ICC Technical Note
Embedding ICC profiles

Introduction

ICC profiles can be embedded in a wide range of media objects such as images and documents. In many cases the media object specification includes details of how ICC profiles are to be embedded. For those that do not define the embedding method, details are given below. It is also the case that certain media object specifications restrict the ICC profile versions that are to be supported by conforming readers and writers.

The reason that one would choose to embed an ICC profile into a media object is to indicate the colour space of the object, and to define how the colour data encoded in the file is to be converted into the ICC Profile Connection Space (PCS). From the PCS, the data can then be converted to another data colour encoding by applying the desired destination profile.

NOTE 1: In ICC.1 (v2 and v4 profiles), the PCS is based on an unambiguous specification of colorimetry using the D50 illuminant and CIE 1931 (2 degree) standard observer. Where the original colorimetry is different, the data must be converted into D50/2 degree colorimetry, and the conversion matrix included in the profile in the 'chad' tag. ICC.1 v4 is defined in ISO 15076-1:2010.

NOTE 2: In ICC.2 (v5, also known as iccMAX profiles), a colorimetric PCS can be defined more flexibly, using any combination of illuminant and observer. ICC.2 also supports connection spaces based on spectral data or on arbitrary channels. Where the standard ICC.1 PCS is not used, ICC.2 profiles also define a conversion to D50/2 degrees for purposes of connection to ICC.1 profiles, or to destination profiles with any other PCS. ICC.2 is defined in ISO 20677-1:2019.

In the case of PDF, one can embed profiles into individual media objects to define the conversion into the ICC PCS. Additionally, a PDF/A, PDF/X or PDF/VT file may contain an OutputIntent profile which is embedded to indicate the intended conversion from PCS to destination colour encoding at either the level of the entire document or for one or more individual pages. A similar feature exists in JPEG2000, which allows a destination profile to indicate the desired conversion to a device-specific output colour space to be included.

Summary

Table 1 summarises various media object formats into which ICC profiles can be embedded, together with some media identification formats that also support the identification of profiles for image colour processing.

For each media object format listed in Table 1, this document either references the description of the method of embedding in the file format specification, or, where this is not defined in the format specification, the embedding procedure is given. Table 1 also identifies which ICC profile format version(s) are supported by the image file format specification.

Table 1: Media Object Formats

Media object format	Media object specification	Documentation defining embedding	Version	v2*	v4
AVIF	ISO/IEC 23008-12	ISO/IEC 23008-12	v4.3	Y	Y
DNG		ISO 15076 (based on TIFF)	Not specified	Y	Y
EPS		ISO 15076	Not specified	Y	Y
HEIF	ISO/IEC 23008-12, ISO/IEC 14496-12	ISO/IEC 23008-12	v4.3	Y	Y
HEVC	ISO/IEC 23008-12	ISO/IEC 23008-12	v4.3	Y	Y
JPEG		ISO 15076	Not specified	Y	Y
JPEG XL	ISO 18181	ISO 18181	v4	Y	Y
JPEG2000 (JP2)	ISO/IEC 15444-1	ISO 15444-1 Annex I	ICC.1:1998-09	Y	N
JPEG2000 (JPX)	ISO/IEC 15444-2	ISO 15444-2 Annex M	ICC.1	Y	Y
OpenXPS		ECMA	v4.2	Y	Y
PDF	ISO 32000	ISO 32000	v4	Y	Y
PDF/X	ISO 15930-x	ISO 32000	v4	Y	Y
PNG	ISO/IEC 15948:2003	https://www.w3.org/TR/PNG/#11iCCP	v2**	Y	N
TIFF	TIFF 6.0	ISO 15076	Not specified	Y	Y
TIFF EP	ISO 12234-2	ISO 15076 (based on TIFF)	v4.1	Y	Y
WebP	https://developers.google.com/speed/webp/docs/riff_container	ICCP	Not specified	Y	Y

Table 2: Media identification formats supporting ICC profiles

CSS	https://www.w3.org/TR/css-color-4/		v4.3	Y	Y
MIME		IANA Application media types	v4.2	Y	Y

*Where the table indicates that ICC v2 is allowed, profiles should, where possible, follow ICC v2 profile recommendations (http://www.color.org/v2profiles.xalter) to ensure compatibility with current workflows.

