White Paper 51

Level: Intermediate

Date: May 2021

Making connections with iccMAX

A guide to understanding how profile connection works using iccMAX profiles

Contents

1 Introduction

This is a document with a fairly limited scope. It is a teaching document that is mainly focused on the concept of profile connection – especially when iccMAX profiles are involved. The examples provide a useful reference for elementary iccMAX profile connection.

This document is intended for people who want to have a rudimentary understanding about what it means to connect and work with ICC profiles and especially iccMAX profiles. It is not primarily about implementing CMM's nor is about what is put in a profile or profile creation. The main focus is about how one configures profile connection and profile usage with a fairly high-level description of basically what the CMM is doing when profiles are connected (while contrasting and expanding upon profile connection using version 2 and version 4 ICC profiles).

Several questions one should be able to answer with this document related to connecting profiles are:

- What options are needed to have/use for configuring the connection?
- What parts of the profiles are used, and how are they used (on a high level)?
- What is the CMM doing (on a high level) to make the connection work?
- What kinds of things can one accomplish using different profile connection parameters?

It is recognized that in using the words "on a high level" there is some technical understanding required. However, the use of equations, detailed data structures and algorithms have intentionally been avoided in providing the high-level descriptions of what is involved. References to the specifications are provided for those interested in a more technical understanding.

It is hoped that this document might help foster a shared understanding about iccMAX connection by those working with and utilizing both the iccMAX specification as well as Interoperability Conformance Specification (ICS) documents – thus helping to make ICS documents more useful and understandable.

2 ICC Colour Management Background and Basics

With the advent of personal computers that could drive colour displays and colour desktop printers in the 1980s leading into the 1990s, the need arose to provide mechanisms for representing and reproducing colours on these devices. Initially proprietary methods were utilized that provided direct transformations from one device to another (See Figure 1).

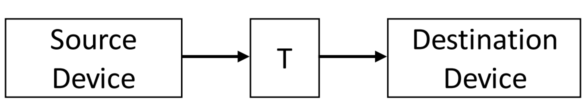


FIGURE 1 – DIRECT TRANSFORM (T) CONVERTS FROM SOURCE DEVICE ENCODING TO DESTINATION DEVICE ENCODING

This works well when the number of devices is limited, but as additional devices are added to the device ecosystem the number of transforms between devices grows extremely quickly with each possible device connection requiring a unique transform. A pictorial view of this of situation is shown in Figure 2.

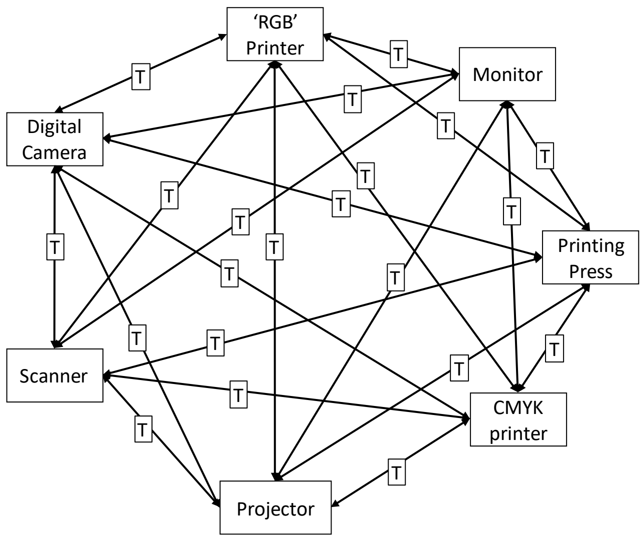


FIGURE 2 – EXAMPLE DEVICE-TO-DEVICE TRANSFORM CONNECTION WEB

To simplify things a "hub model" similar to that used by airlines to provide flight options between cities can be utilized. Rather than provide transforms between every device, one only needs to provide transforms between a Reference Colour Space and the encoding used by the device. The transformation from one device to another can then be performed as a two-step process. First the source device encoding in transformed to a reference colour space, and then a transform is used to go from a reference colour space to the destination device encoding (see Figure 3).

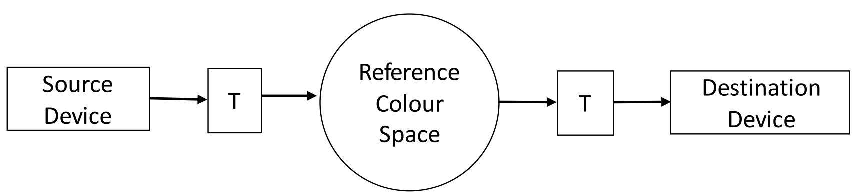


FIGURE 3 – CONVERSION FROM SOURCE DEVICE ENCODING TO DESTINATION DEVICE ENCODING USING REFERENCE COLOUR SPACE

When additional devices are added to the colour management ecosystem, only an additional transform set is needed for each new device. This approach is shown in Figure 4.

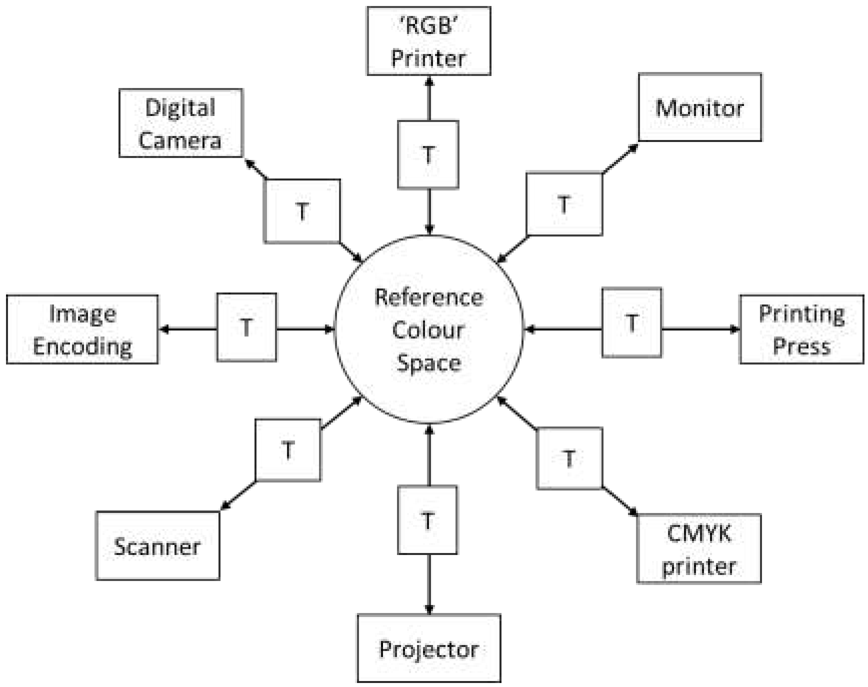


FIGURE 4 – INTER-DEVICE COLOUR TRANSFORMATION USING A REFERENCE COLOUR SPACE

Competing proprietary solutions of implementing colour management in such a fashion were in place at the start of the 1990's with significant interoperability and implementation challenges. As a result of this, key industry players came together to form the International Color Consortium with the goal to develop an open, cross platform, vender neutral approach to colour management based largely on Apple's Colorsync profiles and colour management architecture.

3 ICC Colorimetric Profile Connection Spaces

In the architecture standardized by the ICC, colour transforms are encoded in files called ICC profiles, and they are connected by a Colour Management Module (CMM) via a Profile Connection Space (PCS). The PCS standardized in V2 and V4 ICC profiles is a reference colour space based on human colour matching experiments performed in the 1920s, together with a standardized daylight illuminant (D50) defined in the 1960s.

The colour matching experiments resulted in colour matching functions for an average observer that were adopted by the CIE (the international standardization body for light and colour) in 1931. The 1931 standard observer colour matching functions were derived for a visual field with an angular subtense to the eye of 2 degrees, and can be used to determine resulting tristimulus XYZ values.

(Note: The XYZ values for surface reflectances are found by integrating the scalar product of the surface reflectance by the illuminant and colour matching functions over the range of wavelengths of visible light and normalizing by the Y value of the light source, so that Y=100 for a perfect reflecting diffuser. For radiant light sources, XYZ values are found by integrating the spectral distribution of the light source by the colour matching function and multiplying by a constant that ensures that tristimulus Y corresponds to the luminance in cd/m2).

The key property of CIE colorimetry is that two colours with identical XYZ values will appear the same (under identical viewing conditions).

One challenge with CIEXYZ coordinates is that equal Euclidean differences between coordinates do not normally correspond to equal perceptual differences. In 1976, the CIE adopted a set of equations that could be used to convert CIEXYZ coordinates to a more perceptually uniform space known as CIELAB. More recently, colour appearance spaces have been developed that can take into account the effect of the viewing conditions.

In ICC profiles the PCS can be based on either CIEXYZ or CIELAB. CIELAB provides better uniformity for interpolation of colour lookup tables, while colour displays often utilize a simple math model to convert between display RGB and XYZ.

4 ICC profiles

ICC profiles are binary data files with a header and data elements known as tags. The header provides information about the type and usage of the profile along with device and PCS connection encoding information. Each tags is uniquely identified with a tag signature, and is encoded using one of the various binary tag types defined by an ICC profile specification. Tags in a profile provide both transform encoding data as well as other useful metadata. Profiles can contain one or more transform tags depending on the type (or class/sub-class) of the profile and the scenarios in which the profiles are used. An example overview of the contents of a V4 CMYK printer ICC profile is shown in Figure 5. The use of the contents will be discussed in the next section.

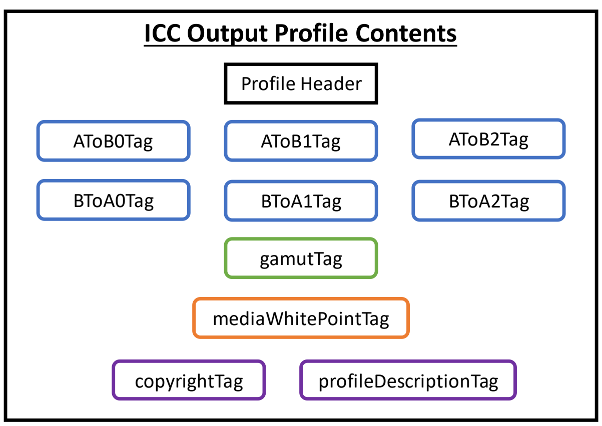


FIGURE 5 – OVERVIEW OF CONTENTS OF A CMYK OUTPUT PRINTER ICC PROFILE

Initially there were three basic types of transform that could be encoded as tags in ICC profiles: Look-Up Table (LUT) based, Matrix/Tone Reproduction Curve (TRC) based, and Named Color Table based. With Version 4.3 profiles, Multiple Processing Element (MPE) based transform tags were introduced, and MPE based transforms are more fully utilized and extended in iccMAX profiles.

