Interoperability Conformance Specification: extendedOutput for printing– Part 1: Spectral and custom colorimetric PCS support

Contents

Foreword

This document has been prepared following the ICC Intellectual Property Policy. This policy is based on the ITU-T/ITU-R/ISO/IEC Guidelines for Implementation of the Common Patent Policy (23 April 2012), with interpretations and clarifications to make it specific to ICC. A Patent Statement and Licensing Declaration form is available.

ICC Interoperability Conformance Specifications, of which this document is an example, may be submitted to the competent ISO Technical Committee for consideration and development as an ISO document. If so, this foreword is to be replaced by the appropriate wording supplied by ISO.

Introduction

ISO 20677-1 defines specifications that provide a platform for defining extended (iccMAX) colour management profiles and systems for various colour workflow domains. It provides a platform for which domain specific specifications can be defined that make use of iccMAX extensions to the existing cross-platform profile format of ISO 15076-1. Thus there is greater flexibility for defining colour transforms and profile connection spaces to meet needs that cannot easily be met with ISO 15076-1. It is not envisioned that all colour management systems that use ISO 20677-1 will implement all the features or capabilities it specifies. Requirements specifying restrictions to iccMAX that apply to a particular workflow are defined in workflow domain specifications known as Interoperability Conformance Specifications, of which this document is one example. Additionally, for some domain specific workflows it is envisioned that workflows will connect both to profiles defined by ISO 20677-1 (iccMAX) and those defined by ISO 15076-1.

An Interoperability Conformance Specification (ICS) is approved and registered by the International Color Consortium (ICC). It defines minimum structural and operational requirements for writing and reading ICC profiles in order to address a specific problem and/or functionality that cannot readily be handled using the profile format defined by ISO 15076-1. An ICS document essentially defines restrictions to ISO 20677-1 for a specific use case.

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1 Scope

All parts of this specification define scenario requirements and restrictions to profiles based on ISO 20677-1:2019 for the purpose of defining relationships between print output device encodings a colorimetric Profile Connection Space (PCS) as well as a spectral PCS.

The particular sub-set of the tags defined in ISO 20677-1:2019 that are required to be present is defined, together with any optional tags that are permitted. The connections between profiles are described, and the processing elements that the CMM is required to support are identified.

This part of this ICS defines transforms with limited processing element support but more extended PCS support thus enabling printer profiles to be defined for arbitrary observers and/or illuminants.

This part of this ICS allows for the use of a custom colorimetric PCS using different illuminants and observers with associated PCC tags as defined in ISO 20677-1.

This part of this ICS allows for the ability to use a spectral PCS to determine colorimetry for any observer/illuminant using a Profile Connection Conditions override.

Additionally, other parts of this ICS may allow transforms with more extended processing element support for more complicated modeling and color management situations that allow transforms to provide modeling of surface and lighting geometry.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20677-1:2019, *Image technology colour management — Extensions to architecture, profile format, and data structure: iccMAX*

NOTE: The most recent version of the iccMAX specification is available on the ICC web site [2].

3 Terms and definitions

All terms and definitions relevant to this document are provided in ISO 20677-1:2019.

4 Use case

4.1 Domain

Profiles and workflows conforming to this ICS shall apply to either the domain of printing and output color reproduction with the ability to perform color management for a specified illuminant and observer and determine expected spectral reflectances for any device encoding.

4.2 Intended use

The intended use of this specification is to define workflows for the colour management of printers where there is a need to use data representing spectral reflectance or custom colorimetry. Custom observer and illuminant information are provided (in the spectralViewingConditionsTag) along with transforms to convert between standard (D50 for 2-degree standard observer) and custom observing conditions (via the customToStandardPccTag and the standardToCustomPccTag).

4.3 Restrictions

ISO 20677-1 provides full details of the requirements for iccMAX profiles. This document defines a set of restrictions which apply to profiles created for the specific use case described above. Such restrictions include the sub-set of tags from ISO 20677-1:2019 which are permitted in profiles conforming to this document.

5 Workflow

5.1 Profile sub-classes

A supporting CMM shall support the sub-classes of the profile classes identified in Table 1 for conformance with this ICS. All profile classes are defined in ISO 20677-1.

