How to use the Perceptual Reference Medium Gamut

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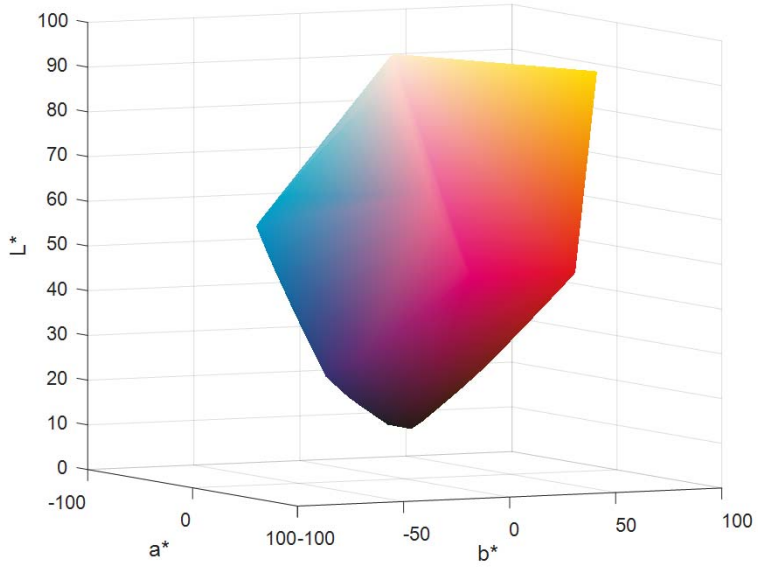
Outline

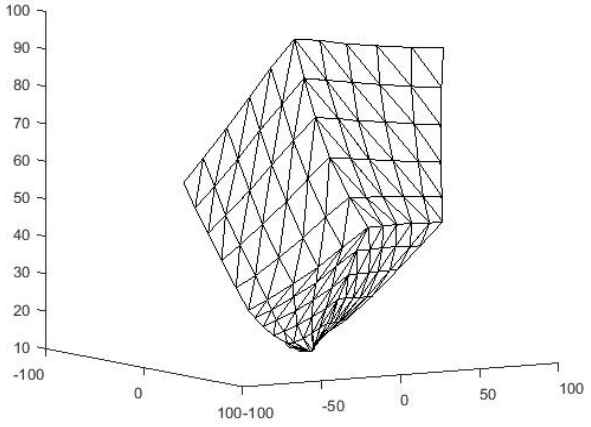
- What is a colour gamut?
- Gamut mapping in ICC workflows
- What is the PRMG?
- Gamut mapping in ICC v4
- New gamut boundary encoding

What is a colour gamut?

- Range of colours that exist within a colour encoding
  - Usually defined as the boundary of the encoding in CIELAB colour space
  - Colour gamut can be obtained from characterization data or the ICC profile for the colour encoding



Colour gamut of FOGRA51



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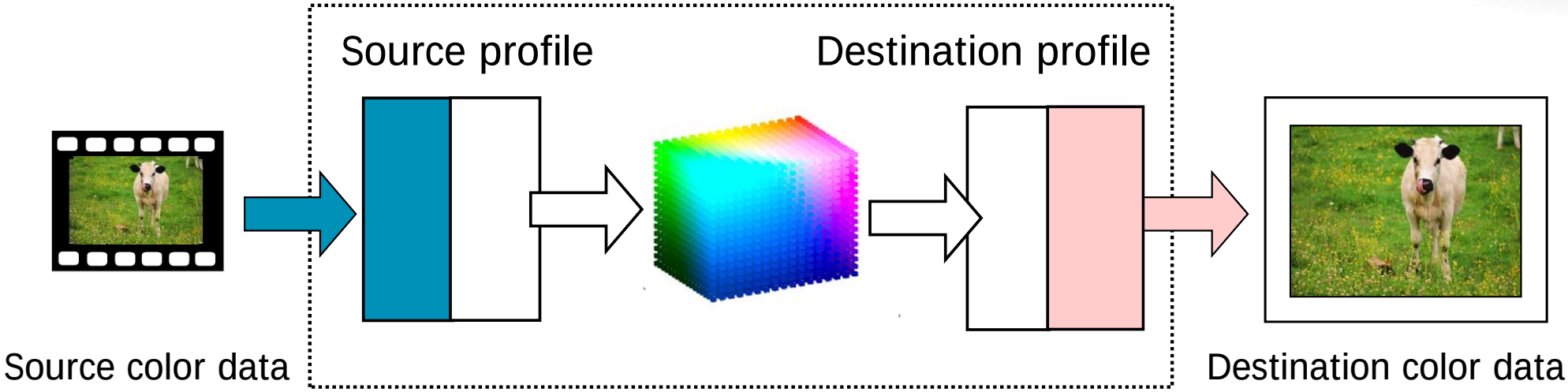
ICC colour management workflow