5 Connecting and using V2 / V4 ICC profiles

Figures 1 and 3 are intended to illustrate an overall view of colour management transformation. However, two important concepts are needed to be able to understood how these figures relate to the application of ICC profiles: transform selection and PCS conversion and/or adjustment.

5.1 Transform Selection

Transform selection is used to determine the part(s) of the profile that are used to perform the colour transformation (represented by the "T" boxes in Figures 1 and 3). Several parameters are involved in transform selection including:

- Profile class – The type of profile that is being used.
- Position – Where in the sequence of transforms the profile is being used.
- Rendering Intent – Defines a user selectable "flavour" of colour transformation. The ICC profile specifications define four rendering intents: Perceptual (or preferred reproduction), Relative (matching media white), Absolute (exact match), and Saturation (business graphics). Transform selection based on rendering intent allows for alternates when a transform for a rendering intent is not available. (Example: The perceptual intent transform will be used if the relative intent is selected but the relative transform is not available). The precedence of rendering intent usage is explicitly defined by the ICC profile specifications.
- Transform Type – Defines how the profile is used, and is associated with the workflow "scenario" that is involved. Transform type options are dependent on the profile class, and transforms for different transform types may have different connection endpoints. Transform type may either be explicitly selected as a CMM control option (in addition to rendering intent) or transform type may simply involve the use of different interfaces of the CMM. Transform types that can be associated with V2 and V4 profiles include: colour transformation, named colour, gamut, and preview. Additionally, the "colour transformation" transform type can further be thought of as being subdivided into colour LUT-based, colour matrix/TRC, and colour MPE-based (V4.3) transform types (as implied by the "Required tags" and "Precedence order of tag usage" sections in the specification). This aspect of transform selection is often overlooked because the transform type is explicitly assumed (usually colour transformation with tag precedence applied) or only one transform type is supported/implemented by the CMM. However, the concept of transform type is an important aspect of transform selection that is critical for achieving predictable behaviour when applying profiles that contain multiple types of transform tags.

5.2 PCS Conversion and/or Adjustment

The concept of a Reference Colour Space in Figures 3 and 4 is expressed in ICC colour management using PCS connection. The CMM applies the transform of the profile going into the PCS (source profile) performs PCS adjustments (as needed) and then applies the transform of the profile going out of the PCS (destination profile).

The PCS adjustment in the middle may involve one or more of the following operations performed by the CMM:

- Pass-through (No change) – This happens when the PCS configuration of the source profile transform directly matches the PCS configuration of the destination profile transform (and no further CMM controls are applied). For example, when either both the source and destination profiles use an XYZ PCS then the CMM passes the data directly from the source profile transform to the destination profile transform. (The same applies if both profiles use a Lab PCS).
- Colour space conversion – This happens when the source and destination profiles do not have the same PCS configuration. The following conversions may then apply:
  - If the source profile uses an XYZ space and the destination profile uses a Lab space, then an XYZ to Lab conversion is applied as part of PCS processing by the CMM.
  - If the source profile uses a Lab space and the destination profile uses an XYZ space, then a Lab to XYZ conversion is applied as part of PCS processing by the CMM.
  - When a V2 profile and V4 profile are connected using the perceptual intent, then a black point adjustment is performed since the V2 and V4 perceptual intents have different reference medium black points.
- Rendering intent adjustment – For V2/V4 profiles, the absolute colorimetric intent uses relative colorimetric transforms with a PCS adjustment in XYZ space scaling between the media white point and the illuminant. The mediaWhitePointTag of each profile is used to get the XYZ colorimetry of the media to perform this operation. The relative-to-absolute adjustment scales the XYZ PCS values by the ratio of the media XYZ divided by the illuminant XYZ. The absolute-to-relative adjustment scales the PCS values by the ratio of the illuminant XYZ divided by the media XYZ. (Note: Since absolute-relative adjustment is XYZ based, colour space conversion is also applied when a profile uses a Lab based PCS).
- CMM controlled adjustment – A CMM might have a control option (requested by the calling application) that causes the CMM to perform additional PCS adjustments. An example of a CMM control that results in a PCS based adjustment is Black Point Compensation (BPC). (Note: This normalization is similar in concept to absolute-relative adjustment described in the previous section). BPC involves determining the black points for the profiles on both sides of the transform and then performing an XYZ scaling to normalize the black point from source profile to the black point of the destination profile. BPC scaling involves having the CMM use the associated transform tags from each of the profiles to determine the black points.

5.3 Combining Transform Selection and PCS Adjustment

The table below provides an example of combining V2/V4 transform selections based on transform selection parameters and rendering intents. A full table of various combinations can be found in Section 9.1.

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	**<u>1</u>** → 2	Perceptual	Colour LUT-based	AtoB0Tag	Device to XYZ/Lab PCS	None

Note: The transform shown here is relative to the profile position that is bold and underlined.

5.4 Device-to-device connection

One additional common form of profile connection using V2/V4 profiles is to apply successive sequences of profiles passing the results coming out of one sequence directly as input to the following sequence. This can either be done by the calling application or within some CMMs. When a CMM performs this successive application the device values are passed directly in the same order without any modification. An example of this is simulation or soft proofing where the first sequence performs colour management to an intermediate device (with its associated gamut mapping and rendering), and the second sequence uses colour management to provide a "view" of the results on a tertiary device. This is accomplished using a sequence such as (1→2 : 2→3) where the ':' represents a direct transfer of device values.

6 Decisions and Capabilities

Decision-making is a shared responsibility between an Application making use of colour management, the Colour Management Module (CMM) and the colour Profile(s). There was considerable debate in the early days of the ICC related to the role of decision making by the CMM. There were two groups of opinion.

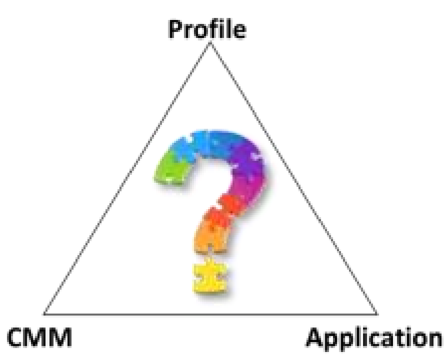


FIGURE 6 – WHERE ARE THE COLOUR MANAGEMENT DECISIONS PERFORMED?

In the first group, few decisions are made by the profile maker in creating the profile resulting in "dumb" profiles that only provide measurement data and most decisions are made by a “smart” CMM about how colour management should be accomplished involving things like (but not limited to): device modelling, colour rendering, gamut mapping, and colour channel (ink) separation.

In the second group, most decisions are made by the profile maker in creating the profile resulting in “smart” profiles that have the same aspects of colour management encoded within transforms in the profile which are then applied by a “dumb” CMM that only knows how to apply the transforms. Variability can be encoded as separate transforms that the Application could select from.

The choice between these approaches was tempered by the desire to create an open, vendor-neutral platform that would provide interoperability, predictability, and consistency. The first approach provides much greater flexibility, but it is much more difficult to achieve these objectives as many of the decisions to be made are generally solved using proprietary solutions and standardizing a smart “CMM” quickly becomes untenable.

Thus, the second approach was taken, various limitations were accepted, and any operations performed by the CMM (like PCS processing) were spelled out by the specification to ensure interoperability, predictability, and consistency. This has proved to be a very successful approach in most workflows (particularly with ICC-based colour management implementations used in the graphic arts).

However, various limitations of the approach adopted in V2/V4 profiles have prevented (or made impractical) the use of ICC-based colour management in scenarios where more complex communication about colour, colour appearance, and transform expression are needed or desired.

An endeavour was undertaken within the ICC (over the course of a decade) to address limitations and new requirements that were identified by groups interested in (but unable to use) ICC-based colour management. These efforts resulted in the iccMAX specification.

It is critically important to note that though limitations have been overcome and capabilities have increased with iccMAX, the fundamental approach of having limited CMM decision-making has remained for the same reasons as for V2/V4 profiles. Thus, more information is required in iccMAX profiles and more selections are presented to or by calling applications. This results in removing limitations, increasing capabilities, and providing support for more colour management scenarios using an open, vendor-neutral platform that provides interoperability, predictability, and consistency.

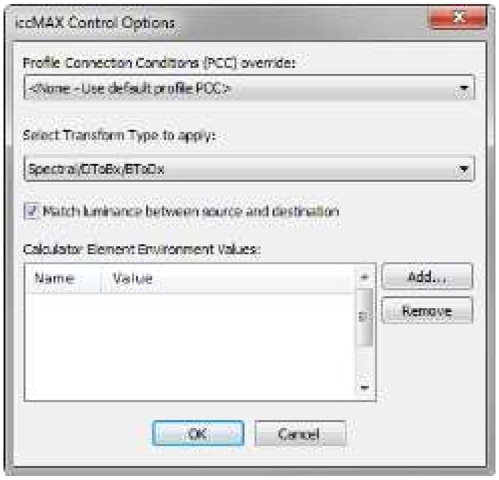


FIGURE 6 – EXAMPLE APPLICATION ICCMAX CONTROL OPTIONS DIALOG

Additional selection information needed for a calling application to an iccMAX-enabled CMM for iccMAX profile handling may include: transform type selection, profile connection conditions override, luminance matching flag, and calculator element environment values.

7 Connecting using iccMAX / V5 ICC profiles

More complex colour management scenarios are possible with iccMAX profiles defined by the ICC.2 and ISO 20677 specifications. The iccMAX profile file format uses the same general structure as V2/V4 profiles but defines V5 profiles. The iccMAX specification introduces several new tags and tag types, and extends the MultiProcessElementsType tag type to provide greater flexibility in transform encoding. However, for the most part, connection using iccMAX profiles can be thought of as just an extension of the connection concepts described above for V2 /V4 profiles. Transform selection and PCS Conversion / Adjustment are still the key aspects of connecting with iccMAX profiles. However, significant extensions of these concepts are introduced to allow for a wider variety of colour management scenarios to be accomplished.

7.1 Transform Selection

Transform selection for iccMAX profiles uses the same parameters discussed for V2/V4 profiles above: profile class, position, rendering intent and transform type.

Although the concept of transform type exists for V2/V4 profiles it is in practice largely assumed to be defined by the profile class for most implementations (with no separate selection option of transform type by the application). However, for iccMAX workflows (especially those defined by Interoperability Conformance Specification (ICS) documents) the use of transform type becomes critically important to differentiate and select between workflow scenarios. In some ICSs, only one transform type is defined and thus allowed in conforming profiles. In other cases, transform type selection precedents and rules are defined by the ICS.

