The reasons for changing to the v4 ICC profile format.

Advantages

The v4 profile format has introduced a number of changes when compared to the v2 specification previously published. These changes provide a number of advantages, the most significant of which follow from the removal of ambiguities from the specification and a more precise definition of the PCS. **These lead to an improved predictability of performance of a profile in use which will lead to a reduction of major differences of interpretation. Therefore, when pairs of profiles are used they should always produce the same result – regardless of which CMM is used.**

The specific improvements made to the specification are summarised below:

- ***The definition of rendering intents has been made more precise to reduce ambiguities:***
  - ***The relative colorimetric rendering intent is now defined as measurement based and the media white point specification has been improved***. In v2 profile builders were allowed to modify measurement data prior to building the relative colorimetric tables for a profile. This sometimes led to differences in the way in which colorimetric data could be interpreted when a colorimetric match is required. By specifying that the data for colorimetric rendering is measurement based the colorimetric rendering intents are more clearly defined. The improved media white point specification ensures less ambiguity when calculating the absolute colorimetric rendering tables.
  - ***For perceptual rendering the dynamic range of the PCS, and the assumed level of illumination for viewing has been specified.*** 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 and the Bradford transform has been recommended as the default.*** When data is derived from, or 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 chromatic adaptation transformation should be included in the overall colour transformation (depending on the chromatic adaptation condition assumed for the various profiles being processed) is now specified. This change is particularly important for colour monitor profiles, which often do not assume a D50 chromatic adaptation state, but can have applications elsewhere (e.g. where prints or transparencies are expected to be viewed in non-standard conditions). An important consequence of this clarification is that Version 4 profiles for RGB displays and working spaces should only contain D50 tristimulus values in the media white point tag indicating the transformation to the PCS white point.
- ***Where profiles involve more than the usual 4 (CMYK) colorants it is now required that the colour of the additional colorants be specified by their XYZ or L*a*b* co-ordinates.*** 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 offering some other benefits of profile management by having a similar structure for all types of profiles. Another specification enables a simpler specification of 1-d LUTs for typical display devices.
- ***Various clarifications have been introduced into the document covering such issues as 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 colours 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.***

Background

The v2 ICC profile format specification has been widely adopted by the colour imaging community and proved very important in achieving and maintaining colour fidelity of images. However, despite its successful usage in many situations this widespread use has also identified ways in which it can be even further improved. That was the main driving force behind the v4 revision of the specification (dated December 2001) - in particular ways to improve interoperability. Certain ambiguities in the previous versions of the specification have occasionally permitted producers of profiles to misinterpret the reference colour space and also the information they need to provide in the profile. Thus profiles could be produced that were inconsistent with those produced by other vendors and when two such profiles are used together can give rise to unexpected results. Furthermore, these ambiguities permitted ICC compliant profiles to be produced that were interpreted slightly differently when used with different Colour Management Modules (CMMs). This meant that different CMMs could produce slightly different results to each other, even when using the same pair of profiles.

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 ICC to identify the major areas where ambiguities could permit poor interoperability and attempt to resolve those in the specification.

To understand the reasons for the main amendments to the specification it is helpful to put these in context. The changes are designed to ensure that profile builders understand the reference colour space precisely, and exactly what is required of the profile. They also ensure that CMM producers are able to provide CMMs that 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 colour transformation provide a similar transformation. This improvement has largely been attained by removing ambiguities from the specification, rather than by imposing specific additional requirements on profile building or CMM developers – though there are some additional mandatory requirements.

Thus this revision 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 colour reproduction and 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 produced in such a way that they are made to a common reference so that when combined with other profiles any results are predictable. It also means that when pairs of profiles are used they should always 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. ICC is not proposing specific workflows and control procedures – that is the responsibility of the user and/or specific industry standardisation groups to recommend. However, within that context this version of the ICC

specification provides users with the best tool for communicating the colour rendering associated with devices to implement in their workflows.

Thus we can summarise 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.