In an ICC color managed workflow, profiles convert between source and destination color encodings

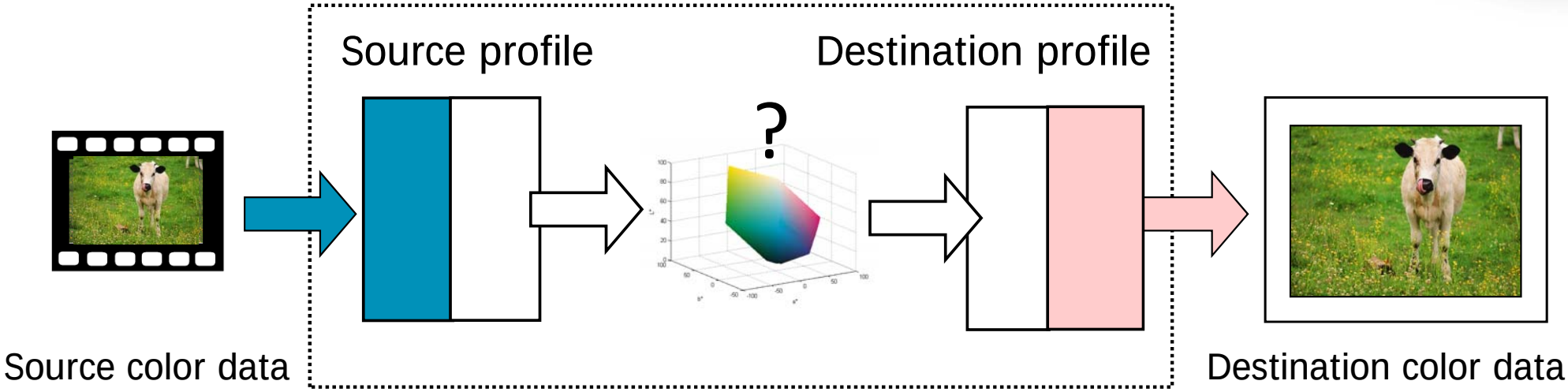


The characterization model, viewing condition adjustments and gamut mapping are incorporated into the transform. The Perceptual intent also includes preference adjustments

ICC v2 Perceptual gamut mapping

In ICC v2:

The source profile does not know the destination gamut

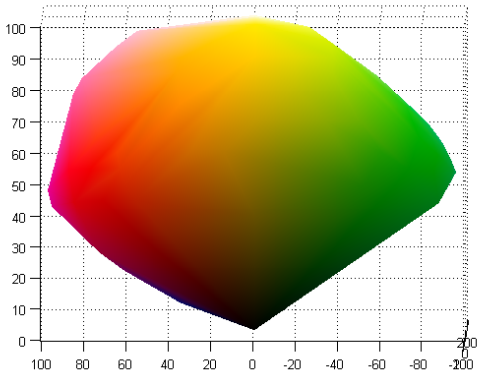


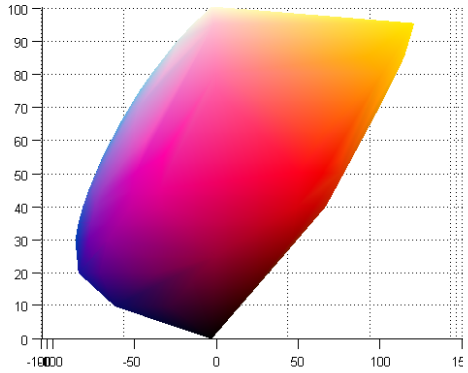
The destination profile does not know the source gamut

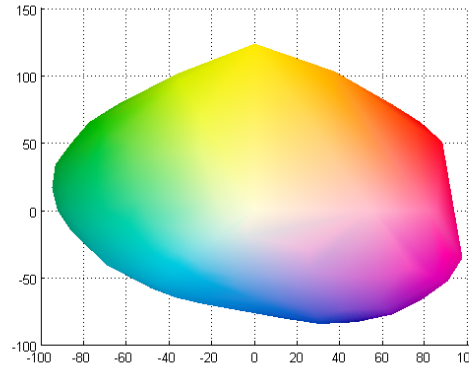
Result: profile creator has to ‘guess’ what gamut to match