Because transform type selection allows for multiple scenarios to be involved with a single ICC profile, applications that support iccMAX workflow scenarios may require additional UI related to transform type selection to feed into CMM control options that control transform selection.

(Note: A discussion of transform type selection in terms of CMM control options can be found in annex K of the iccMAX specification).

The set of transform types that can be encoded in iccMAX profiles is different than what can be encoded in V2/V4 profiles, and they all generally have two flavours that specify either the use of a colorimetric or a spectrally based PCS. Both colorimetric and spectrally-based transforms can be present in a single iccMAX profile, so transform type selection is very important for obtaining predictable results.

The colour LUT transform type identified previously for V2/V4 profiles can more correctly be referred to in iccMAX profiles as a colorimetric colour transform type with transforms that utilize a colorimetric based PCS. The tags associated with the colour MPE-based transform type in V4.3 have been repurposed in iccMAX to define a spectral colour transform type with transforms that utilize a spectrally based PCS.

(Note: The preview tags were deprecated in V4.3 as well as in iccMAX).

Additional iccMAX transform types have different transform endpoints than simple Device and PCS channels. These additional transform types are used in more advanced colour management scenarios, and, in most cases, they also have both Colorimetric and Spectral flavours. These more extended transform types in iccMAX profiles include: BRDF parametric, BRDF sampled, directional, and multiplex channel-based. The multiplex channel-based type will be discussed further below. It is recommended that the iccMAX specification be consulted related to the other more extended transform types.

7.2 PCS Conversion and/or Adjustment

Transform type selection with iccMAX profiles establishes both the transform tag as well as the associated PCS configuration (associated with colour space encoding, illuminant, observer, and spectral ranges as they apply) that will be used for the profile connection within the CMM. Once PCS configurations are established for both the source and destination profiles, the PCS operations are generally the same as PCS operation with V2/V4 profiles (though with more options and details involved). The CMM applies the transform of the profile going into the PCS (source profile) performs PCS adjustments (as needed), and then applies the transform of the profile going out of the PCS (destination profile). And, PCS adjustment in the middle by the CMM generally involves the same operations as for V2/V4 profiles:

- Pass-through (No change) – This happens when the PCS configuration of the source profile transform directly matches the PCS configuration of the destination profile transform (and no further CMM controls are applied).
- Colour configuration conversion – This happens when the source and destination profiles do not have the same PCS configuration. There are two aspects of PCS configuration

conversion that apply with iccMAX based PCS connection: Colour space conversion and observing condition conversion.

Colour space conversion – PCS connection with iccMAX profiles can performed with spectrally-based colour spaces (in terms of reflectance, transmittance, emission, or fluorescence) in addition to colorimetric XYZ and CIELAB colour spaces. (Note: Annex A in the iccMAX specification defines all valid inter PCS connections and the operations involved in their conversion). For example: When a spectral PCS is connected to a colorimetric PCS then observer and illuminant information from the profile connection conditions is applied to convert to colorimetry (which requires application of both an illuminant and colour matching functions of an observer). The profile connection conditions that define the illuminant and observer that are to be used may be obtained either from the profile (in the spectral viewing conditions tag, which is required) or provided as a CMM control option external to the profile.

Observing condition conversion – Conversions are applied by a CMM when the illuminant and/or colorimetric observer do not match between the source PCS and the destination PCS.

The conversion transforms between custom observing conditions and standard observing conditions (for the 1931 standard 2-degree observer under a D50 illuminant) are encoded as required tags in an iccMAX profile whenever it has a colorimetric PCS with custom observing conditions or a spectral PCS. These tags are required for the CMM to be able to make one of the following three observing condition conversions:

- Custom-to-standard conversion applied for the source profile
- Standard-to-custom conversion applied for the destination profile
- Custom-to-standard conversion applied for the source profiled followed by the standard-to-custom conversion applied for the destination profile

(Note: In some cases, a CMM may be provided with control options by the application that provide overrides of the PCC tags used for observing condition conversion).

- An additional colour space conversion may be performed when a V2 profile and an iccMAX profile are connected using the same adjustment that is performed for the perceptual intent between V2 and V4 profiles.

- Rendering intent adjustment – iccMAX profiles can encode transform tags for either absolute or relative intent. When one is not present then absolute/relative adjustments are performed to achieve the missing rendering intent transformation. PCS adjustment in XYZ is performed for colorimetric PCS connection and spectral PCS adjustment relative to the spectralWhitePointTag is performed for spectral PCS connection in similar fashion to absolute/relative processing performed by V2/V4 CMMs.
- CMM controlled adjustment – An iccMAX capable CMM might have a control option (requested by the calling application) that causes the CMM to perform additional PCS adjustments. In addition to Black Point Compensation for colorimetric PCS connection, a CMM might be instructed to perform luminance matching. This uses the luminances of the

illuminants in the connecting profiles to linearly scale the XYZ colorimetry, thus providing a match of the luminances.

7.3 Extending device-to-device connection with multiplex channel connection

With device-to-device connection the device values are passed directly from one profile to another in the same order without any modification by the CMM. This can be thought of as an alternate connection space mechanism from using a PCS. Rather than describing what a colour looks like, or how it is related to light, it provides a representation of what a colour is or how it is made.

Multiplex channel connection in iccMAX can be thought of as an extension of device-to-device connection, with flexibility in the order and number of channels. Like device-to-device connection, tThe CMM performs no modification of the values that are passed from one profile to another when performing multiplex channel connection. The data channels are identified by name rather than order, and data is passed between channels that have the same name.

Multiplex channel connection is useful when there is flexibility in the number of data channels, or when the order of data channels is not important. The flexibility can be controlled in terms of requirements from both the source and destination profiles.

Examples where multiplex channel connection could be useful include: pigment identification of artwork, disease state indicators in whole slide imaging, terrain-type identification in satellite imagery, ink overprint simulation in printing, and adding an alpha channel to a PCS for 3D printing.

7.4 Combining Transform Selection and PCS Adjustment

The table below provides an example of combining iccMAX transform selections based on transform selection parameters and rendering intents. A full table of various combinations can be found in Section 9.2.

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	**<u>1</u>** → 2	Perceptual	Colorimetric Colour	AtoB0Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	**<u>1</u>** → 2	Perceptual	Spectral Colour	DtoB0Tag	Device to Spectral PCS	None

Note: The transform shown here is relative to the profile position that is bold and underlined.

8 Profile Application Examples

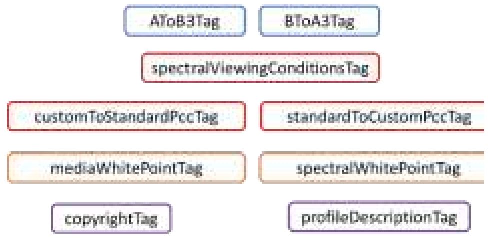
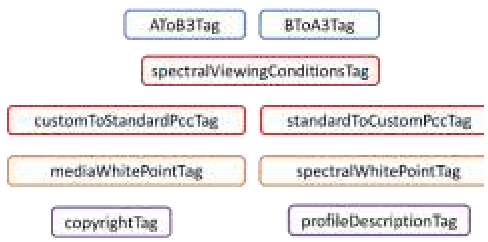
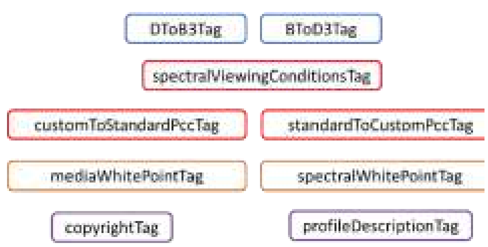
The preceding sections of this document have presented various aspects of profile connection from an abstract point of view. This section provides more concrete examples of profile connection to better help understand the possibilities and associated issues.

8.1 Example Profiles

The following table contains a brief overview of the profiles that will be used in situations described in the next section.

ID	Description	Tag Content Overview	Details
A	RGB Profile	redMatrixColumnTag, redTRCTag greenColumnMatrixTag, greenTRCTag blueMatrixColumnTag, blueTRCTag mediaWhitePointTag copyrightTag, profileDescriptionTag	Version: 2.1 Class: ColorSpace Sub-Class: - Colour Space: RGB Colorimetric PCS: XYZ Spectral PCS: - Illuminant: D50 Observer: Std. 2 degree
B	RGB Display Profile	redMatrixColumnTag, redTRCTag greenColumnMatrixTag, greenTRCTag blueMatrixColumnTag, blueTRCTag mediaWhitePointTag copyrightTag, profileDescriptionTag	Version: 2.1 Class: Display Sub-Class: - Colour Space: RGB Colorimetric PCS: XYZ Spectral PCS: - Illuminant: D50 Observer: Std. 2 degree
C	CMYK Printer Profile	AToB0Tag, AToB1Tag, AToB2Tag BToA0Tag, BToA1Tag, BToA2Tag gamutTag, mediaWhitePointTag copyrightTag, profileDescriptionTag	Version: 4.2 Class: Output Sub-Class: - Colour Space: CMYK Colorimetric PCS: Lab Spectral PCS: - Illuminant: D50 Observer: Std. 2 degree

ID	Description	Tag Content Overview	Details
D	iccMAX CMYK Printer Profile	AToB0Tag, AToB1Tag, AToB2Tag BToA0Tag, BToA1Tag, BToA2Tag DToB3Tag, gamutBoundaryDescription1Tag spectralViewingConditionsTag customToStandardPccTag, standardToCustomPccTag mediaWhitePointTag, spectralWhitePointTag copyrightTag, profileDescriptionTag	Version: 5.0 Class: Output Sub-Class: TBD Colour Space: CMYK Colorimetric PCS: Lab Spectral PCS: Reflectance Illuminant: Illum. A Observer: Std. 2 degree PCC Conversion: Wpt MAT ICS: TBD
E	iccMAX RGB Profile	AToB1Tag, BToA1Tag spectralViewingConditionsTag customToStandardPccTag, standardToCustomPccTag mediaWhitePointTag, spectralWhitePointTag copyrightTag, profileDescriptionTag	Version: 5.0 Class: ColorSpace Sub-Class: TBD Colour Space: RGB Colorimetric PCS: Lab Spectral PCS: None Illuminant: D65 Observer: Std. 2 degree PCC Conversion: Wpt MAT ICS: TBD
F	iccMAX RGB Display Profile	AToB1Tag, BToA1Tag spectralViewingConditionsTag customToStandardPccTag, standardToCustomPccTag mediaWhitePointTag, spectralWhitePointTag copyrightTag, profileDescriptionTag	Version: 5.0 Class: Display Sub-Class: TBD Colour Space: RGB Colorimetric PCS: XYZ Spectral PCS: None Illuminant: D65 Observer: Std. 2 degree PCC Conversion: Wpt MAT ICS: TBD

ID	Description	Tag Content Overview	Details
G	iccMAX Colorimetric PCC Profile		Version: 5.0 Class: ColorSpace Sub-Class: TBD Colour Space: Lab Colorimetric PCS: Lab Spectral PCS: None Illuminant: Illum. A Observer: Std. 2 degree PCC Conversion: CAT02 ICS: TBD
H	iccMAX Colorimetric Observer PCC Profile		Version: 5.0 Class: ColorSpace Sub-Class: TBD Colour Space: Lab Colorimetric PCS: Lab Spectral PCS: None Illuminant: D65 Observer: Custom PCC Conversion: Wpt MAT ICS: TBD
I	iccMAX Spectral PCC Profile		Version: 5.0 Class: ColorSpace Sub-Class: TBD Colour Space: 6-Channel Colorimetric PCS: None Spectral PCS: Reflectance Illuminant: F5 Observer: Custom PCC Conversion: Wpt MAT ICS: TBD

8.2 V2/V4 Profile Application Scenarios

The following colour management scenarios utilize some of the profiles outlined in the previous section. These examples are not meant to be exhaustive of all possible combinations, but they do represent some common scenarios.