Table 1. Sub-classes of profile classes defined by this ICS

Profile	Profile class	Sub-class Identifier	Class signature	Sub-class signature
R	printer	extendedOutput	‘prnt’ (70726e74h)	‘ext ’ (78726e67h)

5.2 Connection Scenarios

5.2.1 General

A ‘ext ’ extendedOutput printer profile connects *X* input channels (where *X* corresponds to the number of channels of the Data colour space field of the header) to a Lab or XYZ colorimetric Profile Connection Space. Profiles conformant to this specification can be used as either a source profile or a destination profile.

Additionally, an extendedOutput printer profile can be used to connect *X* input channels (where *X* corresponds to the number of channels of the Data colour space field of the header) to a spectrally based Profile Connection Space.

5.2.2 Profiles for ICS workflow scenarios

Table 2 provides overview information about additional profiles that are used to describe several profile connection scenarios conforming to this part of this ICS.

Table 2. Additional profiles referenced in workflow scenarios defined by this ICS

Profile	Description
C	Profile conforming to ISO 20677-1 or ISO 15076-1 containing (a) colorimetric transform(s) with CMM configured to use a colorimetric transform type
S	Profile conforming to ISO 20677-1 containing (a) spectral transform(s) with CMM configured to use a spectral transform type
P	Profile conforming to ISO 20677-1 containing Profile Connection Condition tags (spectralViewingConditionsTag, customToStandardPccTag, standardToCustomPccTag)
1	Profile conforming to ISO 20677-1 or ISO 15076-1
2	Profile conforming to ISO 20677-1 utilizing Profile Connection Conditions to go into or out of the PCS

5.2.3 Workflow Scenarios

5.2.3.1 General

The following sections document scenarios that conform to this part of this ICS. For each scenario the profile sequence is depicted along with associated CMM control parameters that select between workflow scenarios.

5.2.3.2 Scenario A.1: Connecting an extendedOutput profile as source to a destination profile with a colorimetric PCS

Figure 1 – Profile sequence for Scenario A.1

In this scenario a profile conforming to this ICS (profile R from Table 1) is used as a source profile with a colorimetric PCS connected to an arbitrary profile (profile C from Table 2) that is set up to use a colorimetric PCS. The transform type for profile R is "colorimetric" indicating that the transform from an AToBxTag from profile R is used to transform device values to a colorimetric PCS.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 1 with the associated CMM control parameters as identified in Table 3 and described by ISO 20677:2019 Annex K.

Table 3. CMM control parameters for Scenario A.1

Profile	CMM Control Parameter	Value
R	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	None
C	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	Any

If the observing conditions of profile R do not match those of Profile C then the transform from the customToStandardTag in profile R is applied resulting in standard colorimetry in the PCS.

The resulting colorimetry from the transform in Profile R is transformed and applied as needed according to the rules (ICS or specification) associated with profile C.

5.2.3.3 Scenario B.1: Connecting an extendedOutput profile as source using a PCC override to a destination profile with a colorimetric PCS

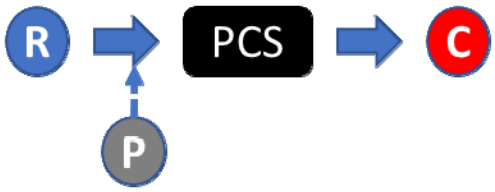

Figure 2 – Profile sequence for Scenario B.1

In this scenario a profile conforming to this ICS (profile R from Table 1) is used as a source profile with a colorimetric PCS connected to an arbitrary profile (profile C from Table 2) that is set up to use a colorimetric PCS. The transform type for profile R is "colorimetric" indicating that the transform from an AToBxTag from profile R is used to transform device values to a colorimetric PCS.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 2 with the associated CMM control parameters as identified in Table 4 and described by ISO 20677:2019 Annex K.

Table 4. CMM control parameters for Scenario B.1

Profile	CMM Control Parameter	Value
R	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	P
C	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	Any

If the observing conditions of profile R do not match those of Profile C then the transform from the customToStandardTag in profile P is applied (as it supplies the PCC override) resulting in standard colorimetry in the PCS. The observing conditions associated with profile P shall match the observing conditions of Profile R.

The resulting colorimetry is then transformed and applied as needed according to the requirements (ICS or specification) associated with profile C.

5.2.3.4 Scenario C.1: Connecting an extendedOutput profile as spectral source to a destination profile with a colorimetric PCS

Figure 3 – Profile sequence for Scenario C.1

In this scenario a profile conforming to this ICS (profile R from Table 1) is used as a source profile with a spectral PCS connected to an arbitrary profile (profile C from Table 2) that is set up to use a colorimetric PCS. The transform type for profile R is "spectral" indicating that the transform from an AToBxTag from profile R is used to transform device values to a spectral PCS.

