International Color Consortium®

White Paper #26

Level: Intermediate

Using the *sRGB_v4_ICC_preference.icc* profile

Introduction

The sRGB v4 ICC preference profile is a v4 replacement for commonly used sRGB v2 profiles. It gives better results in workflows that implement the ICC v4 specification. It is intended to be used in combination with other ICC v4 profiles.

The advantages of the new profile are:

1. More pleasing results for most images when combined with any correctly-constructed v4 output profile using the perceptual rendering intent.
2. More consistently correct results among different CMMs using the ICC-absolute colorimetric rendering intent.
3. Higher color accuracy using the media-relative colorimetric intent.

General recommendations

In workflows where only v4 ICC profiles are used,

- The ICC-absolute colorimetric rendering intent should be used when the goal is to maintain the colors of the original on the reproduction,

- The media-relative colorimetric intent should be used when the goal is to map the source medium white to the destination medium,

- The perceptual intent should be used when the goal is to re-optimize the source colors to produce a pleasing reproduction on the reproduction medium while essentially maintaining the “look” of the source image. The perceptual intent will not enhance or correct images.

CMMs may offer additional functions and rendering intents, such as:

- Black Point Compensation (BPC), where the source medium black point is mapped to the destination medium black point using CIE XYZ scaling.

- Partial or no chromatic adaptation instead of complete adaptation.

Differences between the sRGB_v4_ICC_preference profile and v2 sRGB profiles

The sRGB v4 profile is different from commonly used sRGB v2 ICC profiles in three fundamental ways:

1. The ICC-absolute and media-relative colorimetric rendering intent transforms are not black point scaled.

2. The ICC-absolute colorimetric transforms are correct implementations of the ICC v4 specification, which has been defined in a narrower way than the ICC v2 specification and assumes the viewer is fully adapted to the display white point.

3. The perceptual rendering intent transforms use the v4 Perceptual Reference Medium (PRM) assuming the Perceptual Reference Medium Gamut (PRMG).

These differences will produce different results when the v4 sRGB profile is used, as compared to commonly used v2 sRGB profiles.

NOTE: The PRM is defined in all ICC profile format specifications starting with ICC.1 2001-12 and in ISO 15076-1. The PRMG is defined in the approved amendment to the ICC v4 specification, and will be incorporated in ISO 15076-1 Edition 2.

ICC-absolute colorimetric rendering intent

ICC v2 sRGB profiles can be grouped into five different types depending on the nature of the ICC-absolute colorimetric rendering intent:

1. Those that assume full adaptation to the display white point and do not include BPC.

2. Those that assume full adaptation to the display white point and include BPC.

3. Those that assume partial or no adaptation to the display white point and do not include BPC.

4. Those that assume partial or no adaptation to the display white point and include BPC.

5. Profiles where the RGB to XYZ matrix assumes full adaptation, but the media white point values are un-adapted. Such profiles typically include BPC (but do not have to).

ICC v2 sRGB profiles of types 1 and 2 can be downloaded from:
http://www.color.org/srgbprofiles.html

ICC v2 profiles of types 3 and 4 are uncommon, but can be constructed for special purposes.

Unfortunately, the widely used *sRGB Color Space Profile.icm* (sRGB IEC 61966-2.1) v2 profile is type 5.

The ICC-absolute colorimetric intent of the new ICC v4 profile is comparable to a type 1 sRGB v2 profile. Due to clarifications of the ICC specification type 2, 4 and 5 profiles are not valid as v4 profiles. The additional restrictions are intended to improve accuracy and reduce the variations of results achieved from using the ICC-absolute colorimetric rendering intent with different CMMs. Details are provided below.

Results using the ICC-absolute colorimetric rendering intent of the v4 sRGB profile versus using a v2 sRGB profile

- The results using type 1 v2 sRGB profiles should be the same as when using the v4 sRGB profile. In this case, the only differences will be due to the precision of the profiles. The v4 sRGB profile uses a mathematical function instead of a Look-Up Table.

- The results using type 2 v2 sRGB profiles should be the same as when using the v4 sRGB profile with BPC (but many CMMs don't enable BPC in combination with the ICC-absolute colorimetric rendering intent).

