Differences between ICC profile versions

Phil Green

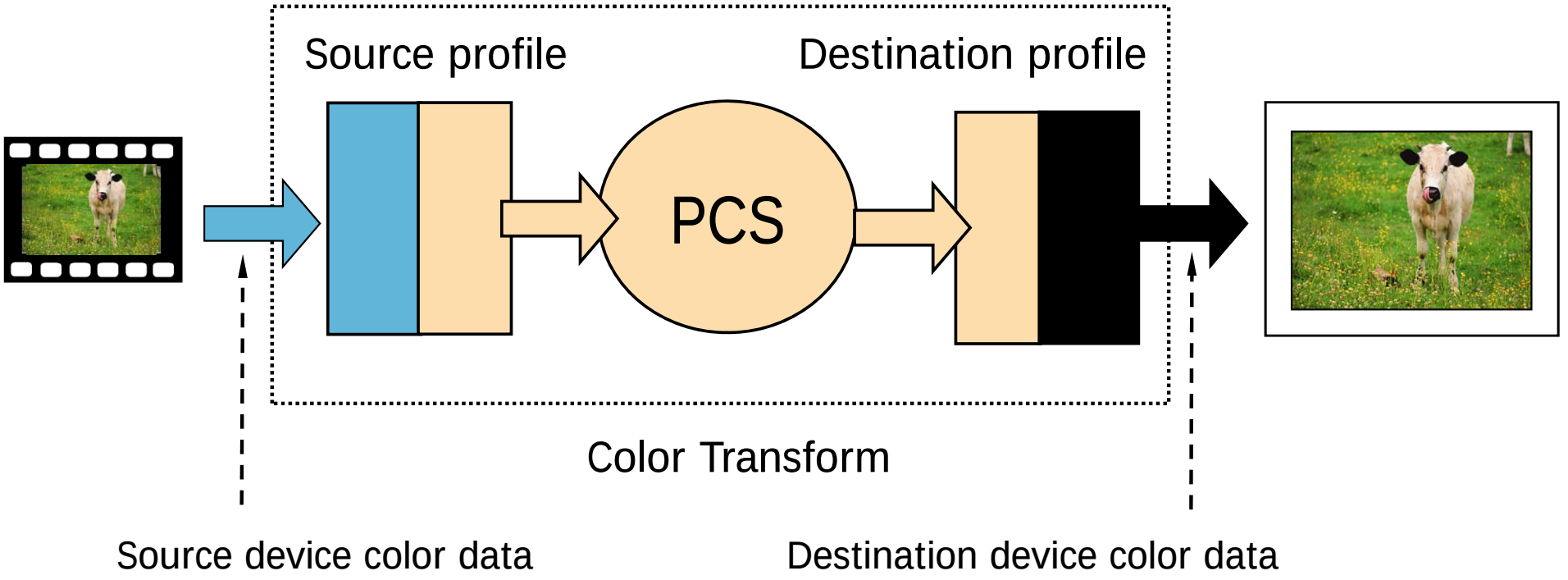
NTNU

Outline

- **ICC profile format history**
- **Key changes in v4**
- **Making good v2 profiles**