The following scenarios are presented:

- A1 - Displaying an RGB image
- A2 - Printing a CMYK image (to be viewed under D50 by standard 2-degree observer)

- A3 - Printing an exact match of a CMYK image (to be viewed under D50 by standard 2-degree observer)
- A4 - Displaying a CMYK image
- A5 - Printing an RGB image (to be viewed under D50 by standard 2-degree observer)
- A6 - Soft Proof of Printing an RGB Image

Scenario A1 - Displaying an RGB image

Profile Sequence	Profile Setup		
	A	Rendering Intent: Transform Type:	Relative Colour
	B	Rendering Intent: Transform Type:	Relative Colour

In this scenario RGB colour space profile is connected to an RGB display Profiles.

<u>Transform Selection</u>

The Matrix/TRC tags (associated with the Relative Intent) from profile A are used directly. The Matrix/TRC tags from profile B are inverted to transform from XYZ to RGB.

<u>PCS Endpoints</u>

The PCS values coming out of the Matrix/TRC tags from profile A represent media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the inverse Matrix TRC tags from profile B represent media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

<u>PCS Adjustment/Conversion</u>

There is no PCS conversion since the PCS end points between the two profiles are the same. PCS values coming out of the transform for profile A are directly passed to the transform for profile B.

Scenario A2 - Printing a CMYK image (to be viewed under D50 by standard 2-degree observer)

<table>
<tr><th>Profile Sequence</th><th colspan="3">Profile Setup</th></tr>
<tr><td rowspan="2">
</td><td></td><td>Rendering Intent:
Transform Type:</td><td>Perceptual
Colour</td></tr>
<tr><td></td><td>Rendering Intent:
Transform Type:</td><td>Perceptual
Colour</td></tr>
</table>

In this scenario two different CMYK profiles are used with the Perceptual intent to get a pleasing reproduction.

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB0Tag used from profile C_1, and the BToA0Tag used from profile C_2.

PCS Endpoints

The PCS values coming out of the AToB0Tag from profile C_1 represent V4 perceptual media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the BToA0Tag from profile C_2 represent v4 perceptual media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

There is no PCS conversion since the PCS end points between the two profiles are the same. PCS values coming out of the transform for profile C_1 are directly passed to the transform for profile C_2.

Scenario A3 - Printing an exact match of a CMYK image (to be viewed under D50 by standard 2-degree observer)

Profile Sequence	Profile Setup		
C_1 → PCS → C_2	C_1	Rendering Intent:	Absolute
		Transform Type:	Colour
	C_2	Rendering Intent:	Absolute
		Transform Type:	Colour

In this scenario two different CMYK profiles are used with the Absolute rendering intent to get an exact match for the standard observing conditions.

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB1Tag used from profile C_1, and the BToA1Tag used from profile C_2. These tags are associated with the Relative intent and PCS adjustment is performed to achieve Absolute colour rendering.

PCS Endpoints

The PCS values coming out of the AToB1Tag from profile C_1 represent media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the BToA1Tag from profile C_2 represent media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

Although the PCS end points between the two profiles are the same, they do not match the expectations of absolute colorimetry required by the rendering intent. The PCS adjustment/conversions are as follows:

1. The Lab-encoded values coming out of the transform for profile C_1 are converted to XYZ values.
2. The absolute intent for profile C_1 is applied by using the mediaWhitePointTag from profile C_1 to convert from relative to absolute XYZ colorimetry.
3. The absolute intent for profile C_2 is applied by using the mediaWhitePointTag from profile C_2 to convert from absolute to relative XYZ colorimetry.
4. The XYZ values are converted to Lab encoding to go into the transform from profile C_2.

Scenario A4 - Displaying a CMYK image

Profile Sequence	Profile Setup		
C → PCS → B	C	Rendering Intent: Transform Type:	Perceptual Colour
	B	Rendering Intent: Transform Type:	Perceptual Colour

In this scenario an CMYK colour space profile is connected to an RGB display Profiles.

Transform Selection

The tag selection based on rendering intent and transform type results in the BToA0Tag from profile C being used, and inverted Matrix/TRC tags being used from profile B.

PCS Endpoints

The PCS values coming out of the AToB0Tag from profile C represent V4 perceptual media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the inverse Matrix/TRC tags from profile B represent v2 perceptual media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

The PCS end points between the two profiles are different. Therefore, the following PCS adjustment/conversions are applied as follows:

1. The Lab-encoded values coming out of the transform for profile C are converted to XYZ values.
2. V4 to V2 perceptual black point adjustment is performed.
3. These XYZ values passed to the transform from profile B.

Scenario A5 - Printing an RGB image (to be viewed under D50 by standard 2-degree observer)

Profile Sequence	Profile Setup		
A → PCS → C	A	Rendering Intent: Transform Type:	Perceptual Colour
	C	Rendering Intent: Transform Type:	Perceptual Colour

In this scenario an RGB colour space profile is connected to a CMYK printer profile.

Transform Selection

The tag selection based on rendering intent and transform type results in the Matrix/TRC tags being used from profile A, and the BToA0Tag from profile C being used.

PCS Endpoints

The PCS values coming out of the Matrix/TRC tags from profile A represent perceptual V2 media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the BToA0Tag from profile C represent v4 perceptual media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

The PCS end points between the two profiles are different. Therefore, the following PCS adjustment/conversions are applied as follows:

1. The XYZ encoded values coming out of the transform for profile A are adjusted using a V2 to V4 perceptual black point XYZ adjustment
2. XYZ encoding to Lab encoding applied
3. These Lab values are passed into the transform from profile C.

Scenario A6 - Soft Proof of Printing an RGB Image

<table>
<tr><th>Profile Sequence</th><th colspan="3">Profile Setup</th></tr>
<tr><td rowspan="8">
</td><td rowspan="2">A</td><td>Rendering Intent:</td><td>Perceptual</td></tr>
<tr><td>Transform Type:</td><td>Colour</td></tr>
<tr><td rowspan="2">C_d</td><td>Rendering Intent:</td><td>Perceptual</td></tr>
<tr><td>Transform Type:</td><td>Colour</td></tr>
<tr><td rowspan="2">C_s</td><td>Rendering Intent:</td><td>Relative</td></tr>
<tr><td>Transform Type:</td><td>Colour</td></tr>
<tr><td rowspan="2">B</td><td>Rendering Intent:</td><td>Relative</td></tr>
<tr><td>Transform Type:</td><td>Colour</td></tr>
</table>

In this scenario two sequences are concatenated, and in the following discussion the C_d and C_s represent the use of the same profile C as both a destination profile C_d, and as a source profile C_s.

Transform Selection

In the first sequence, the tag selection based on rendering intent and transform type results in the Matrix/TRC tags being used from profile A, and the BToA0Tag from profile C_d being used.

In the second sequence, the tag selection based on rendering intent and transform type results in the AToB1Tag from profile C_s being used, and inverted Matrix/TRC tags being used from profile B.

PCS Endpoints

The PCS values coming out of the Matrix/TRC tags from profile A represent V2 perceptual media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the BToA0Tag from profile C_d represent V4 perceptual media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values coming out of the AToB0Tag from profile C_s represent V4 media-relative Lab colorimetry for the 2-degree standard observer under D50 lighting.

The PCS values going into the inverse Matrix/TRC tags from profile B represent media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

In both sequences, PCS adjustment/conversion is needed because the PCS endpoints are different.

In the first sequence, the PCS adjustment/conversion involves:

1. The XYZ encoded values coming out of the transform for profile A are adjusted using a V2-to-V4 perceptual black point XYZ adjustment.
2. XYZ encoding to Lab encoding is applied.

3. These Lab values are passed into the transform from profile C_d.

The results of applying the BToA0 transform from profile C in the first sequence are passed directly in as input the AToB1 transform from profile C_s in the second sequence.

In the second sequence the PCS conversion involves:

1. The Lab encoded values coming out of the transform from profile C_s are converted to XYZ values.
2. These XYZ values passed to the transform from profile B.

8.3 iccMAX Profile Application Scenarios

The following colour management scenarios utilize some of same set of profiles outlined previously. These examples are not meant to be exhaustive of all possible combinations, but they do represent some practical scenarios.