- The results using type 3 v2 sRGB profiles can be achieved using the v4 sRGB profile in combination with a CMM that supports partial or no adaptation (but these are rare).

- The results using type 4 v2 sRGB profiles can be achieved using the v4 sRGB profile in combination with a CMM that supports partial or no adaptation and BPC.

- Type 5 v2 sRGB profiles are internally inconsistent, and will not produce correct results without a case-specific correction applied by the CMM. Some CMMs will fix the profile while others won't. Thus, the absolute colorimetric rendering intent of a type 5 v2 sRGB profile will produce different results depending on the CMM used. CMMs that fix type 5 v2 profiles then often produce incorrect results with type 3 and 4 v2 profiles. Figure 1 shows the errors of the *sRGB Color Space Profile.icm* if a CMM is used that does not apply a correction.

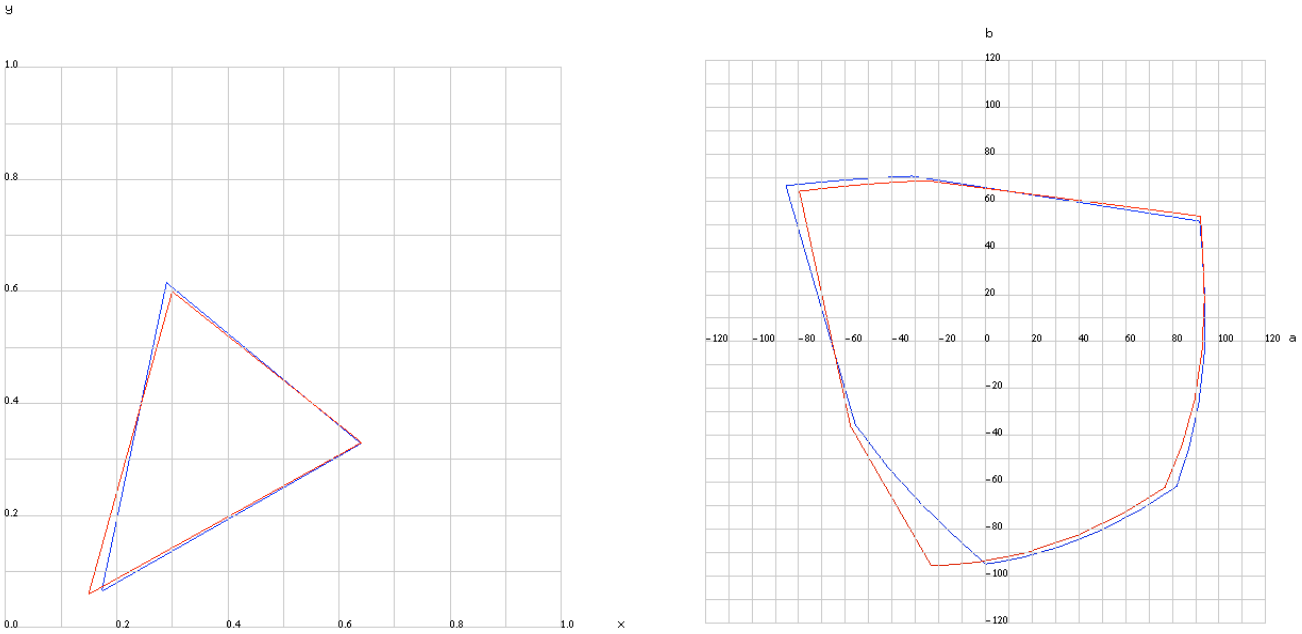

Figure 1: The correct D65 media white point sRGB primaries and gamut boundary (blue) compared to those of the *sRGB Color Space Profile.icm* (red) absolute colorimetric rendering intent. An *x, y* chromaticity diagram is shown on the left, a CIECAM02 a,b diagram is shown on the right.

Media-relative colorimetric rendering intent

Using this rendering intent:

1. The v4 sRGB profile will produce approximately the same results as a type 1 v2 sRGB profile.

2. The v4 sRGB profile should produce the same results as a type 2 or type 5 v2 sRGB profile if the CMM uses the relative colorimetric rendering intent and BPC.