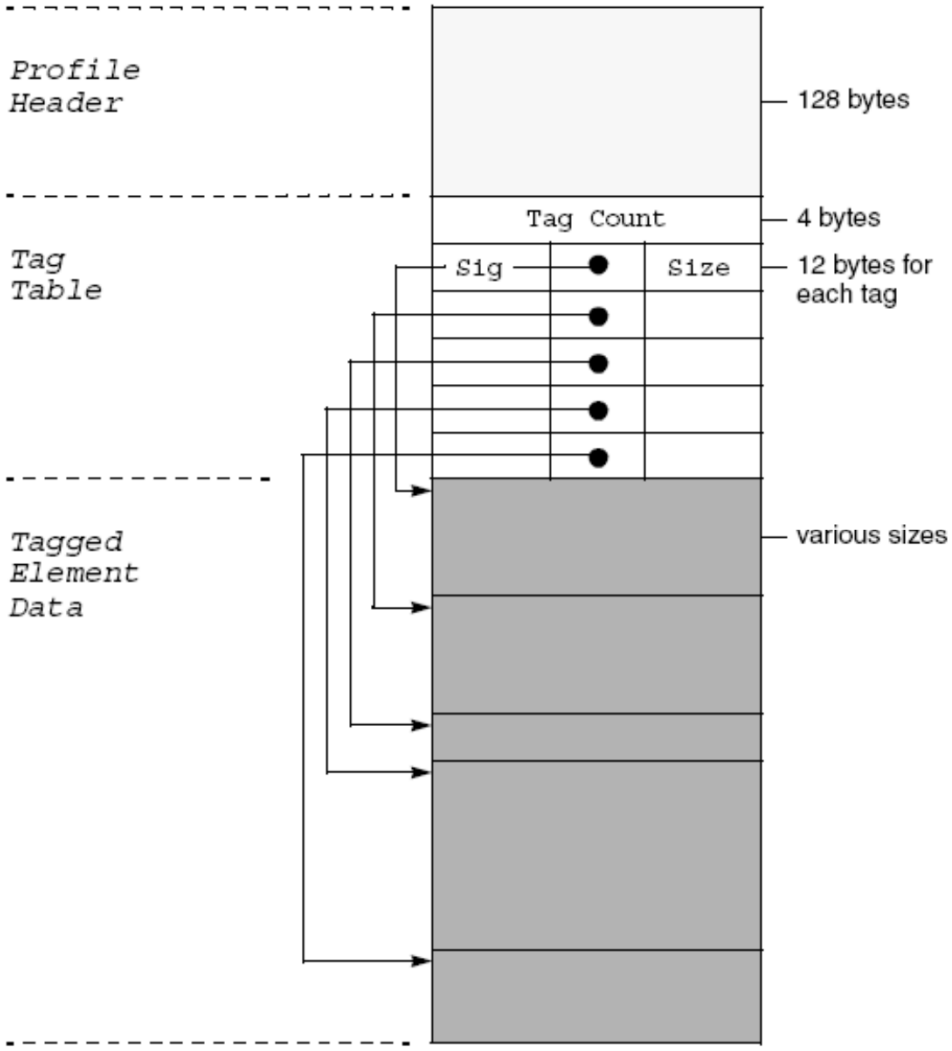
ICC Color Workflow

- **In an ICC color managed workflow, profiles are used to transform between a source and destination color encoding.**



ICC Profile Anatomy

- **ICC profiles use a tagged format.**
- **A profile is made up of a header plus individual tags.**
- **Tags can be informational or numeric, optional or required.**
- **Profile version (v2, v4, v5) located in profile header.**



ICC profile specification – brief history

Version 2

- June 1994 - First published specification
- Apr 2001 - ICC.1:2001-04 (Final v2 specification)

Version 4

- Dec 2001 - ICC.1:2001-12
- Oct 2004 - ICC.1:2004-10 (ICC v4.2.0)

Published as ISO standard

- May 2005 - ISO 15076-1 (based on ICC v4.2.0)
- May 2006 - ICC.1:2004-10 with errata, identical to ISO 15076-1

Current version (4.3)

- Dec 2010 - ICC.1:2010-12 (v4.3.0)
- Dec 2010 - ISO 15076-1: 2010-12 (identical to ICC v4.3.0)

iccMAX - Published as ICC.2:2016, current version in ballot as DIS in ISO TC130 and as ICC.2:2017 in ICC

ICC v2 to v4: some key changes

- **Profile Connection Space**
- **Chromatic adaptation**
- **Media white point**
- **Display profiles**
- **Gamut for Perceptual intent**
- **Transform types**

Profile Connection Space

- **Colorimetric intents**
  - Clarified that colorimetry must be measurement-based, no preference adjustments
  - Black scaling (black point compensation) done by CMM
- **Perceptual intent (+ saturation intent)**
  - Perceptual rendering intent must re/render to and from the standard Perceptual Reference Medium
  - PRM has dynamic range corresponding to high-quality reflection print
  - PRM gamut also defined