The following scenarios are presented:

- B1 - Displaying an RGB image using iccMAX profiles
- B2 - Displaying a legacy RGB image to an iccMAX characterized display
- B3 - Displaying a legacy RGB image to an observer-specific iccMAX-characterized display
- B4 - Getting colorimetry of a CMYK image
- B5 - Getting custom colorimetry of a CMYK image
- B6 - Getting estimated custom colorimetry of a CMYK image
- B7 - Getting a spectral representation of a CMYK image
- B8 - Printing a material match of a legacy CMYK image (to be viewed under Illuminant A by standard 2-degree observer)
- B9 - Printing an appearance match of a legacy CMYK image (to be viewed under Illuminant A by standard 2-degree observer)
- B10 – Viewing an appearance match of a CMYK print (viewed under Illuminant A by the standard 2-degree observer) on a display
- B11 – Simulating to the standard observer on an RGB display how a CMYK print under D65 lighting is seen by a custom observer
- B12 – Simulating to the standard observer on an RGB display how a CMYK print generated for one observing condition is seen for a different observing condition

Scenario B1 - Displaying an RGB image using iccMAX profiles

Profile Sequence	Profile Setup		
	E	Rendering Intent:	Relative
		Transform Type:	Colorimetric
		PCC Override:	None
	F	Rendering Intent:	Relative
		Transform Type:	Colorimetric
		PCC Override:	None

In this scenario an iccMAX RGB colour space profile is connected to an iccMAX RGB display profile where both profiles use actual D65 colorimetry for PCS connection. The main difference between this scenario and scenario A1 is that there is a richer set of transform encodings available with iccMAX profiles:

1. Tags based on the multiProcessElementType use floating point encoding and therefore are not subject to possible clipping for encoding HDR transforms.
2. Tags may contain processing elements that combine a spectral characterization of the display with the observer’s colour matching functions (from the spectralViewingConditionsTag of the PCC associated with the profile) to determine an appropriate transform between observer specific colorimetry and device values. (Note: In this scenario the PCC override is “none” for both profiles so the spectralViewingConditionsTag from the respective profile would be used for the spectral to colorimetric transform creation).
3. Tags that utilize a calculator processing element can have CMM environment variables passed in as part of profile setup for each profile to customize the transform. Examples of using CMM variables include selection of gamma or providing ambient lighting level to maintain just noticeable differences.

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB1Tag being used from profile E, and the BToA1Tag being used from profile F.

PCS Endpoints

The PCS values coming out of the AToB1Tag from profile E represent media-relative XYZ colorimetry for the 2-degree standard observer under D65 lighting.

The PCS values going into the BToA1Tag from profile F represent media-relative XYZ colorimetry for the 2-degree standard observer under D65 lighting.

PCS Adjustment/Conversion

There is no PCS adjustment/conversion since the PCS end points between the two profiles are the same. PCS values coming out of the transform for profile E are directly passed to the transform for profile F.

Scenario B2 - Displaying a legacy RGB image to an iccMAX characterized display

Profile Sequence	Profile Setup		
A → PCS → F	A	Rendering Intent:	Relative
		Transform Type:	Colorimetric
		PCC Override:	Ignored
	F	Rendering Intent:	Relative
		Transform Type:	Colorimetric
		PCC Override:	None

In this scenario an image with a legacy V2 profile is connected to an iccMAX RGB display profile. This demonstrates the backwards compatibility between legacy and iccMAX profiles.

Transform Selection

The tag selection based on rendering intent and transform type results in the Matrix/TRC tags being used from profile A, and the BToA1Tag from profile F being used.

PCS Endpoints

The PCS values coming out of the Matrix/TRC tags profile A represent media-relative XYZ colorimetry for the 2-degree standard observer with a D50 illuminant.

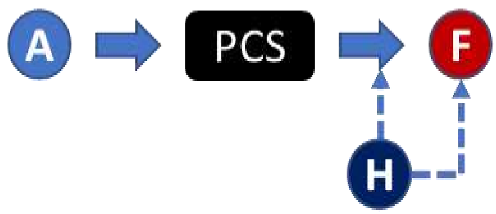
The PCS values going into the BToA1Tag from profile F represent media-relative XYZ colorimetry for the 2-degree standard observer with a D65 illuminant.

PCS Adjustment/Conversion

PCS adjustment/conversion is needed because the PCS endpoints are different (specifically because the illuminants are different). The following PCS conversion is applied:

1. The standardToCustomPccTag from profile F is applied to the XYZ values coming out of the transform for profile A to convert standard D50/2-degree XYZ values to custom D65/2-degree XYZ values which are then passed into the transform from profile F.

Scenario B3 - Displaying a legacy RGB image to an observer-specific iccMAX-characterized display

Profile Sequence	Profile Setup
	A Rendering Intent: Relative Transform Type: Colorimetric PCC Override: Ignored
	F Rendering Intent: Relative Transform Type: Colorimetric PCC Override: H

This scenario is an extension of scenario B2 where an image with a legacy V2 profile is connected to an iccMAX RGB display profile. However, a PCC override is used to specify that the image is to be viewed by a custom observer taking into account the differences that the custom observer has from that of the standard observer. This is especially critical when important observer-based decisions are made related to what is being displayed to the observer and there is significant observer metamerism involved with the display (possibly due to sharp peaks in the spectral emission of the display). This demonstrates the ability to separate the characterization of the display from the observer that views it.

Note: Similar extensions to scenario B1 are appropriate when alternate PCC overrides are provided.

Transform Selection

The tag selection based on rendering intent and transform type results in the Matrix/TRC tags being used from profile A, and the transform from the BToA1Tag in profile F being used.

In this scenario the transform from Profile F uses one or more processing elements that combine the spectral characteristics of the display with colour matching functions from the overridden PCC spectralViewingConditionsTag to arrive at custom colorimetry in the PCS. Thus, the PCC override provides an alternate definition of the observer's colour matching functions.

(Note: PCC override profiles that apply to this scenario should have the same illuminant as the profile they are overriding to ensure that the standardToCustomPccTag transform is meaningful).

PCS Endpoints

The PCS values coming out of the AToB0Tag from profile E represent media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

This scenario differs from that of scenario B2 in that the PCC information provided to processing elements in BToA0Tag from profile F result in a conversion from colorimetry from a custom observer to RGB device values. Therefore, the PCS values going into the BToA0Tag from profile F represent media-relative XYZ colorimetry for the custom standard observer under D65 lighting.

Transform application with PCS Adjustment/Conversion

Even though the colorimetric PCS encoding (XYZ) is the same between the two profiles, PCS conversion is needed because the illuminants are different.

After the Matric/TRC transform from profile A is applied then the transform in the standardToCustomPccTag from profile H is applied (since profile H provides the PCC override) to convert standard D50/2-degree XYZ values to custom D65/custom observer XYZ values used by the transform in profile F. These resulting XYZ values are then applied to the transform in the BToA1Tag from profile F to get the RGB values to display.

Scenario B4 – Getting colorimetry of a CMYK image

Profile Sequence	Profile Setup		
D → PCS → G	D	Rendering Intent:	Absolute
		Transform Type:	Colorimetric
		PCC Override:	None
	G	Rendering Intent:	Absolute
		Transform Type:	Colorimetric
		PCC Override:	None

In this scenario the CMYK image data is converted to colorimetry.

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB1Tag (associated with the relative intent) being used from profile D are used. This is because the absolute intent is desired and there is no AToB3Tag, so PCS adjustment is performed to covert relative colorimetry to absolute colorimetry.

The tag selection based on rendering intent and transform type results in the BToA3Tag being used from profile G.

PCS Endpoints

The PCS values coming out of the AToB1Tag from profile D represent media-relative Lab colorimetry for the 2-degree standard observer under Illuminant A.

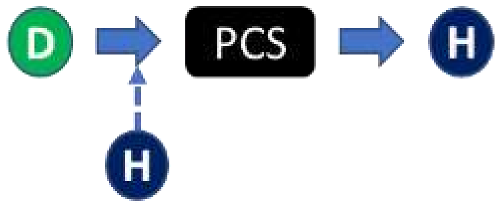
The PCS values going into the BToA0Tag from profile G represent absolute Lab colorimetry for the 2-degree standard observer under Illuminant A.

PCS Adjustment/Conversion

Both profiles share the same colorimetric PCS, illuminant, and observer. However, relative to absolute adjustment is needed and therefore the following PCS adjustment is used:

1. The Lab values coming out of the transform for profile D are converted to XYZ encoding relative to the illuminant XYZ of profile D.
2. The resulting XYZ values are adjusted from relative to absolute XYZ colorimetry using the mediaWhitePointTag from profile D.
3. These resulting XYZ values are converted to Lab encoding and passed into the transform for profile G.

Scenario B5 – Getting custom colorimetry of a CMYK image

Profile Sequence	Profile Setup		
	D	Rendering Intent:	Absolute
		Transform Type:	Spectral
		PCC Override:	H
	H	Rendering Intent:	Absolute
		Transform Type:	Colorimetric
		PCC Override:	None

In this scenario the CMYK image data is converted to custom colorimetry for a specific observer and illuminant. It differs from scenario B4 because a spectral reflectance representation of the CMYK data is used.

This is an example of where a profile is used as both a PCC override as well as a destination profile.

Transform Selection

The tag selection based on rendering intent and transform type results in the DToB3Tag used from profile D, and the BToA3Tag used from profile H.

PCS Endpoints

The PCS values coming out of the DToB3Tag from profile D represent absolute spectral reflectance values.

The PCS values going into the BToA3Tag from profile H represent absolute Lab colorimetry for a custom observer under D65 lighting.

PCS Adjustment/Conversion

PCS conversion is needed because the PCS Endpoints are different. The following PCS conversions/adjustments are performed:

1. The spectral reflectance values coming out of the transform for profile D are used in conjunction with the observer and illuminant from the spectralViewingConditionsTag from profile H (since profile H is used as the PCC override) to get XYZ colorimetry for the custom observer under a D65 illuminant. (Note: spectral range adjustments may also be performed as needed as part of the conversion from spectral reflectance to custom XYZ colorimetry).
2. The custom XYZ values are converted to Lab encoding and passed into the transform for profile H.

Scenario B6 – Getting estimated custom colorimetry of a CMYK image

Profile Sequence	Profile Setup		
D → PCS → H	D	Rendering Intent:	Absolute
		Transform Type:	Spectral
		PCC Override:	None
	H	Rendering Intent:	Absolute
		Transform Type:	Colorimetric
		PCC Override:	None

This scenario is almost identical to scenario B5 with the only difference being that there is no PCC override provided as part of profile D's connection to the PCS.

However, the results of not providing a PCC override in this case are nearly identical to that of using a colorimetric transform type selection for profile D. This is because the conversion to colorimetry going into the PCS will be for the same observer and illuminant as when using the colorimetric transforms from profile D.

This is an example of how using conversion between colorimetry with different observers and illuminants works with iccMAX resulting in an estimation of the change in colorimetry.

This example is also included to point out that subtle differences in the profile setup provided to the CMM can result in significant differences in the PCS adjustment/conversion as well as the final results.

Transform Selection

The tag selection in this scenario are identical to those of scenario B5.

The tag selection based on rendering intent and transform type results in the DToB3Tag being used from profile D, and the BToA3Tag being used from profile H.

PCS Endpoints

The PCS endpoints in this scenario are also identical to those of scenario B5.

The PCS values coming out of the DToB3Tag from profile D represent absolute spectral reflectance values.

The PCS values going into the BToA3Tag from profile H represent absolute Lab colorimetry for a custom observer under D65 lighting.