In this scenario the observing conditions in the spectralViewingConditions tag in profile R are used to convert spectral PCS values to colorimetric values.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 3 with the associated CMM control parameters as identified in Table 5 and described by ISO 20677:2019 Annex K.

Table 5. CMM control parameters for Scenario C.1

Profile	CMM Control Parameter	Value
R	Rendering Intent	Any
	Transform Type	Spectral
	PCC Override	None
C	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	Any

If the observing conditions associated with profile R do not match those of profile C then the customToStandardTag in profile R is applied resulting in standard colorimetry in the PCS.

The resulting colorimetry from the transform in Profile R is transformed and applied as needed according to the requirements (ICS or specification) associated with profile C.

5.2.3.5 Scenario D.1: Connecting an extendedOutput profile as spectral source using a PCC override to a destination profile with a colorimetric PCS

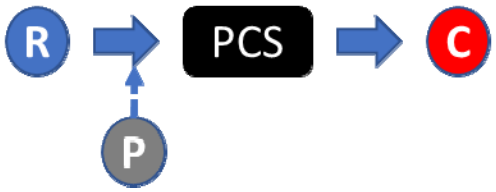

Figure 4 – Profile sequence for Scenario D.1

In this scenario a profile conforming to this ICS (profile R from Table 1) is used as a source profile with a spectral PCS connected to an arbitrary profile (profile C from Table 2) that is set up to use a colorimetric PCS. The transform type for profile R is "spectral" indicating that the transform from a DToBxTag from profile R is used to transform device values to a spectral PCS.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 4 with the associated CMM control parameters as identified in Table 6 and described by ISO 20677:2019 Annex K.

Table 6. CMM control parameters Scenario D.1

Profile	CMM Control Parameter	Value
R	Rendering Intent	Any
	Transform Type	Spectral
	PCC Override	P
C	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	Any

In this case the observing conditions of profile R need not match those of profile C. The observing conditions in the spectralViewingConditions tag in profile P are used to convert spectral PCS values to colorimetric values (as it provides the PCC override).

If the observing conditions of profile P do not match those of profile C then the CustomToStandardTag in profile P is applied (as it provides the PCC override) resulting in standard colorimetry in the PCS.

The resulting colorimetry is then transformed and applied as needed according to the requirements (ICS or specification) associated with profile C.

5.2.3.6 Scenario E.1: Connecting an extendedOutput profile as spectral source to a destination profile with a spectral PCS

Figure 5 – Profile sequences for Scenario E.1

In this scenario a profile conforming to this ICS (profile R in Table 1) is used as a source profile with a spectral PCS connected to an arbitrary profile (profile S in Table 2) that is set up to use a spectral PCS. The transform type for profile R is "spectral" indicating that the transform from a DToBxTag from profile R is used to transform device values to a spectral PCS.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 5 with the associated CMM control parameters as identified in Table 7 and described by ISO 20677:2019 Annex K.

Table 7. CMM control parameters for Scenario E.1

Profile	CMM Control Parameter	Value
R	Rendering Intent	Any
	Transform Type	Spectral
	PCC Override	None
S	Rendering Intent	Any
	Transform Type	Spectral
	PCC Override	Any

Spectral range adjustment and PCS conversion are performed as needed.

The resulting spectral data is then transformed and applied as needed according to the requirements (ICS or specification) associated with profile S.

5.2.3.7 Scenario F.1: Connecting a source profile to an extendedOutput profile as destination

Figure 6 – Profile sequences for Scenario F.1

In this scenario an arbitrary profile (profile 1 in Table 2) is connected to a profile conforming to this ICS (profile R in Table 1) used as a destination profile.

Device values are first transformed to a colorimetric PCS according to the rules (ICS or specification) associated with profile 1.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 6 with the associated CMM control parameters as identified in Table 8 and described by ISO 20677:2019 Annex K.

Table 8. CMM control parameters for Scenario F.1

Profile	CMM Control Parameter	Value
1	Rendering Intent	Any
	Transform Type	Any
	PCC Override	Any
R	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	None

If the observing conditions for profile R do not match those of the PCS resulting from applying profile 1 and the observing conditions for profile R are not the same as the 2-degree observer under D50 then the transform in the standardToCustomPccTag from profile R is applied.

The resulting colorimetry is then transformed by a BToAxTag from profile R since it is using the colorimetric transform type.