- It is not possible to obtain results equivalent to those obtained with a v4 profile and BPC off using a type 2, 4 or 5 profile. If BPC is undesired, either a v4 sRGB profile or a v2 profile without BPC should be used.

- The only way to produce the same results using the v4 profile as obtained using a v2 profile with BPC included in the profile but with BPC off in the CMM is if the CMM enables BPC to be on for the v4 sRGB profile but off for the other profile. Typically this option is not available. Thus, if this result is desired it may be necessary to use a v2 sRGB profile with BPC included.

- The only way to produce the same results using the v4 profile as obtained using a v2 profile with partial or no adaptation to the display white is to use a CMM that supports partial or no adaptation.

Color re-rendering and the v4 PRM

The third primary difference between v4 ICC profiles and earlier versions is the v4 Perceptual Reference Medium, which is a virtual large gamut reflection print similar to prints obtained using high-quality photo printers and glossy paper. V4 ICC profile perceptual intent transforms *color re-render* to and from the Perceptual Reference Medium in the ICC Profile Connection Space, which is the color space where source and destination ICC profiles connect.

Color re-rendering is the process where colors that are optimized for one medium are transformed to re-optimize them for a different medium. The transforms are designed considering the characteristics of the two different media, such as the dynamic ranges, color gamuts, viewing modes (e.g. monitor and print), and viewing environments. Color re-rendering is not needed when the characteristics of two media are similar, or when the goal is to produce an exact copy of the source medium on the destination medium (i.e. proofing). In the former case the perceptual and media-relative colorimetric transforms will be identical. In the latter case a colorimetric rendering intent should be used.

Good color re-rendering will maintain the artistic intent of the source image, and for the most part the appearance, although some colors will change as is necessary to deal with color gamut and viewing differences. Color re-rendering is to some extent image specific and a matter of personal preference, but it is possible to develop default color re-rendering transforms that produce results that are pleasing to most people when applied to most images. This was the design objective for the perceptual rendering intent of the sRGB v4 profile.

Color re-rendering transforms assume the source image is the intended reproduction for its medium, and will not attempt to correct or enhance a poor image, but will only re-optimize it for the destination medium. It is possible that in some cases a poor image will be slightly improved, but it is also possible that it will be made worse.

A side benefit of using color re-rendering transforms for cross-media conversions is that well-designed transforms like those in this profile tend to produce small errors when inverted. This means they can be undone to enable re-purposing to different media with a small loss of color information (see roundtrip data below).

Perceptual rendering intent

The color re-rendering between sRGB and the PRM found in the *sRGB_v4_ICC_preference.icc* profile is illustrated in Figure 2.