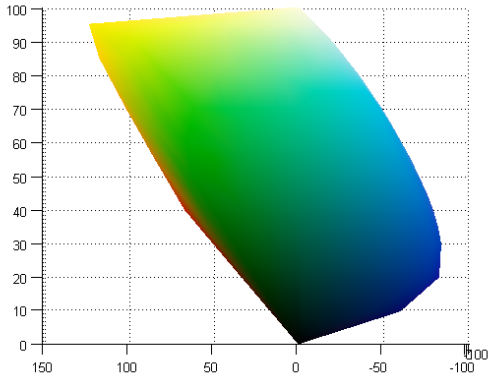
What is the Perceptual Reference Medium Gamut?

The ICC v4 specification introduced a reference intermediate gamut PRMG

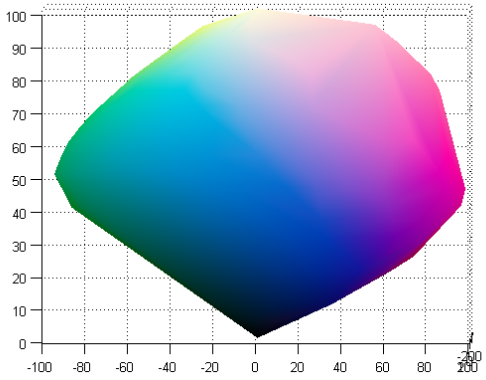








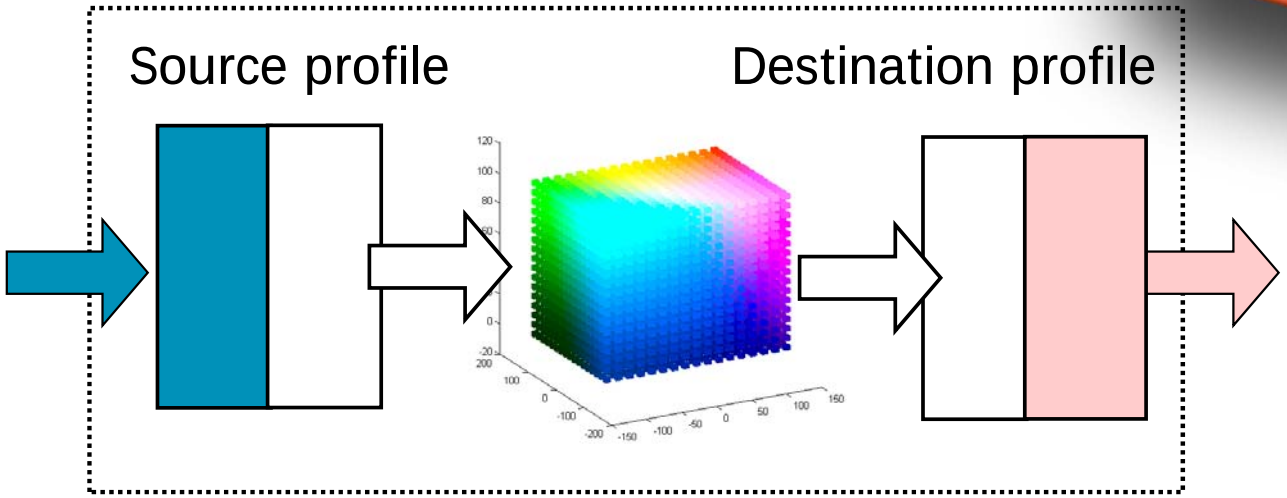
This was published as ISO 12640-3:2005 and corresponds approximately to the gamut of real surface colours