CIELAB PCS encoding

Anomalous encoding of 16-bit CIELAB PCS

- **V2 8-bit PCSLAB**
  L* = 100 -> 255 [hexadecimal FFh]

- **V2 16-bit PCSLAB**
  L* = 100 -> 65280 [FF00h] (255 x 256)
  L* = 100.390625 -> 65535 [FFFFh] (255 x 257)
  - But values above L* = 100 are not valid PCS values

- **V4 16-bit PCSLAB**
  L* = 100 -> 65535 [FFFFh] (255 x 257)
  - V4 also supports 32-bit float encoding of PCSLAB

Chromatic adaptation

PCS is always D50 colorimetry to ensure consistent connection between source and destination profiles

- Implication that non-D50 colorimetry must be chromatically adapted to D50 was not spelled out in v2
- Many profiles store incorrect MediaWhitePoint value
- Result is incorrect mapping

D65 white [95.04 100.00 108.89] interpreted as D50 colorimetry

- CMMs have to implement a work-around to avoid unexpected results

V4 clarifies that non-D50 colorimetry shall be chromatically adapted to D50

- ICC Bradford transform shall be used
- Chromatic adaptation matrix shall be stored as ‘chad’ tag to enable CMM to invert transform and obtain source colorimetry

Display profiles

Correct procedure for display profiles is:

1. Linearly scale display measurements so that Y=100 for display white point
2. Chromatically adapt to D50, using scaled display white as source white point
   - Implication is that media white point for a display profile is always [96.42 100.00 82.49] i.e. D50
   - This allows correct mapping between media white points
   - Absolute colorimetric mapping of display colorimetry not supported

This was not spelled out in v2, resulting in many incorrect profiles and the need for CMM work-arounds

Absolute colorimetric mapping (luminance and chromaticity) of displays is almost never required – but can be achieved in iccMAX

Perceptual Reference Medium Gamut

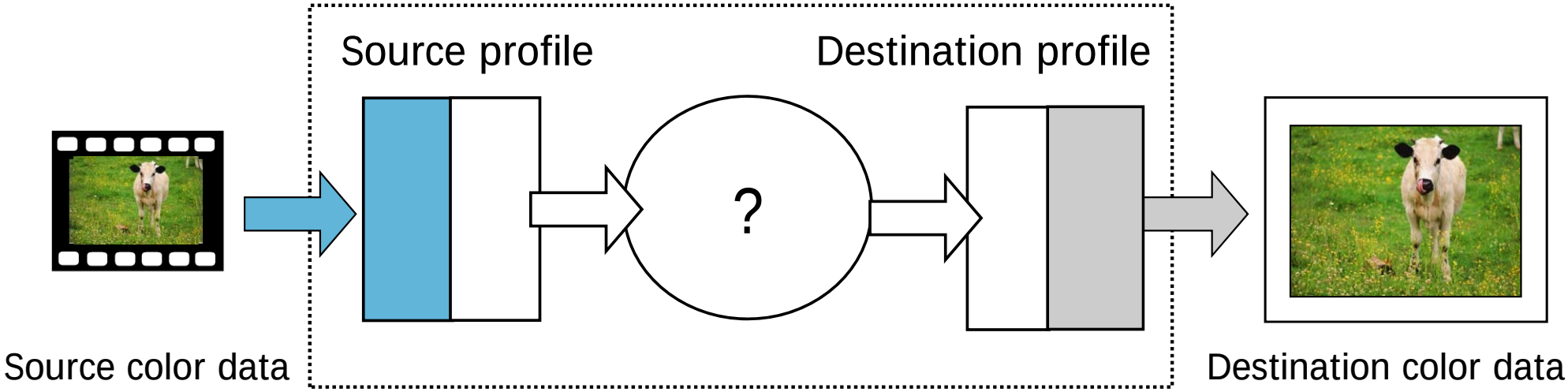
- **Colorimetric intents**
  - Clarified that colorimetry must be measurement-based, no preference adjustments
  - Black scaling (black point compensation) done by CMM