PCS Adjustment/Conversion

PCS conversion is needed because the PCS endpoints are different. The following PCS conversions/adjustments are therefore performed:

1. The spectral reflectance values coming out of the transform for profile D are converted to XYZ colorimetry using the observer and illuminant from the spectralViewingConditionsTag from profile D to get XYZ colorimetry for the 2-degree standard observer under illuminant A. (Note: the profile connection conditions (PCC) will come from the profile that the transform is associated with unless a PCC override is provided).

2. Since the observer and illuminant for the XYZ values from the previous step are different from the PCS endpoint going into profile G, the transform from the customToStandardPccTag from profile D is applied to get XYZ colorimetry for the 2-degree standard observer under a D50 illuminant. (Note: the 2-degree standard observer under a D50 illuminant is used as an intermediate when converting from colorimetry from one observer/illuminant combination to a different observer/illuminant combination).
3. Since the resulting observer and illuminant for the XYZ values from the previous step is different from the PCS endpoint going into profile H, the transform from the standardToCustomPccTag from profile H is applied to get XYZ colorimetry for the custom observer under a D65 illuminant.
4. The XYZ values for the correct observer and illuminant are then converted to Lab and passed into the transform for profile H.

Scenario B7 – Getting a spectral representation of a CMYK image

Profile Sequence	Profile Setup		
D → PCS → I	D	Rendering Intent:	Absolute
		Transform Type:	Spectral
		PCC Override:	None
	I	Rendering Intent:	Absolute
		Transform Type:	Spectral
		PCC Override:	None

In this scenario the CMYK image data is converted to a multi-spectral representation associated with spectral reflectance.

Transform Selection

The tag selection based on rendering intent and transform type results in the DToB3Tag used from profile D, and the BToD3Tag used from profile I.

PCS Endpoints

The PCS values coming out of the DToB3Tag from profile D represent absolute spectral reflectance values.

The PCS values going into the BToA3Tag from profile I represent absolute spectral reflectance.

PCS Adjustment/Conversion

The PCS endpoints for both profiles are the same in the sense that they share the same spectral PCS so the only adjustment that may be needed is if the spectral ranges are different. (Note: The illuminant and observers of the profiles are ignored and not used as part of the transformation).

If both profiles use the same spectral range then results of applying the transform from profile D are passed directly to the transform from profile I to get the final multispectral encoding.

Otherwise, a spectral range conversion is applied to results of the transform from profile D before passing the results to transform from profile I to get the final multispectral encoding.

Scenario B8 - Printing a material match of a legacy CMYK image (to be viewed under Illuminant A by standard 2-degree observer)

Profile Sequence	Profile Setup		
	C	Rendering Intent:	Perceptual
		Transform Type:	Colorimetric
		PCC Override:	Ignored
	D	Rendering Intent:	Perceptual
		Transform Type:	Colorimetric
		PCC Override:	None

In this scenario a legacy CMYK profile is connected to an iccMAX printer profile that has been profiled for output to be viewed under Illuminant A. The Perceptual intent is used to get a pleasing reproduction.

This is an example of how using a different illuminant works with iccMAX. With V2/V4 profiles the chromatic adaptation is baked into the transforms if the profile is for a different viewing condition, but with iccMAX profiles the conversion between observing conditions (different observer and/or illuminant) is a separate explicit step.

In this case the PCC in Profile D uses a Material Adjustment Transform (MAT) to convert from D50 to Illuminant A. A MAT estimates how the colorimetry of an object will change due to a change in the illuminant or observer (a material match).

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB0Tag being used from profile C, and the BToA0Tag being used from profile D.

PCS Endpoints

The PCS values coming out of the AToB0Tag from profile C represent perceptual media-relative Lab colorimetry for the 2-degree standard observer under a D50 illuminant.

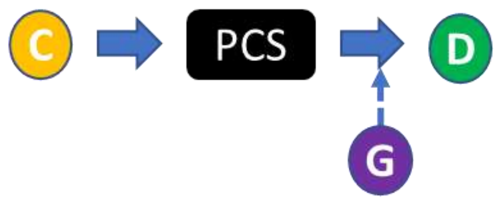
The PCS values going into the BToA0Tag from profile D represent perceptual Lab colorimetry for the 2-degree standard observer under Illuminant A.

PCS Adjustment/Conversion

PCS adjustment/conversion is needed because the PCS endpoints are different (same colour space but different illuminants). The following PCS conversions/adjustments are therefore performed:

1. Lab-to-XYZ conversion is performed on the results coming out of the transform for profile C.
2. Because the XYZ values already represent those of a standard PC, the transform in the standardToCustomPccTag from profile D is applied to convert standard D50/2-degree colorimetry to custom Illuminant A/2-degree colorimetry used by the transform in profile D.
3. An XYZ-to-Lab conversion is then performed and the results are passed to the transform for profile D to get the CMYK values to print.

Scenario B9 - Printing an appearance match of a legacy CMYK image (to be viewed under Illuminant A by standard 2-degree observer)

Profile Sequence	Profile Setup
 	C — Rendering Intent: Perceptual Transform Type: Colorimetric PCC Override: Ignored D — Rendering Intent: Perceptual Transform Type: Colorimetric PCC Override: G

In this scenario a legacy CMYK profile is connected to an iccMAX printer profile that has been profiled for output to be viewed under Illuminant A. The Perceptual intent is used to get a pleasing reproduction.

This is an example of using an alternate transformation from one illuminant to another illuminant through the use of a PCC override. With V2/V4 profiles the chromatic adaptation is baked into the transforms if the profile is for a different viewing condition, but with iccMAX profiles the conversion between observing conditions (different observer and/or illuminant) is a separate explicit step. By using a PCC override, this conversion can be replaced.

In this case, the PCC in Profile G uses a Chromatic Adaptation Transform (CAT) to convert from D50 to Illuminant A. A CAT estimates the colorimetry needed in the target viewing conditions that has the same perceived appearance as the colorimetry in the source viewing condition (an appearance match).

(Note: When replacing the adaptation/adjustment transform using a PCC override, the illuminant and observer of the PCC override should be the same as the illuminant and observer of the profile being overridden).

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB0Tag used from profile C, and the BToA0Tag used from profile D.

PCS Endpoints

The PCS values coming out of the AToB0Tag from profile C represent perceptual media-relative Lab colorimetry for the 2-degree standard observer under a D50 illuminant.

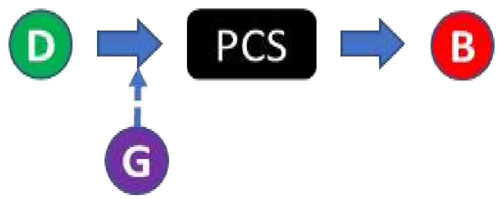
The PCS values going into the BToA0Tag from profile D represent perceptual Lab colorimetry for the 2-degree standard observer under Illuminant A.

PCS Adjustment/Conversion

PCS adjustment/conversion is needed because the PCS endpoints are different (same colour space but different illuminants). The following PCS conversions/adjustments are therefore performed:

1. Lab-to-XYZ conversion is performed to the results coming out of the transform for profile C.
2. Because the XYZ values already represent those of a standard PC, the transform in the standardToCustomPccTag from profile G is applied (since profile G provides the PCC override) to convert standard D50/2-degree colorimetry to custom Illuminant A/2-degree colorimetry used by the transform in profile D.
3. An XYZ-to-Lab conversion is then performed and the results are passed to the transform for profile D to get the CMYK values to print.

Scenario B10 – Viewing an appearance match of a CMYK print (viewed under Illuminant A by the standard 2-degree observer) on a display

<table>
<tr><th>Profile Sequence</th><th colspan="3">Profile Setup</th></tr>
<tr><td rowspan="6">
</td><td rowspan="3">D</td><td>Rendering Intent:</td><td>Relative</td></tr>
<tr><td>Transform Type:</td><td>Colorimetric</td></tr>
<tr><td>PCC Override:</td><td>G</td></tr>
<tr><td rowspan="3">B</td><td>Rendering Intent:</td><td>Relative</td></tr>
<tr><td>Transform Type:</td><td>Colorimetric</td></tr>
<tr><td>PCC Override:</td><td>Ignored</td></tr>
</table>

In this scenario an appearance match on an RGB display is made of a CMYK profile as viewed under Illuminant A by the standard 2-degree observer.

This is an example of using an alternate transformation from one illuminant to another illuminant through the use of a PCC override. With V2/V4 profiles, the chromatic adaptation is baked into the transforms if the profile is for a different viewing condition, but with iccMAX profiles the conversion between observing conditions (different observer and/or illuminant) is a separate explicit step. By using a PCC override, this conversion can be replaced.

In this case the PCC in Profile G uses a Chromatic Adaptation Transform (CAT) to convert from Illuminant A to D50. A CAT estimates the colorimetry needed in the target viewing conditions that has the same perceived appearance as the colorimetry in the source viewing condition (an appearance match).

(Note 1: When replacing the adaptation/adjustment transform using a PCC override, the illuminant and observer of the PCC override should be the same as the illuminant and observer of the profile being overridden).

(Note 2: Though profile D represents a CMYK printer, it could just as easily be a CMYKRGB printer. For legacy V2/V4 profiles this would require large N-dimensional lookup table to encode the CMYKRGB to PCS transform. A CMYKRGB iccMAX profile can implement a device model directly using processing elements in the CMYKRGB to PCS transform tags resulting in smaller / potentially more accurate profiles).

Transform Selection

The tag selection based on rendering intent and transform type results in the AToB1Tag used from profile D, and Matrix/TRC tags are used from profile B. The Matrix/TRC tags from profile B are inverted to transform from XYZ to RGB.

PCS Endpoints

The PCS values coming out of the AToB1Tag from profile D represent media-relative Lab colorimetry for the 2-degree standard observer under illuminant A.

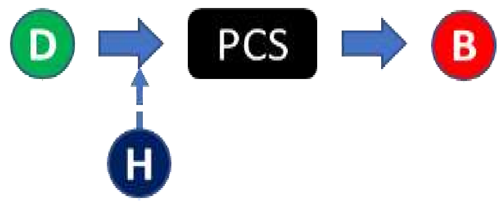
The PCS values going into the inverse Matric/TRC tags from profile B represent media-relative XYZ colorimetry for the 2-degree standard observer with a D50 illuminant.