Using the PRMG in ICC workflows

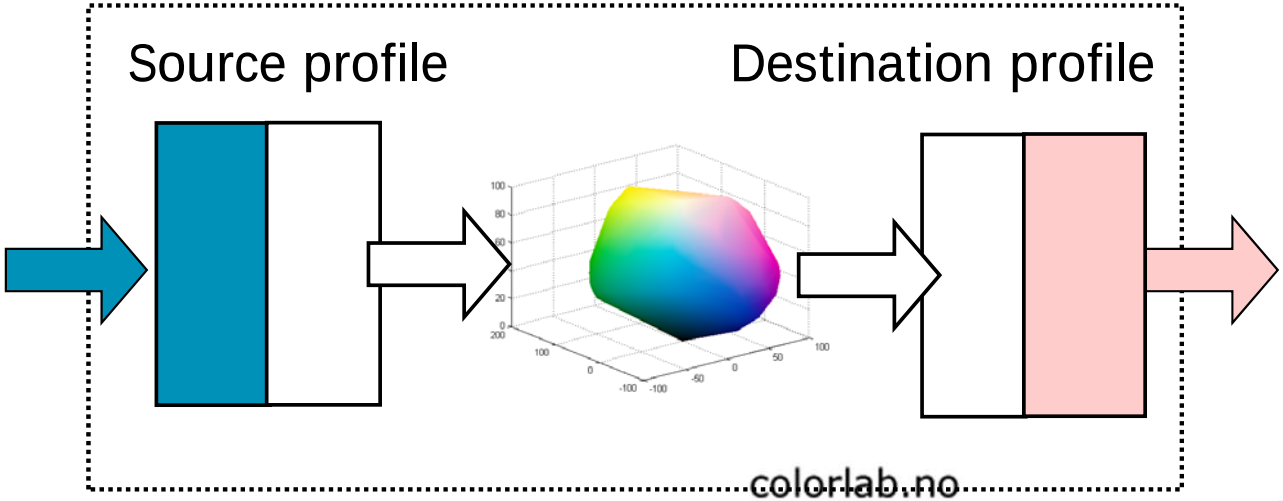
Colorimetric rendering intents:

- Entire CIELAB encoding is mapped to output gamut



Perceptual rendering intent:

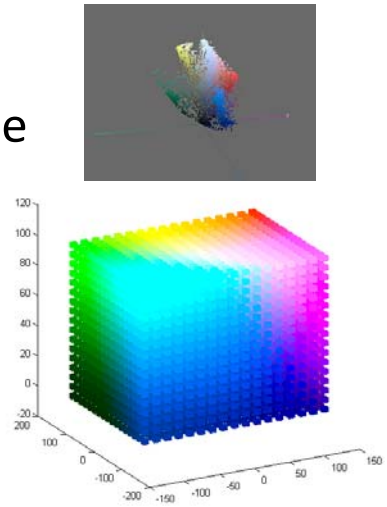
- Profiles map to and from PRMG



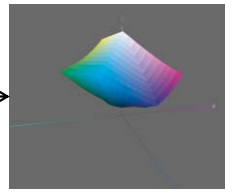
Gamut mapping in ICC v4

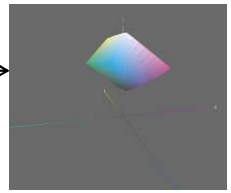
- Colorimetric intent

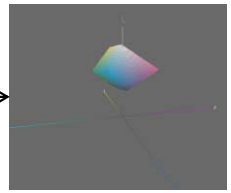
Source transform converts source encoding to CIELAB PCS

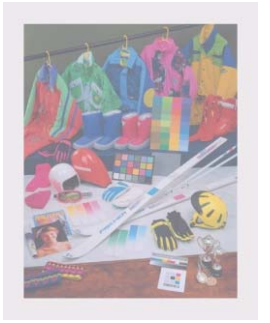


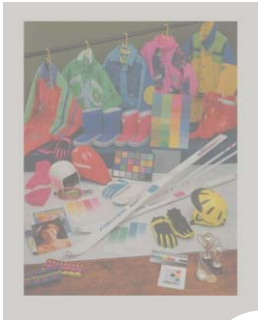
Destination transform clips PCS colorimetry to destination gamut











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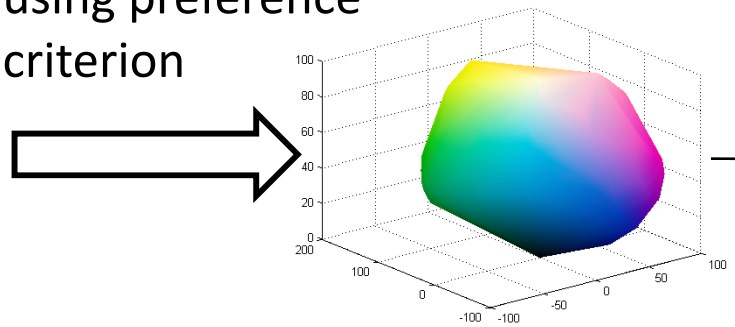
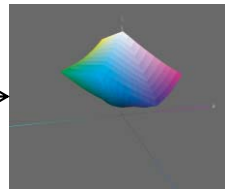
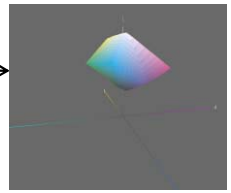
Gamut mapping in ICC v4