- **Perceptual intent (+ saturation intent)**
  - Perceptual rendering intent must re/render to and from the standard Perceptual Reference Medium
  - PRM has dynamic range corresponding to high-quality reflection print
  - PRM gamut also defined

ICC v2 Perceptual gamut mapping

In ICC v2:

The source profile does not have a re-rendering target

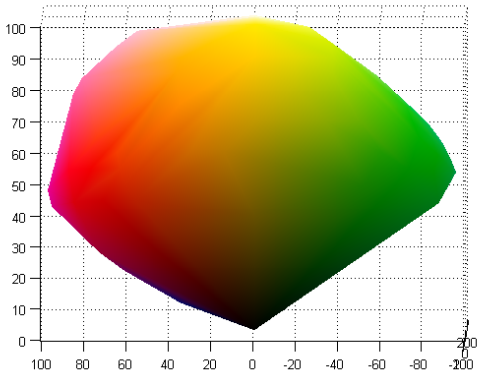


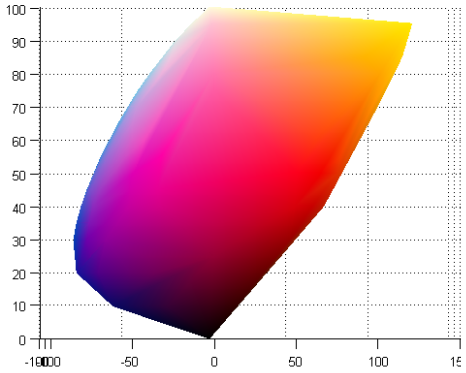
The destination profile does not know the gamut of the source encoding

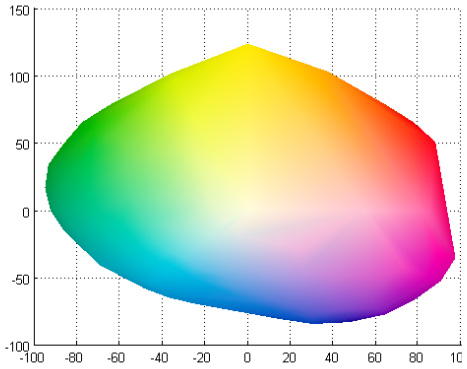
Result: profile creator has to ‘guess’ what the corresponding gamut is