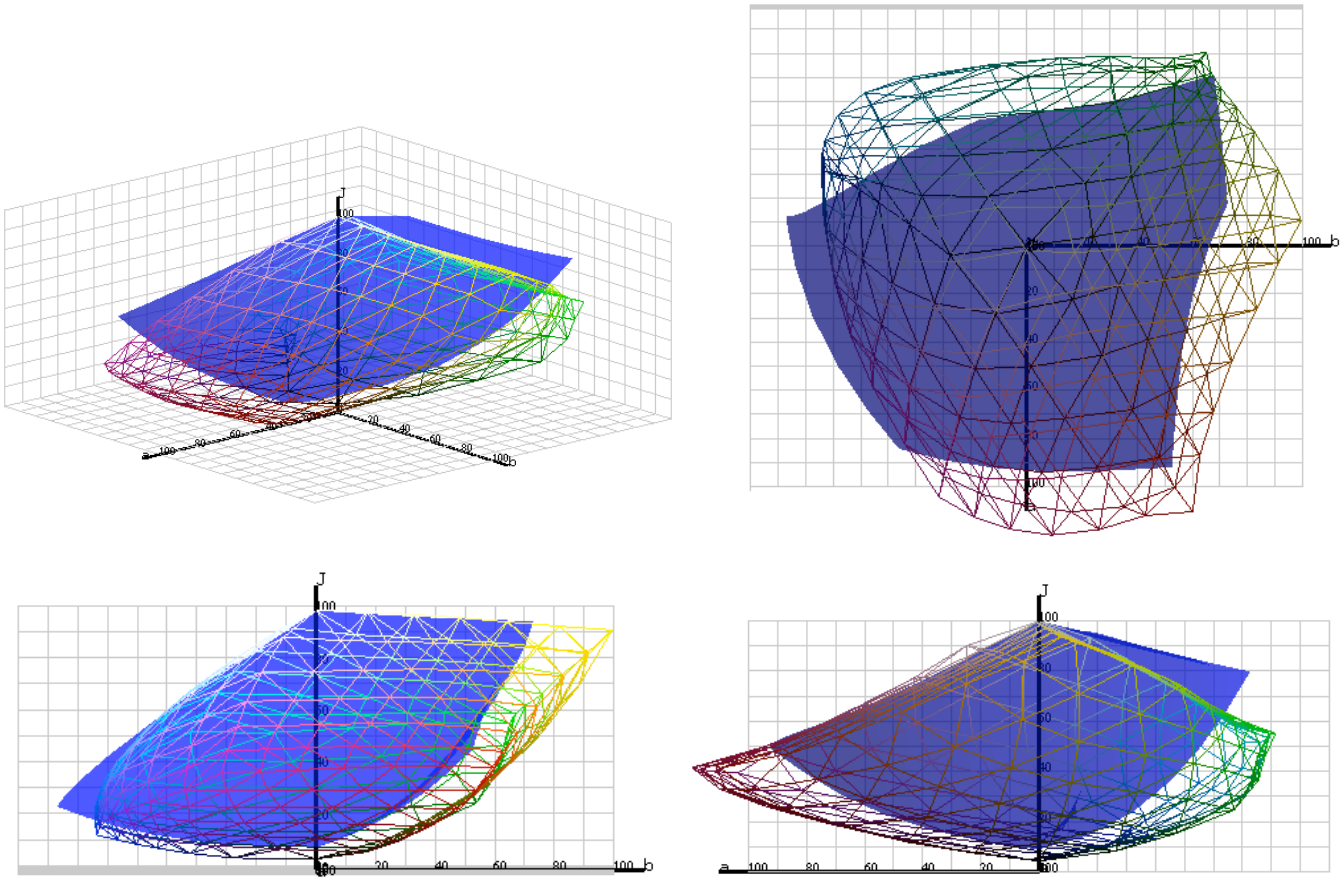

Figure 2: The sRGB color encoding gamut (blue) compared to the sRGB gamut as color re-rendered to the ICC v4 PRM (wireframe). Side view (top left), top view (top right), a-axis view (bottom left), and b-axis view (bottom right); all views are in CIECAM02 Jab color space.

The v4 sRGB ICC preference profile perceptual transforms are bi-directional, providing color re-rendering from sRGB to the PRM when the profile is used as a source profile, and providing color re-rendering from the PRM to sRGB when the profile is used as a destination profile. The round-trip errors are larger than for the colorimetric intents, but are still small:

sRGB -> LAB -> sRGB round trip:

For all 8 bit RGB code values:
Perceptual mean 8-bit RGB code value error, mean ΔRGB = 0.225
Perceptual maximum 8-bit RGB code value error, max ΔRGB = 3.28

LAB -> sRGB -> LAB round trip:

For 1168 color patches that are on a 19x19x19 uniform grid and inside the AtoB0 gamut, the results are:
Perceptual mean ΔE = 0.27
Perceptual maximum ΔE = 4.20

Using the perceptual rendering intent all the primaries and secondaries (Red, Green, Blue, Cyan, Magenta, Yellow, White, Black) invert perfectly using 8 bit encoding:

RGB = RGB -> PCS -> RGB

Generally, the v4 sRGB ICC preference profile perceptual intent should only be used with the perceptual intent transforms of other v4 profiles, as such transforms are required to also color re-render to and from the PRM. It is best to use v4 profiles that indicate the use of the PRMG through the *Perceptual Rendering Intent Gamut* tag (the rig0 tag is set to PRMG), for maximum interoperability.

