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Grafisk teknik — Bildteknik för färgstyrning – Utökad arkitektur, profilformat och datastruktur för iccMAX (ICC v5) (ISO 20677:2019, IDT)

Image technology colour management – Extensions to architecture, profile format and data structure (ISO 20677:2019, IDT)

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The International Standard ISO 20677:2019 has the status of a Swedish Standard. This document contains the official English version of ISO 20677:2019.

Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00. Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.

Information about the content of the standard is available from the Swedish Standards Institute (SIS), telephone +46 8 555 520 00. Standards may be ordered from SIS, who can also provide general information about Swedish and foreign standards.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 130, *Graphic technology*, in cooperation with the International Color Consortium (ICC).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

0 General

This document defines specifications that provide a platform for defining extended (iccMAX) colour management profiles and systems for various colour workflow domains. It can be thought of as an extension to ISO 15076-1, defined by the International Color Consortium® (ICC). ISO 15076-1 specifies a profile format that is intended to provide a cross-platform profile format for the creation and interpretation of colour data. Central to ISO 15076-1 is the encoding of colour transforms between device colour encodings and profile connection spaces (PCSs) based upon D50 colorimetry with the CIE 1931 Standard 2-degree observer. For many workflows ISO 15076-1 has proven adequate for defining successful colour management systems. For other workflows ISO 15076-1 has been found to be limited in the flexibility of encoding colour transforms as well as defining means of profile colour connection that incorporate physical attributes of colour in addition to mere colour appearance.

The intent of this document is to provide a platform on which domain-specific specifications can be defined that make use of these extensions to the existing cross-platform profile format of ISO 15076-1. Thus, there is greater flexibility for defining colour transforms and PCSs to meet needs that cannot easily be met with ISO 15076-1. As such, it is not envisioned that all colour management systems that use this document will implement all the features or capabilities specified by this document. Specific requirements related to what is necessary to be implemented and supported relative to this document can be found in workflow domain specifications. Additionally, for some domain-specific workflows it is envisioned that there will be the need for simultaneous support for and interaction between ISO 15076-1 and profiles defined by this document.

It is assumed that the reader of this document has a good understanding of ISO 15076-1 as well as a good understanding of colour science and imaging, such as familiarity with CIE, ISO and IEC colour standards, general knowledge of device measurement and characterization, and familiarity with at least one operating system level colour management system.

The following subclauses introduce a few of the more significant differences from ISO 15076-1.

0.1 Extended profile connection spaces

0.1.1 ISO 15076-1 PCS encoding

In ISO 15076-1 PCS transform results are encoded relative to D50 with a 2-degree observer. If and when ISO 15076-1-based profiles are used in conjunction with this document, the PCS encoding specified in ISO 15076-1 are used with necessary conversions as needed.

0.1.2 Extended PCS encoding

PCS encoding is extended to allow PCS transform results to be relative to arbitrary illuminants and observers. Profile connection conditions (PCC) provided by either a profile or directly to the colour management module (CMM) can be applied to convert between different illuminants and observers. Additionally, a profile can define use of a spectrally-based PCS independent of the colorimetric-based PCS usage, with separate transform data between device encoding and the colorimetry and spectral PCS encodings.

0.2 Extended transform encoding

0.2.1 ISO 15076-1 transform encoding

ISO 15076-1 defines transforms using integer encoding in AToBx and BToAx tags. Floating point transform encoding can additionally be specified in optional DToBx and BToDx tags using multi-processing element tags.

Integer-based LUT tags have specific requirements for transform data and order.

The multi-processing element tag type allows a sequence of transform elements to be applied in order to transform between device encoding and PCS encoding. The processing elements consist of matrices, one-dimensional curve sets and *n*-dimensional lookup tables.

0.2.2 iccMAX extended transform encoding

Spectrally-based PCS transforms are encoded using DToBx/BToDx tags when a spectral PCS is used. Colorimetric-based PCS transforms are encoded in matrix/TRC based profiles or AToBx/BToAx tags. Additionally, AToBx/BToAx tag transforms can be encoded using the multi-processing element tag type.

The multi-processing element tag type is extended to provide greater flexibility as well as encoding brevity in defining transforms. Extended elements include a stack-based programmable transform calculator, single-segment curves, N-D lookup tables with integer encoding, colour appearance model (CAM) conversions, sparse matrix processing and tint arrays.

Multi-processing element-based tags are used to define PCC within a profile. The CMM applies these tags as needed to perform PCS conversions.

0.2.3 Late-binding processing elements

The multi-processing element tag type has been extended to allow for processing elements that provide late-binding of the observer and/or illuminant from the PCC utilized by the profile. Either spectral information inside select processing elements is converted to colorimetric data shortly before processing of colour transforms is to be performed, or spectral to colorimetric transforms are established for processing of colour transformations. This late-binding of spectral to colorimetric processing is based on the PCC utilized by the multi-processing element. The media-white point and illuminant colorimetry used for absolute/relative PCS processing is also adjusted based upon the combined profile/PCC relationships when late-binding processing elements are used.