** Current practice for PNG is to support both ICC v2 and v4 profiles.

Higher versions of the ICC specification are always backwards-compatible with previous versions, so a CMM that supports a higher version number will always support a lower version number. Higher profile versions may include elements that are not supported in CMMs intended to support only lower version numbers.

No formats currently support ICC v5 (ISO 20677). Certain formats (TIFF, TIFF-EP, WebP), however, do not define which ICC versions are supported and it is technically possible to embed a v5 profile. However, it is not advisable to do so in the absence of applications that can read and apply such profiles.

Where it is desired to use a v5 profile in workflows that may not support ISO 20677, profile creators can embed the v5 profile in a v4 profile that contains a default rendering transform using only v4 elements. Full details of this approach are given in ICC Technical Note 04-2018.

Specifics for some Media Object Formats

EPS

The two places within EPS files that embedding ICC profiles are appropriate are when associated with a screen preview and when associated with the page description. Embedding ICC profiles within a screen preview is necessary so that applications using this screen preview to display a representation of the EPS page description can do so with accurate colours. Embedding ICC profiles within a page description is necessary so that sophisticated applications, such as OPI server software, can perform colour conversions along with image replacement. For general information concerning PostScript's Document Structuring Conventions (DSC), the EPS file format, or specific PostScript operators, see the PostScript Language Reference Manual.

There are a variety of different methods of storing a screen preview within an EPS file depending on the intended environment. For cross platform applications with embedded ICC profiles, TIFF screen previews are recommended. The TIFF format has been extended to support the embedding of ICC profiles. ICC profiles can also be embedded in a platform specific manner.

A given page description may use multiple distinct colour spaces. In such cases, colour conversions should be performed to a single colour space to associate with the screen preview.

ICC profiles can also be embedded in the page description portion of an EPS file using the `%%BeginICCProfile:` / `%%EndICCProfile` comments. This convention is defined as follows.

```
%%BeginICCProfile: <profileid> <numberof> [<type> [<bytesorlines>]] <profileid> ::=
<text> (Profile ID) <numberof> ::= <int> (Lines or physical bytes) <type> ::= Hex |
ASCII (Type of data) <bytesorlines> ::= Bytes | Lines (Read in bytes or lines)
%%EndICCProfile (no keywords)
```

These comments are designed to provide information about embedded ICC profiles. If the type argument is missing, ASCII data is assumed. ASCII refers to an ASCII base-85 representation of the data. If the `bytesorlines` argument is missing, `<numberof>` should be considered to indicate bytes of data. If `<numberof>` = −1, the number of bytes of data are unknown. In this case, to skip over the profile it is necessary to read data until the encountering the `%%EndICCProfile` comment.

`<profileID>` provides the profile's ID in order to synchronize it with PostScript's setcolorspace and findcolorrendering operators and associated operands (see below). Note that `<numberof>` indicates the bytes of physical data, which vary from the bytes of virtual data in some cases. With hex, each byte of virtual data is represented by two ASCII characters (two bytes of physical data). Although the PostScript interpreter ignores white space and percent signs in hex and ASCII data, these count toward the byte count.

Each line of profile data should begin with a single percent sign (%) followed by a space. This makes the entire profile section a PostScript language comment so the file can be sent directly to a printer without modification. The space avoids confusion with the open extension mechanism associated with DSC comments.