If the v4 sRGB ICC preference profile is embedded as the source profile, and it is necessary to use it with a v2 destination profile, and the intention is to use a perceptual rendering intent there are several options:

1. If the objective is to produce a large gamut photo print, convert using the perceptual rendering intent to a color encoding such as ROMM RGB that uses the ICC PRM as its reference medium, and for which a v4 profile is available. Then convert from ROMM RGB to the destination device encoding using media-relative colorimetric with BPC on.

2. Use the media-relative colorimetric rendering intent with BPC as a baseline perceptual color re-rendering to convert directly from sRGB to the destination device encoding.

3. Temporarily replace the v4 sRGB profile with a type 2 v2 sRGB profile (full adaptation to display white point and BPC included) and use the v2 perceptual intent.

In most cases these options will produce acceptable results, but they may be different from the results that would be obtained if a v4 destination profile were used.

Likewise, the v4 sRGB ICC preference profile should generally not be used as the destination profile with v2 source profiles. An exception to this is when the source image colorimetry is for a medium similar to the PRM, such as a large gamut photo print. In this case the v2 source profile can be used to convert to a color encoding that uses the PRM (such as ROMM RGB) using the media-relative colorimetric rendering intent with BPC on. Then, the v4 perceptual rendering intent is used to color re-render from the encoded print colorimetry to sRGB.

The v4 sRGB ICC preference profile was developed and tested by ICC members. The description tag of this profile currently contains the following content ‘‘sRGB v4 ICC preference perceptual intent beta” to indicate that the perceptual intent contains a preference re-rendering from sRGB to the PRMG and vice versa and to further indicate that it is currently in a Beta state and that users are encouraged to provide feedback. If no significant complaints are reported within the next couple of months (~ 6 months) the extension “beta” will be removed from the description tag.

The v4 sRGB ICC preference profile can be downloaded from
http://www.color.org/srgbprofiles.html

Annex A: Additional workflow notes

This Annex contains detailed descriptions of four different example workflows.

A.1 Re-rendering from sRGB to output medium gamut

When the v4 sRGB profile is assigned to sRGB images and used as the source profile, the perceptual rendering intent is designed to transform image colors optimized for sRGB displays into image colors optimized for the PRM. A v4 destination printer profile is intended to be used in combination with the v4 sRGB profile to produce colors on actual print reproductions (see Figure A.1).

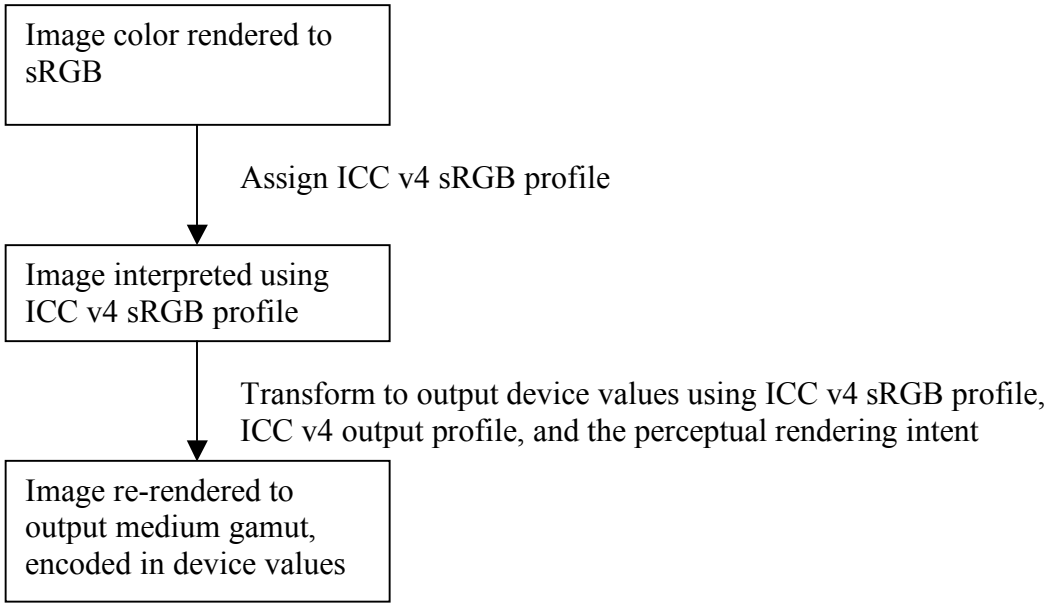

Figure A.1: Using the v4 sRGB profile with a v4 output profile, and the perceptual rendering intent.