0.3 Colour encoding space profiles

0.3.1 General

In ISO 15076-1, profiles define transforms that go from device to PCS. However, in some workflows the essential requirement is a method of defining what the data are rather than providing a transform that converts the data into a representation of colour.

0.3.2 Colour space encoding

This document establishes a ColorEncodingSpace profile class to define profiles that can be used when the content owner wishes to identify the colour encoding of digital colour content and does not wish to provide a colour transformation to be used in converting or adapting the digital colour content from the identified current colour space encoding to any other colour space encoding.

0.4 Multiplex connection space profiles

0.4.1 General

Generally, the data encoding sides of profile transforms are not used to connect profiles using ISO 15076-1. Connection of data encoding channels is only meaningful when the number, order and encoding of the data encoding channels are identical. However, in some workflows, flexibility in the number and order of the channels is desirable with a meaningful way of identifying the encoding of the channels.

0.4.2 Multiplex connection space encoding

This document defines an additional profile connection mechanism that allows multiplex connection space (MCS) channels to be connected. MCS connection provides a means of defining flexible connection between “device like” channels of profiles that are identified by name. Order and existence of channels is flexible with the ability for a profile to specify subset requirements on the MCS channels in the connected profile and default values specified for missing channels. The input profile class has been extended to have an optional tag that connects to an MCS. Additionally, MultiplexLink and MultiplexVisualization profile classes have been defined for MCS processing.

0.5 Bidirectional reflection distribution function (BRDF) and directional emission profiles

0.5.1 General

ISO 15076-1 assumes 0:45 measurement geometry for reflection prints and diffuse radiance of displays. However, in many conditions colour appearance can change due to changes in lighting or viewing angle. Such goniochromatic effects cannot be encoded or communicated using ISO 15076-1.

0.5.2 Bidirectional reflection distribution function encoding

This document provides the ability to encode bidirectional reflection distribution function (BRDF) information, as well as example surface information, that 3D rendering systems can use to emulate goniochromatic effects. In this case the BRDF information is provided directly to the 3D rendering system without extensive colour management system involvement. Additionally, BRDF information can be used to define and communicate goniochromatic properties of named colours.

0.5.3 Directional emission function encoding

This document provides the ability to encode directional emission information which can be used to define and communicate goniochromatic properties of colours by viewing angle and relative position on a display.

0.6 Rendering intents

In ISO 15076-1 four rendering intents are defined: perceptual, media-relative colorimetry, ICC-absolute colorimetry and saturation. For the purposes of supporting spectrally-based PCSs, the media-relative colorimetry and ICC-absolute colorimetry intents are referred to in this document as media-relative and ICC-absolute intents which apply to both colorimetric as well as spectral conditions.

Image technology colour management — Extensions to architecture, profile format and data structure

1 Scope

This document is based on ISO 15076-1, and describes an expanded profile specification and profile connections that permit greater flexibility and functionality than ISO 15076-1. All definitions and requirements in ISO 15076-1 are therefore in force unless otherwise specified by this document. This document defines minimum structural and operational requirements for writing and reading ICC profiles. Additional workflow requirements and restrictions are defined in domain-specific interoperability conformance specification (ICS) documents approved and registered by the ICC.

In this document, some ISO 15076-1 types have been removed, and others have been added. A colour management module (CMM) compatible with profiles conforming to this document will have backwards compatibility with profiles conforming to ISO 15076-1.

Where the name of a type in this document is the same as a type in ISO 15076-1, the type definition is based on the ISO 15076-1 definition. The exception is the definition of the MPE type, which has been expanded.

Where the extensions described in this document are not required in a particular workflow, ISO 15076-1 is used as the basis for colour management profiles and architectures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15076-1, *Image technology colour management — Architecture, profile format and data structure — Part 1: Based on ICC.1:2010*

ISO 17972-1, *Graphic technology — Colour data exchange format — Part 1: Relationship to CxF3 (CxF/X)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
profile connection conditions
PCC
information used to define illuminant, observer for PCS along with transforms to convert to and from custom colorimetry and standard D50 colorimetry for the standard 2° observer

3.1.2
profile connection space
PCS
colour space used to connect the source and destination profiles

Note 1 to entry: See ISO 15076-1:2010, Annex D for a full description.