ICC profiles can be embedded within EPS files to allow sophisticated applications, such as OPI server software, to extract the profiles, and to perform colour processing based on these profiles. In such situations it is desirable to locate the page description's colour space and rendering intent, since this colour space and rendering intent may need to be modified based on any colour processing. The `%%BeginSetColorSpace:` / `%%EndSetColorSpace` and `%%BeginRenderingIntent:` / `%%EndRenderingIntent` comments are used to delimit the colour space and rendering intent respectively.

```
%%BeginSetColorSpace: <profileid> <profileid> ::= <text> (ICC Profile ID)
%%EndSetColorSpace (no keywords)
```

`<profileid>` provides the ICC profile's ID corresponding to this colour space. The ICC profile with this profile ID should have occurred in the PostScript job using the `%%BeginICCProfile:` /

`%%EndICCProfile` comment convention prior to this particular `%%BeginSetColorSpace:` comment.

NOTE 3 An example of usage is shown here for CIE 1931 XYZ with D65 white point that refers to the ICC profile with <profileid> = XYZProfile.
%%BeginSetColorSpace: XYZProfile [/CIEBasedABC << /WhitePoint [0.9505 1 1.0890] /RangeABC [0 0.9505 0 1 0 1.0890] /RangeLMN [0 0.9505 0 1 0 1.0890] >>] setcolorspace %%EndSetColorSpace
The setcolorspace command is included within the comments. The PostScript enclosed in these comments should not perform any other operations other than setting the colour space and should have no side effects.
%%BeginRenderingIntent: <profileid> <profileid> ::= <text> (ICC Profile ID) %%EndRenderingIntent (no keywords)
<profileid> provides the ICC profile's ID corresponding to this rendering intent. The ICC profile with this profile ID sholuld have occurred in the PostScript job using the %%BeginICCProfile: / %%EndICCProfile comment convention prior to invocation of this particular %%BeginRenderingIntent: comment.

NOTE 4 An example of usage is shown here for the Perceptual rendering intent that refers to the ICC profile with <profileid> = RGBProfile.
%%BeginRenderingIntent: RGBProfile /Perceptual findcolorrendering pop /ColorRendering findresource setcolorrendering %%EndRenderingIntent
The setcolorrendering command is included within the comments. The PostScript enclosed in these comments should not perform any other operations other than setting the rendering intent and should have no side effects.

ISO 15076-1 Annex C describes the method to be used to identify ICC profiles used to generate PostScript CSAs and CRDs.

TIFF

The discussion below assumes some familiarity with TIFF internal structure. It is beyond the scope of this ICC to detail the TIFF format, and readers are referred to the "TIFF™ Revision 6.0" specification, which is available from Adobe.

The International Color Consortium has been assigned a private TIFF tag for purposes of embedding ICC device profiles within TIFF image files. This is not a required TIFF tag, and Baseline TIFF readers are not currently required to read it. It is, however, strongly recommended that this tag be honoured.

This private TIFF tag applies to all profile versions.

An ICC profile is embedded, in its entirety, as a single TIFF field or Image File Directory (IFD) entry in the IFD containing the corresponding image data. An IFD should contain no more than one embedded profile. A TIFF file may contain more than one image, and so, more than one IFD. Each IFD may have its own embedded profile. Note, however, that Baseline TIFF readers are not required to read any IFDs beyond the first one.

The structure of the ICC Profile IFD Entry is given in Table 2.

ICC profile IFD entry structure Byte offset	Field length bytes	Content
0 to 1	2	The TIFFTag that identifies the field = 34675(8773h)
2 to 3	2	The field Type is 7 = UNDEFINED (treated as 8-bit bytes).
4 to 7	4	The Count of values = the size of the embedded ICC profile in bytes.
8 to 11	4	The Value Offset = the file offset, in bytes, to the beginning of the ICC profile.

PDF

PDF documents allow for images or other graphics objects to have an ICC profile associated with them. Images in PDF files can also include an embedded profile within the image file, using the

method of embedding defined by the image file format specification. That profile is not normally used during rendering, with some exceptions such as an image encoded in JPEG2000 where there is no ColorSpace entry in the image XObject. Embedding profiles in PDF documents is fully described in ISO 32000.

PDF/X
Additional restrictions for PDF/X file can be found in ISO 15930, parts 1 through 9.

PDF/A
Additional restrictions for PDF/A files can be found in ISO 19005, parts 1 through 4.