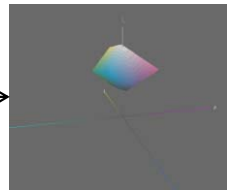
- Perceptual intent

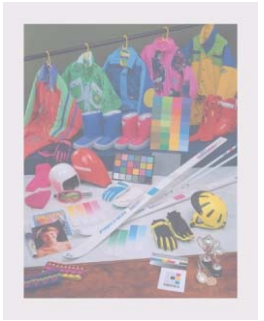
Source transform re-renders source encoding to PRMG using preference criterion









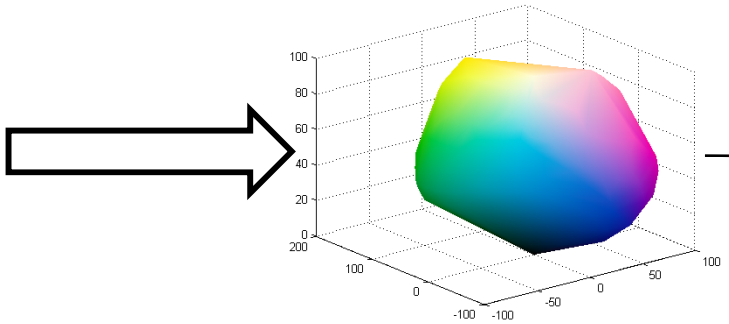


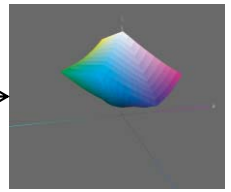
Destination transform maps from PRMG to destination gamut using subjective accuracy criterion

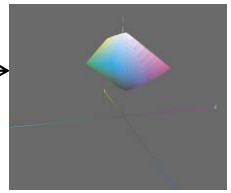
Gamut mapping in ICC v4

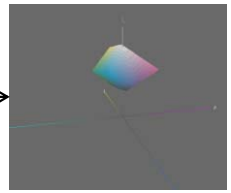
- How to use the PRMG

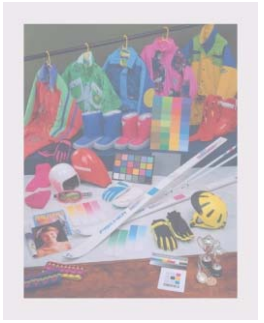
Use the sRGB v4 preference profile to render to the PRMG







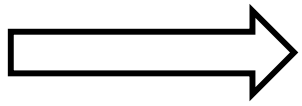


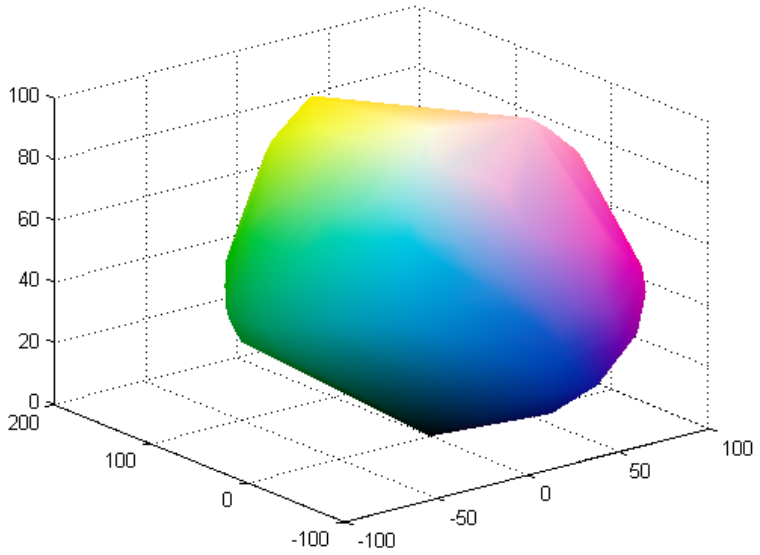


Destination transform maps from PRMG to destination gamut using subjective accuracy criterion