3.2 Abbreviated terms

ANSI	American National Standards Institute
BRDF	bidirectional reflectance distribution function
CAM	colour appearance model
CIE	*Commission Internationale de l'eclairage* (International Commission on Illumination)
CLUT	colour lookup table (multi-dimensional)
CMM	colour management module
CMY	cyan, magenta, yellow
CMYK	cyan, magenta, yellow, key (black)
CRD	colour rendering dictionary
CRT	cathode-ray tube
EPS	encapsulated postscript
ICC	International Color Consortium
ICS	interoperability conformance specification
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LCD	liquid crystal display
LUT	lookup table
MCS	multiplex connection space
PCC	profile connection conditions
PCS	profile connection space
RGB	red, green, blue
TIFF	tagged image file format
TRC	tone reproduction curve

4 Extended basic types

4.1 General

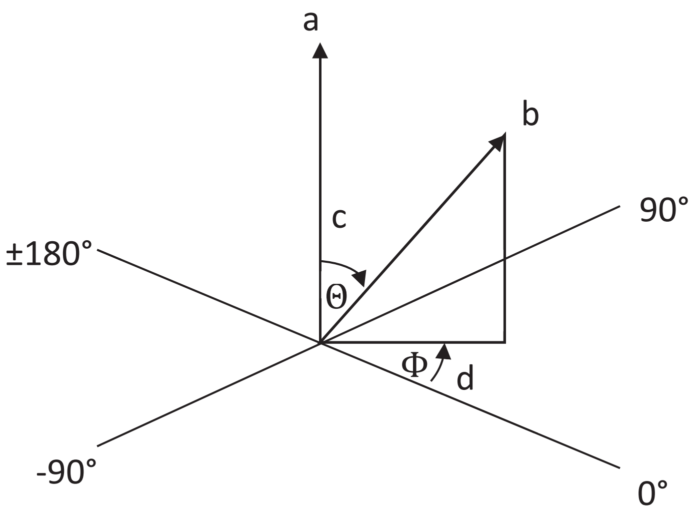
This document assumes the inclusion of all basic types listed in ISO 15076-1, with the exception of 7-bit ASCII. Only extended types in this document are listed below.

4.2 Extended basic type listing

4.2.1 azimuthNumber

An azimuthNumber corresponds to an azimuth angle for BRDF and directional transformations. It shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the BRDF function tags (brdfAToB0Tag, brdfAToB1Tag, brdfAToB2Tag, brdfAToB3Tag, brdfBToA0Tag, brdfBToA1Tag, brdfBToA2Tag, brdfBToA3Tag, brdfBToD0Tag, brdfBToD1Tag, brdfBToD2Tag, brdfBToD3Tag, brdfDToB0Tag, brdfDToB1Tag, brdfDToB2Tag, brdfDToB3Tag, directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The azimuthNumber encoding range shall be from 0,0 to 1,0, with 0,0 representing −180,0 degrees and 1,0 representing +180,0 degrees. Figure 1 shows the azimuth angle in relation to the normal and zenith angles.



Key

a surface normal

b lighting/viewer

c zenith angle

d azimuth angle

Figure 1 — Normal, zenith and azimuth angles

4.2.2 float16Number

A float16Number shall be a half-precision 16-bit floating-point number as specified in IEEE 754, excluding infinities and “not a number” (NaN) values.

NOTE 1 A 16-bit IEEE 754 floating-point number has a 5-bit exponent and a 10-bit mantissa.

NOTE 2 Although infinities and NaN values are not stored in the ICC profile, such values can occur as a result of CMM computations.

4.2.3 float64Number

A float64Number shall be a double-precision 64-bit floating-point number as specified in IEEE 754, excluding infinities, and "not a number" (NaN) values.

NOTE 1 A 64-bit IEEE 754 floating-point number has an 11-bit exponent and a 52-bit mantissa.

NOTE 2 Although infinities and NaN values are not stored in the ICC profile, such values can occur as a result of CMM computations.

4.2.4 horizontalNumber

A horizontalNumber corresponds to the horizontal relative position of a viewing field for directional transformations. It shall be encoded as a floating point number that is provided as input to a multiProcessElementType in any of the directional function tags (directionalAToB0Tag, directionalAToB1Tag, directionalAToB2Tag, directionalAToB3Tag, directionalBToA0Tag, directionalBToA1Tag, directionalBToA2Tag, directionalBToA3Tag, directionalBToD0Tag, directionalBToD1Tag, directionalBToD2Tag, directionalBToD3Tag, directionalDToB0Tag, directionalDToB1Tag, directionalDToB2Tag, directionalDToB3Tag).

The horizontalNumber encoding range shall be from −1,0 to 1,0 with −1,0 representing the leftmost position, 0,0 representing the center and 1,0 representing the rightmost position.

4.2.5 Sparse matrix encodings

4.2.5.1 General

Sparse matrices shall be encoded using compressed row order, which facilitates efficient multiplication of column vectors as well as the interpolation between sparse matrices. A sparse matrix shall be encoded as a variable structure with internal padding within a fixed size data block. The use of a fixed data block size allows for the efficient indexing of arrays of sparse matrices.