5.2.3.8 Scenario G.1: Connecting a source profile to an extendedOutput profile as destination using a PCC override

Figure 7 – Profile sequences for Scenario G.1

In this scenario an arbitrary profile (profile 1 from Table 2) is connected to a profile conforming to this ICS (profile R from Table 1) used as a destination profile.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 7 with the associated CMM control parameters as identified in Table 9 and described by ISO 20677:2019 Annex K.

Table 9. CMM control parameters Scenario G.1

Profile	CMM Control Parameter	Value
1	Rendering Intent	Any
	Transform Type	Any
	PCC Override	Any
R	Rendering Intent	Any
	Transform Type	Colorimetric
	PCC Override	P

Device values are first transformed to a colorimetric PCS according to the requirements (ICS or specification) associated with profile 1.

If the observing conditions for profile R do not match those of the PCS resulting from applying profile 1 and the observing conditions for profile R are not the same as the 2-degree observer under D50 then the transform in the standardToCustomPccTag from profile P is applied (as it provides the PCC override).

The resulting colorimetry is then transformed by a BToAxTag from profile R since it is using the colorimetric transform type.

5.2.3.9 Scenario H.1: Using an extendedOutput profile as a PCC override

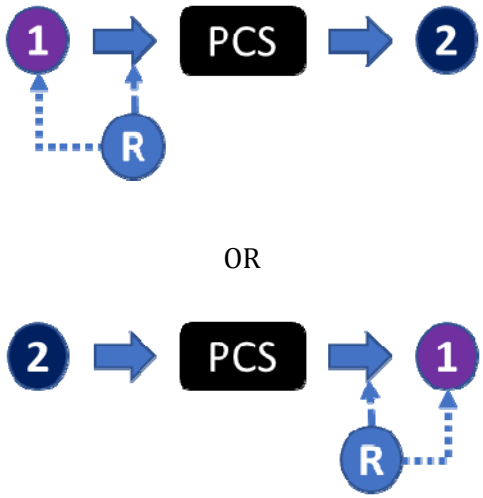

Figure 8 – Profile sequences for Scenario H.1

In this scenario the profile connection conditions of a profile conforming to this specification (from Table 1) are used as a PCC override of an arbitrary profile 1 (from Table 2). The observing conditions from the spectralViewingConditions Tag of Profile R may be used as part of the application of the transform (via processing elements that use a PCC observer or illuminant to perform transform) or PCS conversion/adjustment for profile 1. Additionally, the transform from the standardToCustomPccTag or customToStandardPccTag of profile R may be applied as needed as part of the PCS conversion/adjustment for profile 1.

In this case all other transforms of profile R are ignored.

A CMM that supports this scenario shall be configured to process profiles in the sequence shown in Figure 8 with the associated CMM control parameters as identified in Table 10 and described by ISO 20677:2019 Annex K.

Table 10. CMM control parameters Scenario H.1

Profile	CMM Control Parameter	Value
1	Rendering Intent	Any
	Transform Type	Any
	PCC Override	R
2	Rendering Intent	Any
	Transform Type	Any
	PCC Override	Any

5.3 Other scenario implementation details

Application of abstract class profiles is also possible as part of additional PCS processing associated with the scenarios in section 5.2.

6 Sub-class Profile Requirements

6.1 General

Requirements for iccMAX profiles conforming to this ICS document are listed here. ICC v4 profiles shown in Section 5 above shall conform to ISO 15076-1.

6.2 Requirements

The requirements for the extendedOutput sub-class of output class profiles are shown below.

The encoding of the profile header shall be as defined in ISO 20677-1, with the specific requirements shown in Table 11.

Table 11. Header requirements

Header field	Required content
Profile class	'prtr' (70727472h)
Profile subclass	'ext ' (65787420h)
Profile subclass major version	1
Profile subclass minor version	0
Profile flags	0
Device attributes	0 or 1
Data colour space	'CMYK' (434d594bh) or 'CMY ' (434d5920h) or 'RGB' (58595a20h) or 'GRAY' (47524159h) or 'XCLR' or 'ncXXXX (6e63XXXXh)
MCS	0
Colorimetric PCS	'Lab' (4c616220h) or 'XYZ' (58595a20h)
PCS Illuminant XYZ	Normalized XYZ tristimulus values corresponding to illuminant and observer in spectralViewingConditionsTag
Spectral PCS	'rsXXXX' (7273XXXXh) or 'tsXXXX' (7473XXXXh)
Spectral PCS range	startWavelength : endWavelength : numSteps
Bispectral PCS	0

Full details of the encoding of the header fields in Table 11 are given in ISO 20677-1.