PCS Adjustment/Conversion

PCS adjustment/conversion is needed because the PCS endpoints are different. The following PCS conversions/adjustments are therefore performed:

1. A Lab-to-XYZ conversion is performed on the results coming out of the transform for profile D.
2. In order to adjust from one viewing condition to another, the transform in the customToStandardPccTag from profile G is applied (since profile G provides the PCC override) to convert custom Illuminant A/2-degree colorimetry to standard D50/2-degree colorimetry.
3. The resulting XYZ values are passed to the transform for profile B to get the resulting RGB values to display.

Scenario B11 – Simulating to the standard observer on an RGB display how a CMYK print under D65 lighting is seen by a custom observer

Profile Sequence		Profile Setup	
	D	Rendering Intent: Transform Type: PCC Override:	Absolute Spectral H
	B	Rendering Intent: Transform Type: PCC Override:	Absolute Colorimetric Ignored

The profile sequence for this scenario looks very similar to that of scenario B6. However, the use of a spectral transform type completely changes the dynamics of the transformations.

This scenario answers the question "If I give a CMYK print to an observer who sees things differently than the standard 2-degree observer who then views the print under D65 lighting conditions, what will the custom observer see?"

This is an example of using the spectral representation of the CMYK data to determine observer/illuminant-specific colorimetry which is then converted to a form that can be presented on an RGB display that will be viewed by a standard observer. Additionally, the definition of the observer and illuminant to use is provided by the use of a PCC override.

In this case, multiple aspects of the PCC in Profile H are used. The spectralViewingConditionsTag from profile H provides the observer and illuminant information for converting reflectance to custom colorimetry, and the customToStandardPccTag from profile H is used to convert custom colorimetry to standard colorimetry.

(Note 1: In this case the observer and illuminant in profile D are ignored as well as the PCS colour spaces in profile H).

(Note 2: Though profile D represents a CMYK printer, it could just as easily be a CMYKRGB printer. For legacy V2/V4 profiles this would require large N-dimensional lookup table to encode the CMYKRGB to PCS transform. A CMYKRGB iccMAX profile can implement a device model directly using processing elements in the CMYKRGB to PCS transform tags resulting in smaller / potentially more accurate profiles).

Transform Selection

The tag selection based on rendering intent and transform type results in the DToB3Tag used from profile D, and Matrix/TRC tags are used from profile B. The Matrix/TRC tags from profile B are inverted to transform from XYZ to RGB.

PCS Endpoints

The PCS values coming out of the DToB3Tag from profile D represent absolute spectral reflectance.

The PCS values going into the inverse Matric/TRC tags from profile B represent media-relative XYZ colorimetry for the 2-degree standard observer with a D50 illuminant.

PCS Adjustment/Conversion

PCS adjustment/conversion is needed because the PCS endpoints are different. The following PCS conversions/adjustments are therefore performed:

1. Spectral reflectance values coming out of the transform from profile D are converted to custom XYZ colorimetry using the observer and illuminant from the spectralViewingConditionsTag from profile H (since profile H provides the PCC override). (Note: spectral range adjustments may also need to be performed as part of the conversion from spectral reflectance to custom XYZ colorimetry).
2. The transform in the customToStandardPccTag from profile H is applied to convert colorimetry for the custom observer under D65 lighting to standard D50/2-degree colorimetry.
3. The mediaWhitePointTag from profile B is used to convert absolute XYZ colorimetry to relative XYZ colorimetry which is then passed into the transform for profile B to get the resulting RGB values to display.

Scenario B12 – Simulating to the standard observer on an RGB display how a CMYK print generated for one observing condition is seen for a different observing condition

Profile Sequence

Profile Setup

Profile	Rendering Intent	Transform Type	PCC Override
A	Perceptual	Colorimetric	Ignored
D_d	Perceptual	Colorimetric	None
D_s	Absolute	Spectral	I
B	Absolute	Colorimetric	Ignored

The profile sequence (like scenario A5) is the concatenation of two profile sequences. The first sequence involves generation of a print to be viewed under specific conditions. The second involves simulation of how that print is seen under different conditions. This scenario answers the question, “If I generate a CMYK print meant to be viewed by the standard 2-degree observer under illuminant A to an observer who see’s things differently than the standard 2-degree observer and then this custom observer views the print under F11 lighting conditions – what will the custom observer see?” In other words, it might be more simply stated as, “What will the guy that makes the approval decision see?”

This is an example of using both the colorimetric and spectral representations of the CMYK data in a printer profile.

In this case, multiple aspects of the PCC in Profile I are used. The spectralViewingConditionsTag from profile I provides the observer and illuminant information for converting reflectance to custom colorimetry, and the customToStandardPccTag from profile I is used to convert custom colorimetry to standard colorimetry.

In this scenario two sequences are concatenated, and in the following discussion the D_d and D_s represent the use of the same profile D as both a destination profile D_d, and as a source profile D_s.

Transform Selection

In the first sequence, the tag selection based on rendering intent and transform type results in the Matrix/TRC tags being used from profile A, and the BToA0Tag from profile D_d being used.

In the second sequence, the tag selection based on rendering intent and transform type results in the DToB3Tag from profile D_s being used, and inverted Matrix/TRC tags being used from profile B.

PCS Endpoints

The PCS values coming out of the Matrix/TRC tags from profile A represent V2 perceptual media-relative XYZ colorimetry for the 2-degree standard observer with a D50 illuminant.

The PCS values going into the BToA0Tag from profile D_d represent V4/iccMAX perceptual media-relative Lab colorimetry for the 2-degree standard observer under illuminant A.

The PCS values coming out of the DToB3Tag from profile D_s represent absolute spectral reflectance.

The PCS values going into the inverse Matrix/TRC tags from profile B represent media-relative XYZ colorimetry for the 2-degree standard observer under D50 lighting.

PCS Adjustment/Conversion

In the both sequences PCS adjustment/conversion is needed because the PCS endpoints are different.

In the first sequence the PCS adjustment/conversion involves:

1. The XYZ encoded values coming out of the transform for profile A are adjusted using a V2 to V4 perceptual black point XYZ adjustment
2. Because the XYZ values already represent those of a standard PC, the transform in the standardToCustomPccTag from profile D_d is applied to convert standard D50/2-degree XYZ colorimetry to custom Illuminant A/2-degree XYZ colorimetry used by the transform in profile D.
3. XYZ encoding to Lab encoding is applied
4. These Lab values are passed into the transform from profile D_d.

The results of applying the BToA0 transform from profile D_d in the first sequence are passed directly in as input the DToB3 transform from profile D_s in the second sequence.

In the second sequence the PCS conversion involves:

1. Spectral reflectance values coming out of the transform from profile D_s are converted to custom XYZ colorimetry for a custom observer under F11 lighting using the observer and illuminant from the spectralViewingConditionsTag from profile I (since profile I provides the PCC override) . (Note: spectral range adjustments may also need to be performed as part of the conversion from spectral reflectance to custom XYZ colorimetry).
2. The transform in the customToStandardPccTag from profile I is applied to convert colorimetry for the custom observer under F11 lighting to standard D50/2-degree colorimetry.

3. The mediaWhitePointTag from profile B is used to convert absolute XYZ colorimetry to relative XYZ colorimetry which is then passed into the transform for profile B to get the resulting RGB values to display.

9 Appendix: Transform Selection and PCS Adjustment Combinations

9.1 V2/V4 Combinations

The table below outlines combined V2/V4 transform selections based on transform selection parameters and rendering intents as discussed in section 5.

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	<u>1</u> → 2	Perceptual	Colour LUT-based	AtoB0Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	<u>1</u> → 2	Perceptual	Colour MPE-based	DtoB0Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	<u>1</u> → 2	Relative	Colour LUT-based	AtoB1Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	<u>1</u> → 2	Relative	Colour MPE-based	DtoB1Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	<u>1</u> → 2	Saturation	Colour LUT-based	AtoB2Tag	Device to XYZ/Lab PCS	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Saturation	Colour MPE-based	DtoB2Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	Colour LUT-based	AtoB1Tag	Device to XYZ/Lab PCS	Relative to Absolute
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	Colour MPE-based	DtoB1Tag	Device to XYZ/Lab PCS	Relative to Absolute
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Perceptual	Colour LUT-based	BtoA0Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Perceptual	Colour MPE-based	BtoD0Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Colour LUT-based	BtoA1Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Colour MPE-based	BtoD1Tag	XYZ/Lab PCS to Device	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Colour LUT-based	BtoA2Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Colour MPE-based	BtoD2Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Colour LUT-based	BtoD1Tag	XYZ/Lab PCS to Device	Absolute to Relative
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Colour MPE-based	BtoD1Tag	XYZ/Lab PCS to Device	Absolute to Relative
N-component LUT-based Input / Display / Output / ColorSpace	1→**2**→3	Perceptual	Preview	Preview0Tag	XYZ/Lab PCS to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1→**2**→3	Relative	Preview	Preview1Tag	XYZ/Lab PCS to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1→**2**→3	Saturation	Preview	Preview2Tag	XYZ/Lab PCS to XYZ/Lab PCS	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	Profile Position	Rendering Intent	Transform Type	Transform Tag	Transform Endpoints	PCS Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1**	*Any*	Gamut	gamutTag	Device to Boolean	No PCS
3-component Matrix-based Input / Display	**1** → 2	Perceptual / Relative / Saturation	Colour Matrix/TRC	*Curves in* redTRCTag, greenTRCTag, blueTRCTag *followed by matrix using* redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag	Device to XYZ PCS	None
3-component Matrix-based Input / Display	**1** → 2	Absolute	Colour Matrix/TRC	*Curves in* redTRCTag, greenTRCTag, blueTRCTag *followed by matrix using* redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag	Device to XYZ PCS	Relative to Absolute
3-component Matrix-based Input / Display	1 → **2**	Perceptual / Relative / Saturation	Colour Matrix/TRC	*Inverse of matrix using* redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag *followd by inverse of curves in* redTRCTag, greenTRCTag, blueTRCTag	XYZ PCS To Device	None
3-component Matrix-based Input / Display	1 → **2**	Perceptual / Relative / Saturation	Colour Matrix/TRC	*Inverse of matrix using* redMatrixColumnTag, greenMatrixColumnTag, blueMatrixColumnTag *followd by inverse of curves in* redTRCTag, greenTRCTag, blueTRCTag	XYZ PCS To Device	Absolute to Relative
Abstract	1 → **2** → 3	*Any*	Colour LUT-based	AtoB0Tag	XYZ/Lab PCS to XYZ/Lab PCS	None
Abstract	1 → **2** → 3	*Any*	Colour MPE-based	DtoB0Tag	XYZ/Lab PCS to XYZ/Lab PCS	None
DeviceLink	**1**	*Any*	Colour LUT-based	AtoB0Tag	Device to Device	None
DeviceLink	**1**	*Any*	Colour MPE-based	DtoB0Tag	Device to Device	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	Profile Position	Rendering Intent	Transform Type	Transform Tag	Transform Endpoints	PCS Adjustment
NamedColor	**1**	*Any*	*Any*	namedColor2Tag	Name to XYZ/Lab PCS, Name to Device, XYZ/Lab PCS to Name, Device to Name	None

Note: The transforms in the preceding table are relative to the profile position that is bold and underlined.

