve those in the specification.

Before summarizing the main amendments to the specification, it is important to put these in context. The changes are designed to ensure that any ICC-compliant profile is interpreted unambiguously by any ICC-compliant CMM, and that different CMMs processing the same pair of profiles to produce a color transformation provide a similar transformation.

This has been attained by removing ambiguities from the specification, rather than by imposing specific additional requirements on profile building or CMM developers. Thus, it certainly does not mean that all profiles built for a specific device will be identical.

There is still the need in many markets for profile-building vendors to be able to differentiate their products and for users to select those products that best suit their needs. There is still no "one size fits all" in color reproduction, and the ICC has not attempted to impose one. However, what it does mean is that when a user's preferred profiles are used, they should be treated consistently, and when pairs of profiles are used, they should produce the same result—regardless of which CMM is used. There is still a small risk that different CMMs could produce small differences due to differing interpolation procedures, but the more major errors of interpretation have been removed.

Thus, users will still need to select and build profiles that suit their reproduction needs—and ensure that they process the individual images to give their preferred reproduction within the context of those profiles. How this is done will be workflow dependent. The ICC is not proposing specific workflows and control procedures—that is the responsibility of the user and/or specific industry standardization groups to recommend.

What we do believe is that this version of the ICC specification provides users with the correct tools for communicating the color rendering associated with devices to implement in their workflows.

This does not mean that the ICC sees its work as complete. The subject of color reproduction is not a trivial one, and there are important issues still to address. Many users would like to see the ICC ensure conformance of profiles and CMMs to the specification. Others have workflow needs that cannot easily be met with the existing architecture. In order to address

these issues, the ICC is working on developing procedures for conformance testing and also producing recommended workflows to achieve desired results using ICC profiles conforming to the existing specification. An Architecture Working Group is considering what fundamental changes are needed to a future specification to meet ever more complex workflows.

We can summarize the state of the art with this new specification as ensuring improved consistency when using ICC profiles. The system still retains the flexibility to let users produce profiles that best suit their requirements—they can choose when to trade off ease-of-use when building profiles against their individual needs. They can achieve this either by evaluating the various profile-building software packages available and selecting that which produces the best results for them or by editing profiles to produce what they require. But because of the improved consistency, once a profile has been selected, its performance in use should be highly predictable.

Summary of the Main Changes

- For perceptual rendering, the dynamic range of the PCS and the assumed level of illumination for viewing has been identified. These attributes were not identified in previous versions of the specification, and this led to ambiguities when specifying gamut mapping that resulted in white and black being misinterpreted and tone reproduction "errors."

- Chromatic adaptation information is now required. When data are intended for viewing in illumination conditions other than those specified by ISO 3664 (i.e., D50) the transformation required for correction of the data must be specified. A procedure that specifies how the CMM should handle this transformation (depending on the chromatic adaptation condition assumed for the various profiles being processed) is now specified. This change is particularly important for color monitor profiles (which rarely assume a D50 chromatic adaptation state), but can have applications elsewhere (e.g., where prints or transparencies are expected to be viewed in nonstandard conditions).

- Where profiles involve more than the usual four (CMYK) colorants, it is now required that the color of the additional colorants be specified by their XYZ or L*a*b* coordinates. The sequence of printing may also be specified. This helps to avoid ambiguities when building profiles for such processes.

- New look-up table (LUT) specifications have been provided that overcome some issues of invertibility of the previous LUTs—as well as offer some other benefits of profile management by having a similar structure for all types of profiles. Another specification change enables a simpler specification of 1-d LUTs for typical display devices.

- Various clarifications have been introduced into the document covering such issues as rendering intents, the definition of the tags for three-component devices, the content and structure of monochrome profiles, the relationship between PCS XYZ and PCS L*a*b*, and how to handle colors that can be represented in one and not the other.

- Various new procedures have been specified to avoid confusion when using profiles such as improved naming and dating procedures, and to permit profiles containing multiple rendering intents to be specified for input and display devices as they currently are for output profiles.

More Info?

Further information about the ICC is available at the ICC Web site (www.color.org) or from either Kip Smythe at ksmythe@npes.org or Tony Johnson at tony@colouruk.demon.co.uk.