A.2 Re-rendering from sRGB to PRMG with subsequent colorimetric proof

In the case of a large gamut printer, the v4 sRGB profile perceptual intent can also be combined with a colorimetric rendering intent in the destination printer profile (see Figure A.2). This will result in a “proof” of the perceptual intent reference medium colorimetry.

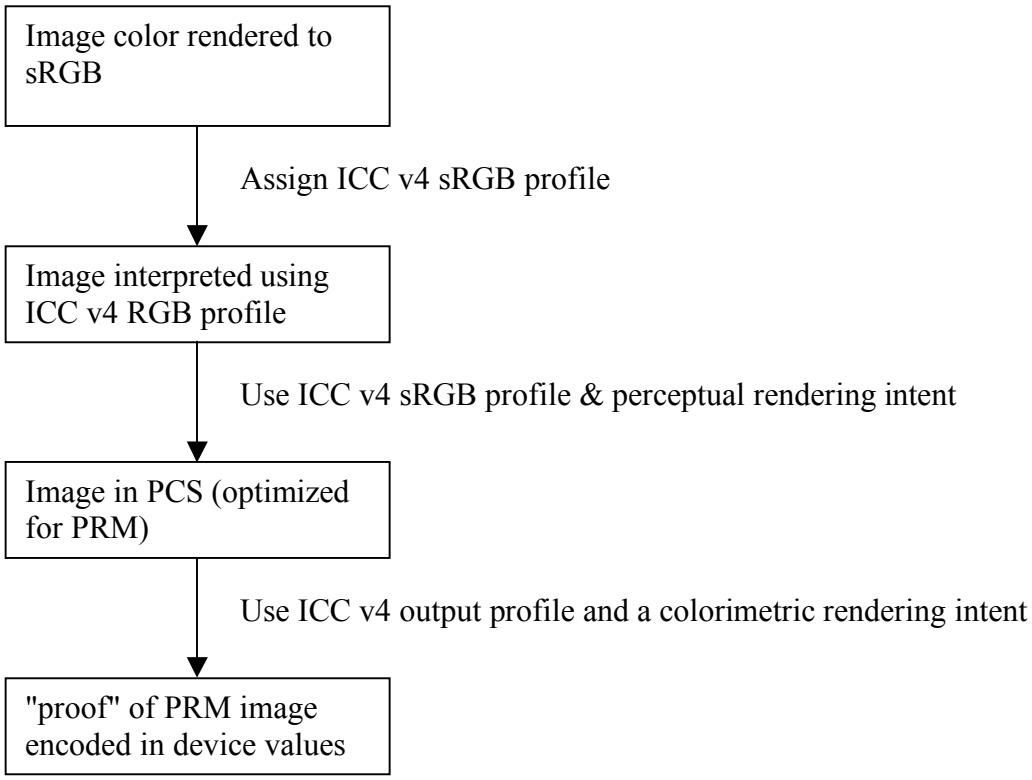

Figure A.2: Using the v4 sRGB profile perceptual rendering intent, and a v4 output profile and the colorimetric rendering intent.

NOTE: Black point compensation may also be used with the relative colorimetric rendering intent to perform a simple color re-rendering from the PRM to the output device.

A.3 Re-rendering from sRGB to intermediate color space with subsequent colorimetric proof

With Adobe Photoshop, a two-step process must be employed to use different rendering intents for source and destination. First the sRGB image is transformed using the perceptual intent to an intermediate color space that is appropriate for the PRM colorimetry, and then the result is transformed using a colorimetric intent to the destination color space (see Figure A.3).