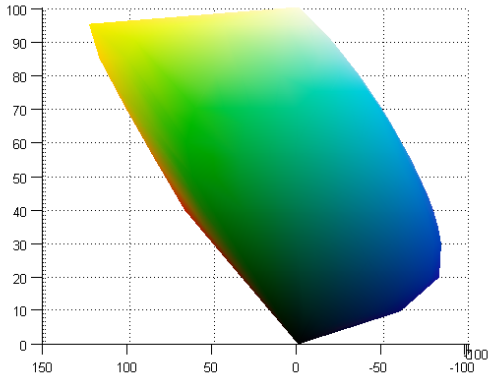
Perceptual Reference Medium Gamut

The ICC v4 specification introduced a reference intermediate gamut PRMG

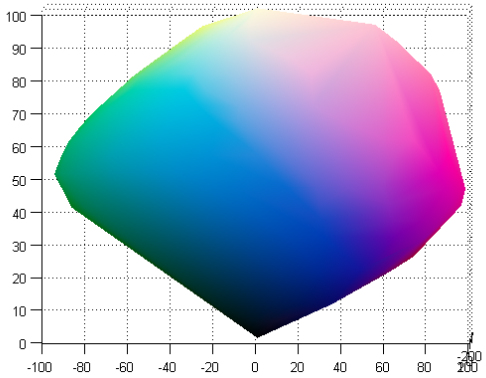








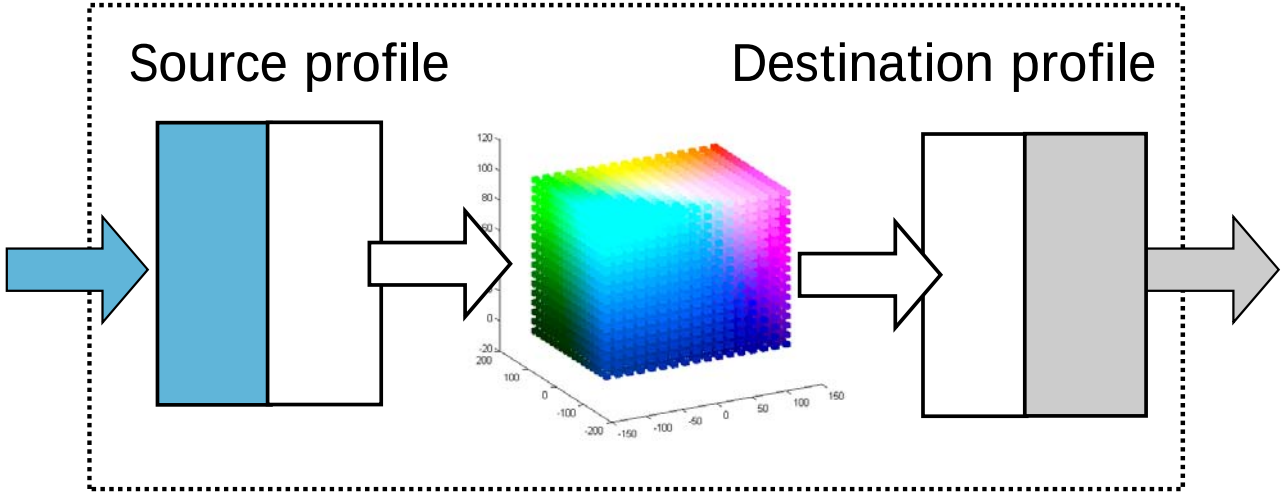
This was published as ISO 12640-3:2005 and corresponds approximately to the gamut of real surface colours



Using the PRMG in ICC workflows

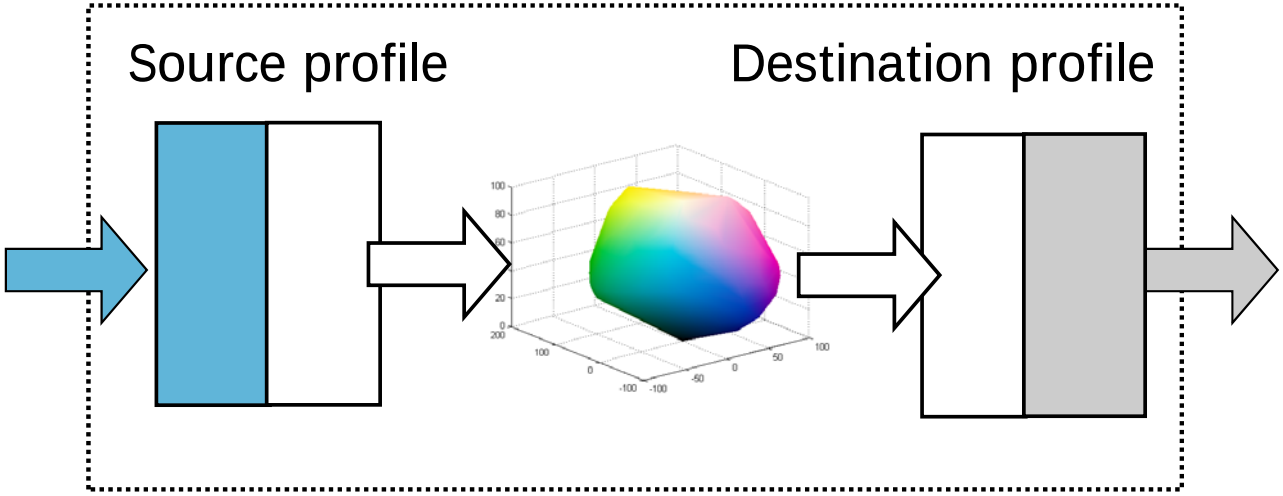
Colorimetric rendering intents:

- Entire CIELAB encoding is mapped to output gamut



Perceptual rendering intent:

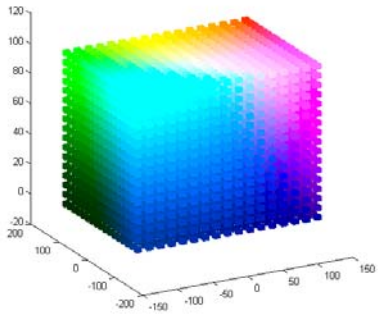
- Profiles map to and from PRMG

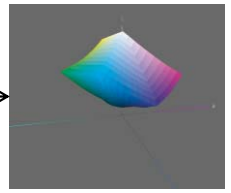


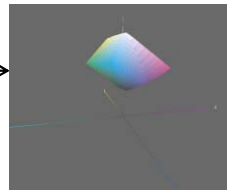
Gamut mapping in ICC v4

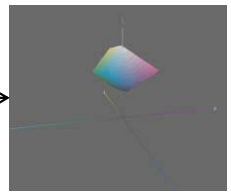
- **Colorimetric intent**

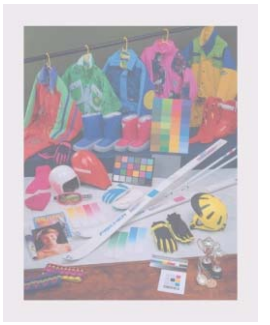
  Source transform
  converts source encoding
  to CIELAB PCS

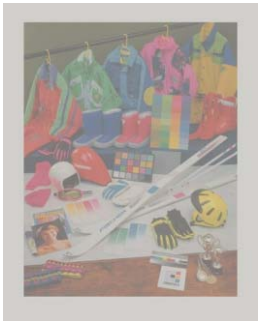










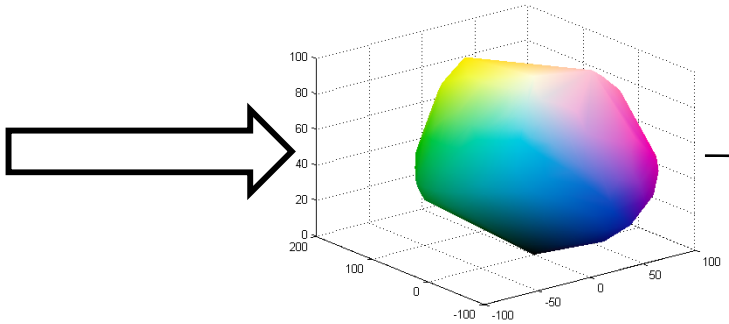


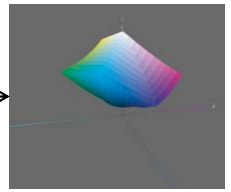
Destination transform
clips PCS colorimetry to
destination gamut

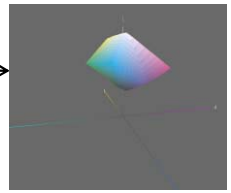
Gamut mapping in ICC v4

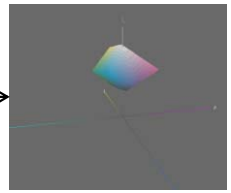
- **Perceptual intent**

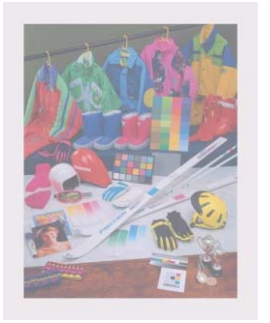
Source transform re-renders source encoding to PRMG using preference criterion