JPEG
Images compressed using the baseline JPEG-1 codecs are commonly encoded as JFIF files, with file extension '.jpg' or '.jpeg'. JPEG-XL is a more recent standard that aims to be a next-generation format with improved performance.

JFIF
The JPEG standard (ISO/IEC 10918-1[2]) supports application specific data segments. These segments may be used for tagging images with ICC profiles. The APP2 marker is used to introduce the ICC profile tag. Given that there are only 15 supported APP markers, there is a chance of many applications using the same marker. ICC tags are thus identified by beginning the data with a special null terminated byte sequence, "ICC_PROFILE".

The length field of a JPEG marker is only two bytes long; the length of the length field is included in the total. Hence, the values 0 and 1 are not legal lengths. This would limit the maximum data length to 65 533. The identification sequence would lower this even further. As it is quite possible for an ICC profile to be longer than this, a mechanism is required to break the profile into chunks and place each chunk in a separate marker. A mechanism to identify each chunk in sequence order is therefore necessary.

The identifier sequence is followed by one byte indicating the sequence number of the chunk (counting starts at 1) and one byte indicating the total number of chunks. All chunks in the sequence should indicate the same total number of chunks. The 1-byte chunk count limits the size of embeddable profiles to 16 707 345 bytes.

JPEG2000
The JPEG2000 specification (ISO/IEC 15444) defines JP2 and JPX file formats. JP2 allows a Restricted ICC profile to be embedded in monochrome and RGB images, while JPX defines an Any ICC method which permits both Input and Display class profiles, but is limited to Matrix/TRC profiles (i.e. LUT-based profiles are excluded).
- In JP2 a single colourspace definition method is defined in a Colorspace box, and may include an ICC Input class profile conforming to ICC.1:1998-09.
- In JPX multiple representations of the image colourspace are permitted, including both Restricted and Any ICC profiles. Profiles are embedded within a Colour Specification box. Profiles defined using the Any ICC method can be any ICC.1 Input or Display class profile (i.e. both ICC v2 and v4 are permitted).

JPEG-XL
The JPEG-XL specification (ISO 18181) references ISO 15076-1:2010 and therefore supports v4 profiles. The profile is not stored as a simple stream but deconstructed for optimal compression by Brotli including special handling of various Tags.

DNG
The DNG specification defines two tags for ICC profiles: the AsShotICCProfile (tag 50831); and the CurrentICCProfile (tag 50833). Both define a default rendering transform from camera colour space to the output-referred ICC PCS, in conjunction with a pre-profile matrix. An ICC profile is only applied if the DNG reader does not apply its own rendering transform. Full details are given in the DNG

specification dng_spec_1.5.0.0.pdf from Adobe Systems. As DNG is based on TIFF, the embedding procedure described above for TIFF files can be used.

PNG

A profile is embedded in a PNG file as a chunk with type 'iCCP', identifying an arbitrary profile name, compression method, and the compressed profile. Alternatively, a PNG file can implicitly reference an sRGB transform in an 'sRGB' chunk type. Full details are given in the PNG functional specification at https://www.w3.org/TR/PNG/. Currently the PNG specification restricts the ICC profile to v2, although the restriction to ICC v.2 is inadvertent and does not correspond to current practice; an erratum has been raised https://github.com/w3c/PNG-spec/issues/22.

WebP

A Resource Interchange File Format (RIFF) container structure for WebP can contain an embedded ICC profile, as a chunk with type 'ICCP'. sRGB is assumed if no ICC profile is present. Details are in the WebP specification at https://developers.google.com/speed/webp/docs/riff_container. There is no restriction on the ICC profile version.

AVIF

AVIF follows the HEIF format, and profiles can be embedded as described for HEIF

HEIF

HEIF uses the ColourInformationBox defined in ISO/IEC 14496-12 to store a v4 profile with type code 'colr'. In addition, type code 'ricc' can be used to define a restricted (monochrome or 3-component matrix/TRC) ICC profile.