NOTE: If the intermediate color space used is the Photoshop LAB color space, black point compensation will be applied automatically when going from sRGB to LAB using the perceptual rendering intent. Consequently, it must also be used when going from LAB to the device values in order to map the sRGB black point, as re-rendered to the PRM and then scaled to zero in LAB, to the black point of the device. This is necessary because v2 profile perceptual intents typically include black point scaling to zero, and Photoshop uses a v2 profile for the LAB color space. However, if an intermediate color space based on a v4 profile is used (such as ROMM RGB) the PRM black point is left unchanged, and when going to the actual output medium black point compensation can be either on or off, as desired.

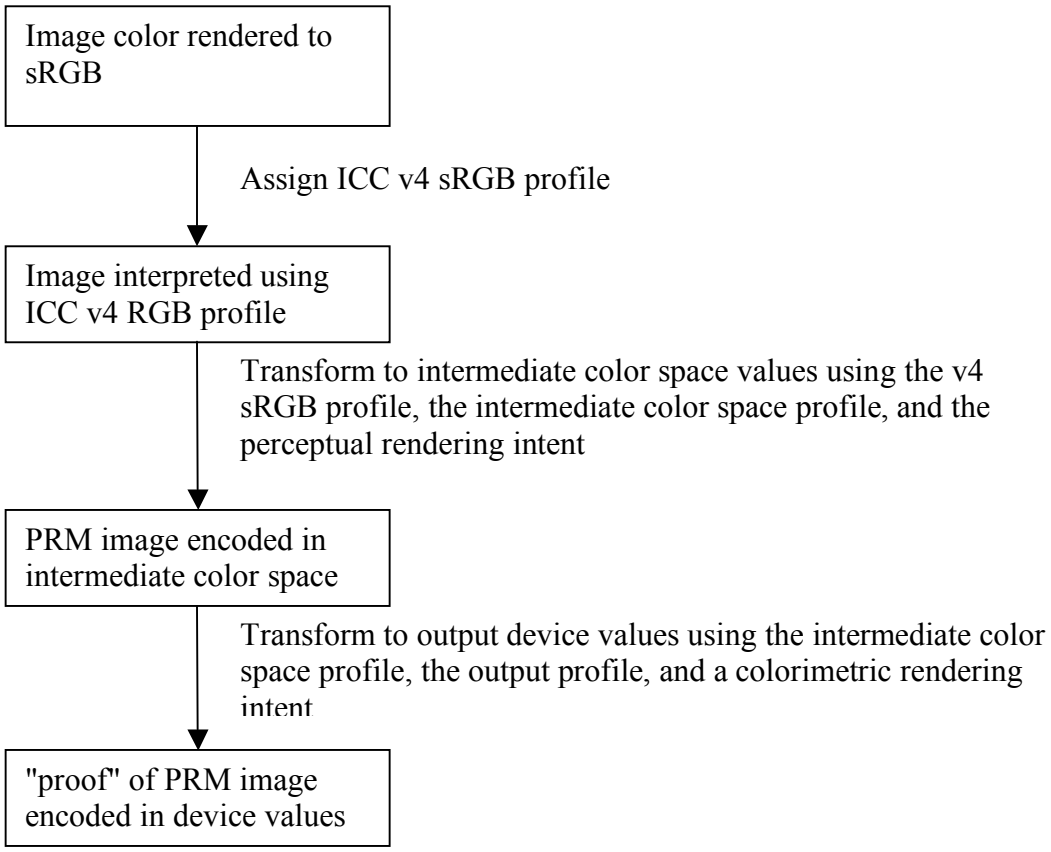

Figure A.3: Using the v4 sRGB profile perceptual rendering intent, and a v4 output profile and a colorimetric rendering intent, two step process.

NOTE: A color space is suitable for use as an intermediate color space in this process if the color space profile absolute colorimetric intent does not perform any color rendering or re-rendering, and does not clip or otherwise alter any colors within the PRM Gamut.