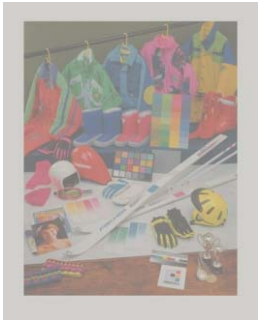








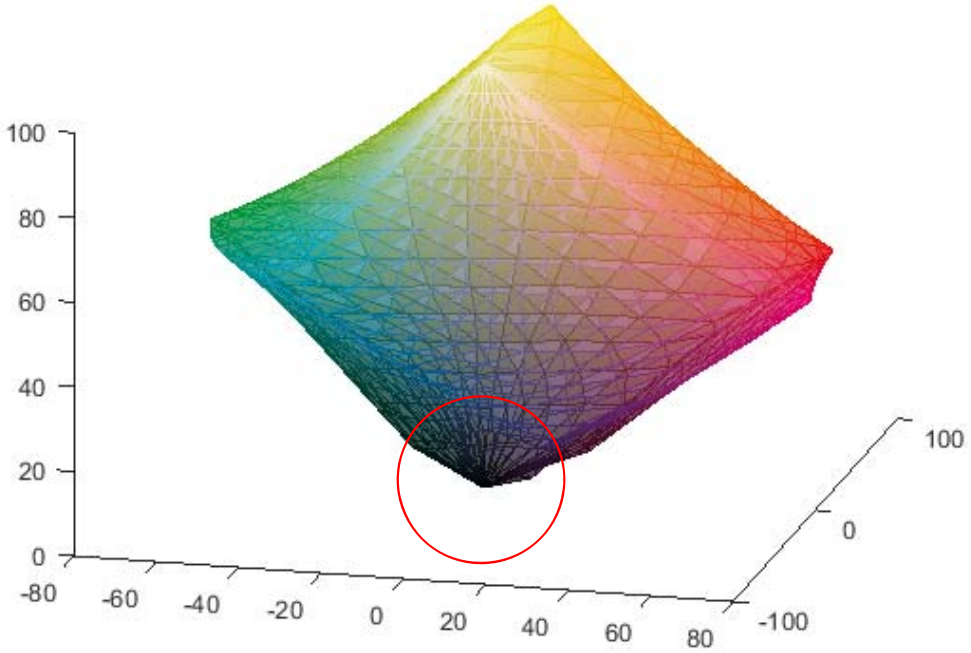




Destination transform maps from PRMG to destination gamut using subjective accuracy criterion

Black point tag

- ICC v2 includes a tag which defines the colorimetry of the profile ‘black point’
  - This can be used for applying black scaling
- The black point can also be determined from the profile
  - A method of doing this is defined in ISO 18619:2015
- As the value encoded in the black point tag was often calculated differently, it was decided to remove it from the v4 specification