In addition to encoding the number of rows, number of columns and number of matrix data entries, the compressed row order encoding shall include three sub-arrays: a padded array of matrix entry data values, a padded array of matrix entry column identifiers, and an array of offsets to successive rows stored in the matrix data and column index arrays.

Successive offset values in the row start offset array shall be greater than or equal to preceding values. The number of matrix data entries associated with a row can therefore be found by subtracting the offset of the row by the offset of the succeeding row.

Successive matrix entry column index values associated with any single row shall be monotonically increasing.

Information about operations with sparse matrices can be found in Annex E.

Multiple sparse matrix encodings are permitted, but shall differ in the encoding of the matrix entry data values as follows:

— The sparseMatrixUInt8 encoding shall use uInt8Numbers to encode matrix data values (Table 1). The internal representation of the values 0 to 255 shall represent matrix values 0,0 to 1,0.

— The sparseMatrixUInt16 encoding shall use uInt16Numbers to encode matrix data values (Table 2). The internal representation of the values 0 to 65 535 shall represent matrix values 0,0 to 1,0.

— The sparseMatrixFloat16 encoding shall use float16Numbers to encode matrix values (Table 3).

— The sparseMatrixFloat32 encoding shall use float32Numbers to encode matrix values (Table 4).

Table 1 — sparseMatrixUInt8 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number of matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column index array	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N-1	N	Matrix entry data array	uInt8Number[N]
O+N...end		Data padding, shall be 0	

Table 2 — sparseMatrixUInt16 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns(C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*2-1	N*2	Matrix entry data values	uInt16Number[N]
O+N*2...end		Data padding, shall be 0	

Table 3 — sparseMatrixFloat16 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*2-1	N*2	Matrix entry data values	float16Number[N]
O+N*2...end		Data padding, shall be 0	

Table 4 — sparseMatrixFloat32 encoding

Byte position	Field length (bytes)	Content	Encoded as...
0...1	2	Rows (R)	uInt16Number
2...3	2	Columns (C)	uInt16Number
4...3+R*2	R*2	Row start offset array	uInt16Number[R]
4+R*2...5+R*2	2	Number matrix entries (N)	uInt16Number

Table 4 *(continued)*

Byte position	Field length (bytes)	Content	Encoded as...
6+R*2...5+R*2 + N*2	N*2	Matrix entry column indices	uInt16Number[N]
6+R*2+N*2...O-1		Index padding, shall be 0	
O...O+N*4-1	N*4	Matrix entry data values	float32Number[N]
O+N*4...end		Data padding, shall be 0	

4.2.5.2 Compact padding

When sparse matrices are encoded in a profile they shall be compacted so that the index and data padding result in the matrix entry data values and the end of the sparse matrix being aligned on a 4 byte boundary.

NOTE Compact padding can result in variability in the size of individual sparse matrices in a sparse matrix array or sparse matrix LUT.

4.2.5.3 Fixed block size padding

When a colour space uses sparse matrix encoding it is useful for the internal encoding to use a fixed block size determined by the number of samples associated with the colour space.

NOTE One method of internally encoding Sparse Matrices within a CMM adjusts the index and data padding to allow the number of matrix entries to vary without the size of the encoded data block size changing. The block size therefore determines a fixed upper limit to the number of entries that can be encoded.

When fixed block size padding is used, the maximum number of matrix entries (M) that can be encoded for each of the sparse matrix encodings is determined by the fixed data block size (B) used to store the sparse matrix, the number of rows (R) and the byte size (S) of a matrix entry data value as shown in Formula (1):

$$M = \text{floor}\ ([B - 8 - 2*R - (S - 1)]/(S + 2)) \quad (1)$$

When fixed block size padding is used for each of the sparse matrix encodings in Table 1 to Table 4 the offset of the matrix entry data array (O) is determined by the number of rows (R) and the maximum number of matrix entries (M), as well as the byte size (S) of a matrix entry data value as shown in Formula (2):

$$O = \text{floor}\ ((8 + 2*R + 2*M + (S - 1))/S)\ *S \quad (2)$$

4.2.6 sparseMatrixEncodingType

When encoding sparse matrices the exact data encoding type used shall be specified using a sparseMatrixEncodingType parameter. Where used, values for a sparseMatrixEncodingType parameter shall be encoded as defined in Table 5.

Table 5 — sparseMatrixEncodingType selection of sparse matrix encoding in SparseMatrixLut

sparseMatrixEncodingType	Sparse matrix encoding
1	sparsematrixUInt8
2	sparseMatrixUInt16
3	sparseMatrixFloat16
4	sparseMatrixFloat32