9.2 iccMAX combinations

The table below outlines combined iccMAX transform selections based on transform selection parameters and rendering intents as discussed in section 7.

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	Profile Position	Rendering Intent	Transform Type	Transform Tag	Transform Endpoints	PCS Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	Colorimetric Colour	AtoB0Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	Spectral Colour	DtoB0Tag	Device to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	MCS	AtoM0Tag	Device to MCS	No PCS
N-component LUT-based Input / Display / Output / ColorSpace	**1**	Perceptual	BRDF Parametric Colorimetric	brdfColorimetricParameter0Tag	Device to BRDF parameters for XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	BRDF Parametric Spectral	brdfSpectralParameter0Tag	Device to BRDF parameters for Spectral PCS	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	BRDF Colorimetric	brdfAToB0Tag	Device + Lighting / Viewing angles to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	BRDF Spectral	brdfDToB0Tag	Device + Lighting / Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	BRDF MCS Colorimetric	brdfMToB0Tag	MCS + Lighting / Viewing angles to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	BRDF MCS Spectral	brdfMToS0Tag	MCS + Lighting / Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	Directional Colorimetric	directional AToB0Tag	Device + Position + Viewing angles to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Perceptual	Directional Spectral	directional DToB0Tag	Device + Position + Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1}$	*Any*	Named Colour	namedColor2Tag	Name to XYZ/Lab PCS, Name to Spectral PCS, Name to Device, XYZ/Lab PCS to Name, Device to Name	None
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	Colorimetric Colour	AtoB1Tag or AToB3Tag	Device to XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	Spectral Colour	DtoB1Tag or DToB3Tag	Device to Spectral PCS	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	MCS	AtoM1Tag	Device to MCS	No PCS
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1}$	Relative	BRDF Parametric Colorimetric	brdfColorimetricParameter1Tag or brdfColorimetricParameter3Tag	Device to BRDF parameters for XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	BRDF Parametric Spectral	brdfSpectralParameter1Tag or brdfSpectralParemeter3Tag	Device to BRDF parameters for Spectral PCS	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	BRDF Colorimetric	brdfAToB1Tag or brdfAToD3Tag	Device + Lighting / Viewing angles to XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	BRDF Spectral	brdfDToB1Tag or brdfDToB3Tag	Device + Lighting / Viewing angles to Spectral PCS	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	BRDF MCS Colorimetric	brdfMToB1Tag or brdfMToB3Tag	MCS + Lighting / Viewing angles to XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	BRDF MCS Spectral	brdfMToS1Tag or brdfMToS3Tag	MCS + Lighting / Viewing angles to Spectral PCS	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	$\underline{1} \rightarrow 2$	Relative	Directional Colorimetric	directional AToB1Tag or directional AToB3Tag	Device + Position + Viewing angles to XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	Profile Position	Rendering Intent	Transform Type	Transform Tag	Transform Endpoints	PCS Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Relative	Directional Spectral	directional DToB1Tag or directional DToB3Tag	Device + Position + Viewing angles to Spectral PCS	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	Colorimetric Colour	AtoB2Tag	Device to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	Spectral Colour	DtoB2Tag	Device to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	MCS	AtoM2Tag	Device to MCS	No PCS
N-component LUT-based Input / Display / Output / ColorSpace	1	Saturation	BRDF Parametric Colorimetric	brdfColorimetricParameter2Tag	Device to BRDF parameters for XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	BRDF Parametric Spectral	brdfSpectralParameter2Tag	Device to BRDF parameters for Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	BRDF Colorimetric	brdfAToB2Tag	Device + Lighting / Viewing angles to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	BRDF Spectral	brdfDToB2Tag	Device + Lighting / Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	BRDF MCS Colorimetric	brdfMToB2Tag	MCS + Lighting / Viewing angles to XYZ/Lab PCS	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	BRDF MCS Spectral	brdfMToS2Tag	MCS + Lighting / Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	Directional Colorimetric	directional AToB2Tag	Device + Position + Viewing angles to XYZ/Lab PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Saturation	Directional Spectral	directional DToB2Tag	Device + Position + Viewing angles to Spectral PCS	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Absolute	Colorimetric Colour	AtoB1Tag or AToB3Tag	Device to XYZ/Lab PCS	None or Relative to Absolute XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Absolute	Spectral Colour	DtoB1Tag or DToB3Tag	Device to Spectral PCS	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Absolute	MCS	AtoM1Tag	Device to MCS	No PCS
N-component LUT-based Input / Display / Output / ColorSpace	1	Absolute	BRDF Parametric Colorimetric	brdfColorimetricParameter3Tag or brdfColorimetricParameter1Tag	Device to BRDF parameters for XYZ/Lab PCS	None or Relative to Absolute XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Absolute	BRDF Parametric Spectral	brdfSpectralParameter3Tag or brdfSpectralParameter1Tag	Device to BRDF parameters for Spectral PCS	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → 2	Absolute	BRDF Colorimetric	brdfAToB3Tag or brdfAToD1Tag	Device + Lighting / Viewing angles to XYZ/Lab PCS	None or Relative to Absolute XYZ Adjustment

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	BRDF Spectral	brdfDToB3Tag or brdfDToB1Tag	Device + Lighting / Viewing angles to Spectral PCS	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	BRDF MCS Colorimetric	brdfMToB3Tag or brdfMToB1Tag	MCS + Lighting / Viewing angles to XYZ/Lab PCS	None or Relative to Absolute XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	BRDF MCS Spectral	brdfMToS3Tag or brdfMToS1Tag	MCS + Lighting / Viewing angles to Spectral PCS	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	Directional Colorimetric	directional AToB3Tag or directional AToB1Tag	Device + Position + Viewing angles to XYZ/Lab PCS	None or Relative to Absolute XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Absolute	Directional Spectral	directional DToB3Tag or directional DToB1Tag	Device + Position + Viewing angles to Spectral PCS	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	Colorimetric Colour	BtoA0Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	**1** → 2	Perceptual	Spectral Colour	BtoD0Tag	Spectral PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Perceptual	Directional Colorimetric	directional BToA0Tag	XYZ/Lab PCS + Position + Viewing angles to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Perceptual	Directional Spectral	directional BToD0Tag	Spectral PCS + Position + Viewing angles to Device	None

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Colorimetric Colour	BtoA1Tag or BToA3Tag	XYZ/Lab PCS to Device	None or Absolute to Relative XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Spectral Colour	BtoD1Tag or BToD3Tag	Spectral PCS to Device	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Directional Colorimetric	directional BToA1Tag or directional BToD3Tag	XYZ/Lab PCS + Position + Viewing angles to Device	None or Absolute to Relative XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Relative	Directional Spectral	directional BToD1Tag or directional BToD3Tag	Spectral PCS + Position + Viewing angles to Device	None or Absolute to Relative Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Colorimetric Colour	BtoA2Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Spectral Colour	BtoD2Tag	Spectral PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Directional Colorimetric	directionalBtoA2Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Saturation	Directional Spectral	directionalBtoD2Tag	XYZ/Lab PCS to Device	None
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Colorimetric Colour	BtoD3Tag or BToD1Tag	XYZ/Lab PCS to Device	None or Relative to Absolute XYZ Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Spectral Colour	BtoD3Tag or BToD1Tag	XYZ/Lab PCS to Device	None or Relative to Absolute Spectral Adjustment
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Directional Colorimetric	directional BtoD3Tag or directional BToD1Tag	XYZ/Lab PCS to Device	None or Relative to Absolute XYZ Adjustment

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
N-component LUT-based Input / Display / Output / ColorSpace	1 → **2**	Absolute	Directional Spectral	directional BtoD3Tag or directional BToD1Tag	XYZ/Lab PCS to Device	None or Relative to Absolute Spectral Adjustment
Abstract	1 → **2** → 3	*Any*	Colorimetric Colour	AtoB0Tag	XYZ/Lab PCS to XYZ/Lab PCS	None
Abstract	1 → **2** → 3	*Any*	Spectral Colour	DtoB0Tag	Spectral PCS to Spectral PCS	None
DeviceLink	**1**	*Any*	Colour	AtoB0Tag	Device to Device	No PCS
MultiplexIdentification	**1** → 2	*Any*	Colour	AtoM0Tag	Device To MCS	No PCS
MultiplexLink	**1**	*Any*	Colour	MtoA0Tag	MCS to Device	No PCS
MultiplexVisualization	**1** → 2	Perceptual	Colorimetric Colour	MtoB0Tag	MCS to XYZ/Lab PCS	None
MultiplexVisualization	**1** → 2	Perceptual	Spectral Colour	MtoS0Tag	MCS to Spectral PCS	None
MultiplexVisualization	**1** → 2	Relative	Colorimetric Colour	MtoB1Tag or MtoB3Tag	MCS to XYZ/Lab PCS	None or Absolute to Relative XYZ Adjustment
MultiplexVisualization	**1** → 2	Relative	Spectral Colour	MtoS1Tag or MToS3Tag	MCS to Spectral PCS	None or Absolute to Relative Spectral Adjustment
MultiplexVisualization	**1** → 2	Saturation	Colorimetric Colour	MtoB2Tag	MCS to XYZ/Lab PCS	None
MultiplexVisualization	**1** → 2	Saturation	Spectral Colour	MtoS2Tag	MCS to Spectral PCS	None
MultiplexVisualization	**1** → 2	Absolute	Colorimetric Colour	MtoB3Tag or MtoB1Tag	MCS to XYZ/Lab PCS	None or Relative to Absolute to XYZ Adjustment

Transform Selection Parameters				Transform and PCS Adjustment		
Profile Class	**Profile Position**	**Rendering Intent**	**Transform Type**	**Transform Tag**	**Transform Endpoints**	**PCS Adjustment**
MultiplexVisualization	**<u>1</u>** → 2	Absolute	Spectral Colour	MtoS3Tag or MToS1Tag	MCS to Spectral PCS	None or Relative to Absolute Spectral Adjustment
NamedColor	**<u>1</u>**	*Any*	*Any*	namedColor2Tag	Name to XYZ/Lab PCS, Name to Spectral PCS, Name to Device, XYZ/Lab PCS to Name, Device to Name	None

Note: The transforms in the preceding table are relative to the profile position that is bold and underlined.