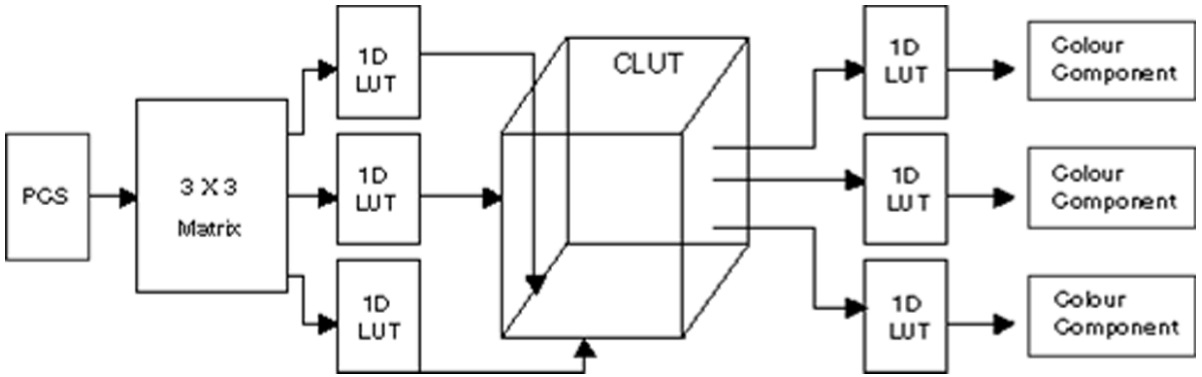


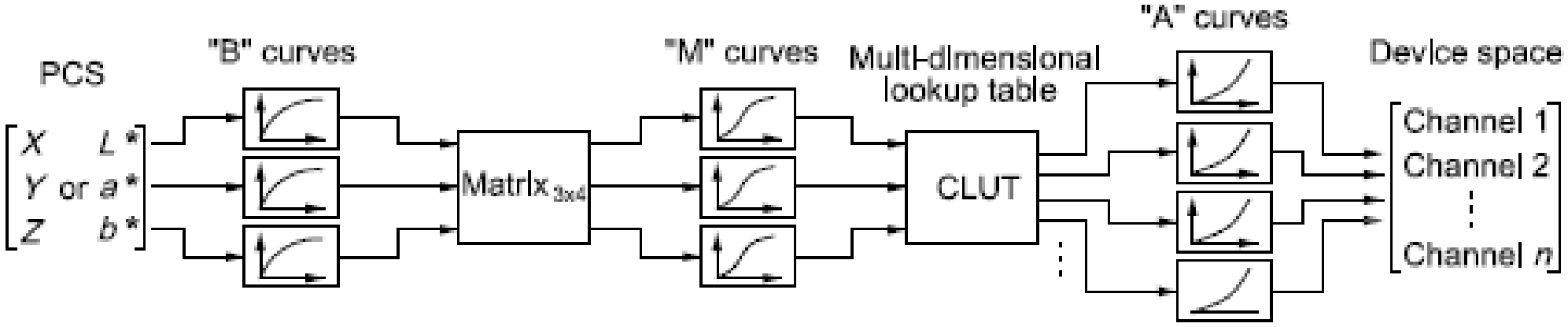
Transform types

- **Look-up tables**
  - v2: LUT8 and LUT16
  - v4: LutAToBType and LutBToAType
- **Curves**
  - v2: gamma and tabulated curve
  - v4: gamma, tabulated curve and parametric curve
- **Transform data types**
  - v2: 8-bit integer, 16-bit integer
  - v4: 8-bit integer, 16-bit integer, 32-bit float

Transform types

V2 LUT





V4 LUT

Current status of ICC v2

- **ICC recommends v4**
- **Many existing profiles are v2**
  - Can be used in conjunction with v4 profiles in colour managed workflows
- **v2 profiles are still being made**
  - Some profile builders only make v2
  - Some older specifications require v2 profiles
  - Some users choose v2 over v4 when building profiles
- **ICC continues to support v2**
  - Specification freely available on ICC web site
  - Information provided on making good v2 profiles
  - ICC.1:2001-04 is final v2 specification; no future versions

Current status of ICC v4

- **ICC recommends v4 for most workflows**
  - Colorimetric matching via D50 PCS
  - Well-proven technology
- **ICC is currently working on the next-generation specification iccMAX**
  - v4 profiles can be used in conjunction with iccMAX profiles
- **ICC continues to support v4**
  - ICC.1:2010 available to download from ICC web site
  - ISO 15076-1:2010 available from ISO
  - No further versions of v4 are currently envisaged but may be developed if the need arises

Making good v2 profiles

- **Recommendations for making good v2 profiles available at http://www.color.org/v2profiles.xalter**

  - Use final v2 specification ICC.1:2001-04
  - Use the PRMG in Perceptual intents
  - Ensure all data is chromatically adapted to D50
  - Follow correct procedure for display profiles
  - Do not apply black point scaling in profile
  - Ensure all colorimetric intents are measurement based
  - Ensure LUT-based transforms invert accurately
  - Include a ProfileID

Conclusions

- **v2 specification last published 2001**
- **v4 specification is current ICC recommendation for most workflows, including graphic arts proofing and printing**
- **v4 is well-defined and unambiguous, widely supported in commercial products**
- **v2 is still supported by ICC and good v2 profiles can be made**
- **For some use cases with requirements beyond D50 colorimetry, iccMAX is recommended**

Thank You