6.2.1 Required tags

Profiles shall contain the tags listed in Table 12.

Table 12. Required tags

Tag name	Signature	Required content
AToB1Tag or AToB3Tag	'A2B1' or 'A2B3'	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement, and extendedCLUTElement
BToA1Tag or BToA3Tag	'B2A1' or 'B2A3'	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement, and extendedCLUTElement
DToA3Tag	'D2B3'	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement, and extendedCLUTElement
spectralWhitePointTag	'swpt'	float16ArrayType, float32ArrayType, or uInt16ArrayType containing spectral PCS values associated with media white point
customToStandardPccTag	'c2sp'	multiProcessElementType containing a single 3x3 matrix element
standardToCustomPccTag	's2cp'	multiProcessElementType containing a single 3x3 matrix element
spectralViewingConditionsTag	'svcn'	Structure defining observer, illuminant and (optionally) surround
colorantInfoTag	'clin'	Information about device channels (Required when device colour space is 'XCLR' or 'ncXXXX'

The encoding of the tags listed in Table 12 shall be as defined in ISO 20677-1:2019.

6.2.2 Additional optional tags

Profiles may also contain (but not limited to) the tags listed in Table .

Table 13. Additional optional tags

Tag name	Signature	Content requirements
AToBxTag	'A2Bx' where x is different from tag used in Table 4	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement, and extendedCLUTElement
BToAxTag	'B2Dx' where x is different from tag used in Table	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement,

	4	and extendedCLUTElement
DToBxTag	'D2Bx' where x≠3	multiProcessElementType using any combination of curveSetElement, matrixElement, CLUTElement, and extendedCLUTElement
gamutBoundaryDescriptionXTag	'gbdX' where X is associated with a rendering intent	gamutBoundaryDescriptionType
colorantOrderTag	'cloo'	Information about print order of device channels
chromaticAdaptationTag	'chad'	s15Fixed16ArrayType containing 9 numbers representing a chromatic adaptation matrix applied to get encoding of adapted XYZ values used in colour transforms when the profile's PCS illuminant is D50 and the profile's PCS observer is the standard 2-degree observer Note: The contents of this tag are informational only and considered as a private tag by the CMM with no implied processing

6.2.3 Processing element restrictions

Processing elements in tags encoded using the multProcessElementType shall be limited in this part of this specification to a subset of the possible processing elements defined in ISO 20677-1:2019. The supported set of multi-processing elements for each of the tags from Tables 12 and 13 are listed in Table 14.

Table 14. Supported processing elements by Tag

Tag names	Element name	Element signature	Special requirements
AToBxTag or BToAxTag or DToBxTag where x is associated with a rendering intent	curveSetElement,	'cvst'	None
	matrixElement	'matf'	None
	CLUTElement	'clut'	None
	extendedCLUTElement	'xclt'	None
customToStandardPccTag or standardToCustomPccTag	matrixElement	'matf '	Limited to 3x3 Matrix

6.2.4 Example

The profile CRPC6-V5-Part1.icc is encoded according to the requirements of this ICS document and is available in the iccMAX Testing Suite v.2.1.17 [3].

NOTE An XML representation of the example profile is also provided in the iccMAX Testing Suite.

7 Conformance

A profile shall be considered to be in conformance with this ICS document if it meets the following conditions:

- The profile connects to the channels specified in section 5.
- The profile header includes the required content from Table 11.
- All required tags listed in Table 12 are present in the profile.
- The profile structure and all tags conform to ISO 20677-1:2019.

A CMM shall be considered to be in conformance with this ICS if it meets the following conditions:

- The CMM is able to parse profiles that conform to this ICS
- The CMM supports and is capable of processing the channels specified in section 5 and any other profiles listed in Table 2 in the scenarios described in section 5.
- The CMM is able to process the tags listed in Tables 12 and Table 13 (as appropriate).
- When processing a profile conforming to this ICS, the CMM produces results that are a close approximation to those produced by the iccMAX Demo Implementation [3]

Bibliography

[1] ISO 20677-1:2019, *Image technology colour management — Extensions to architecture, profile format, and data structure*

[2] iccMAX http://www.color.org/iccmax/

[3] iccMAX Demo Implementation http://www.color.org/iccmax/index.xalter#reficcmax