A.4 Re-rendering print-referred data to sRGB

The ICC v4 sRGB profile can also be used as a destination profile to produce sRGB images from images containing reflection print colorimetry encoded as ROMM RGB, or LAB (such as the ISO 12640-3 SCID images), or printer device values with an appropriate ICC v4 profile (see figure A.4).

Since the ICC v4 sRGB profile performs a color re-rendering in both directions (with no clipping inside the PRM Gamut), there is minimal loss when converting from the PRM to sRGB and back again. This makes it possible to communicate large gamut print colorimetry encoded as sRGB if the v4 sRGB profile is embedded and the perceptual rendering intent is indicated. The intended colorimetry for reproductions on specific media can also be communicated by embedding both the v4 sRGB profile and the output intent profile, such as by using PDF/X-4.

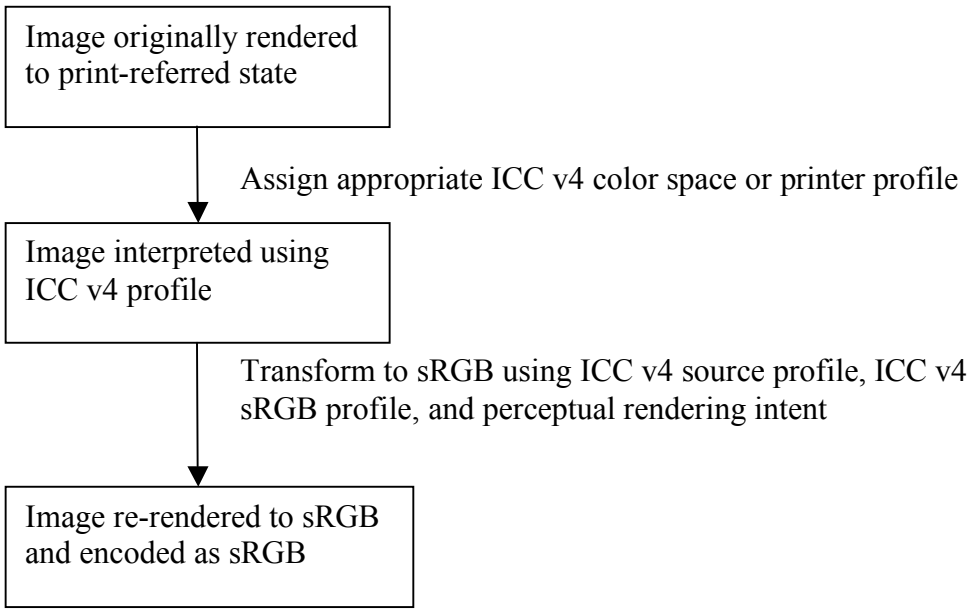

Figure A.4: Using a v4 source profile, the v4 sRGB profile and the perceptual rendering intent to re-render print-referred data to sRGB.

Because of interpolation issues, multiple round trips from sRGB to the PRM and back can result in errors accumulating to the point of significance, so the v4 sRGB profile perceptual intent should not be used as a print-referred working space if multiple round trips are anticipated. In this case ROMM RGB is a better choice, with the v4 sRGB profile used initially to convert to the working space, and finally to convert from the working space to sRGB after all edits and adjustments are completed.

Inferior results may be obtained if Adobe RGB images are converted colorimetrically to sRGB and then the ICC v4 sRGB profile is applied, because the colorimetric conversion from Adobe RGB to sRGB may not produce optimal sRGB colorimetry. As a general rule, if Adobe RGB images are optimized based on previewing them on an sRGB display, it will likely be possible to convert them colorimetrically (with clipping) to sRGB and assign the v4 sRGB profile. For Adobe RGB images optimized by viewing prints produced using large gamut photo printers and a colorimetric rendering intent, acceptable results may be obtained by converting from Adobe RGB to sRGB using the Adobe RGB profile as the source profile and choosing the colorimetric rendering intent used to make the prints, and the v4 sRGB profile as the destination profile and choosing the perceptual rendering intent to sRGB, as illustrated in Figure A.4. This may require a two step process if the software used does not support the selection of different rendering intents for source and destination.