Using the PRMG

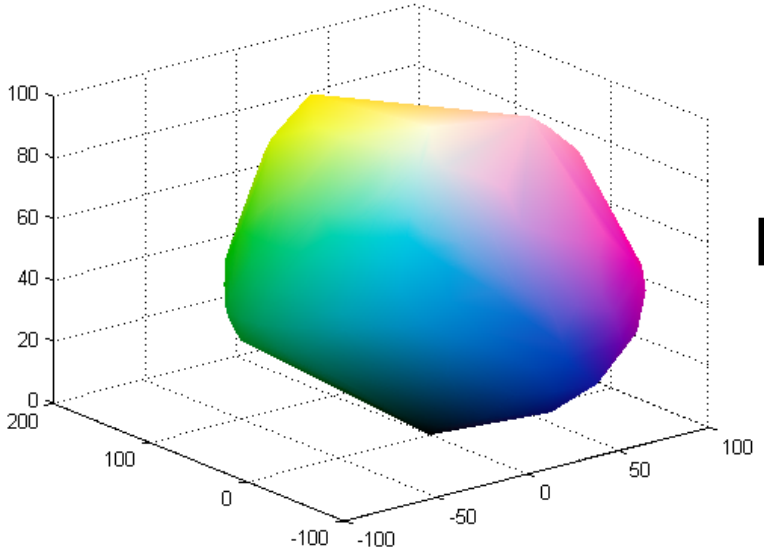
Use the sRGB v4 preference profile to map the source image to the PRMG

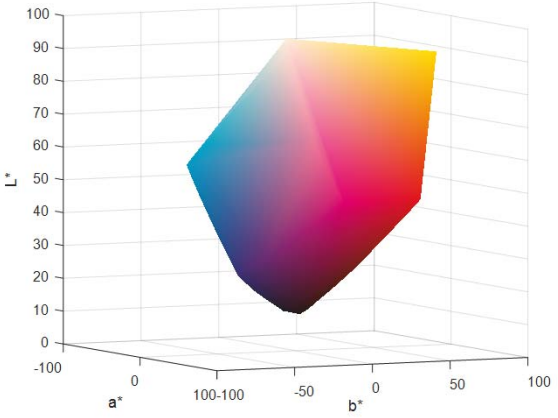




Using the PRMG

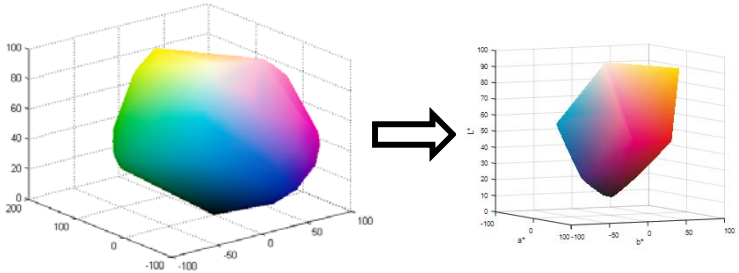
Use an output profile that renders
from the PRMG to the output encoding





Using the PRMG

How to test that the output profile renders from the PRMG to the output encoding?



Use profile with good PRMG round trip interoperability

```
Round Trip Report
Rendering Intent: Relative Colorimetric

 Round Trip 1
 ------------
 Min DeltaE:      0.00
 Mean DeltaE:     0.19
 Max DeltaE:      0.99

 Max L, a, b:   7.743224, -12.254129, 2.206428

 Round Trip 2
 ------------
 Min DeltaE:      0.00
 Mean DeltaE:     0.19
 Max DeltaE:      0.94

 Max L, a, b:   7.550264, -13.394144, 6.771259

 PRMG Interoperability - Round Trip Results
 ------------------------------------------------------
 DE <= 1.0 (  171583): 86.5%
 DE <= 2.0 (  174700): 88.1%
 DE <= 3.0 (  177550): 89.5%
 DE <= 5.0 (  182642): 92.1%
 DE <=10.0 (  191823): 96.7%
 Total     (  198309)

Rendering Intent: Perceptual
Specified Rendering Intent Gamut:  Not Specified
```

Round trip report from Profile Dump (available on ICC web site)

New gamut boundary encoding in iccMAX

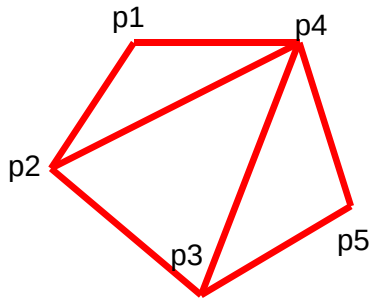
ICC GamutBoundaryDescriptionType

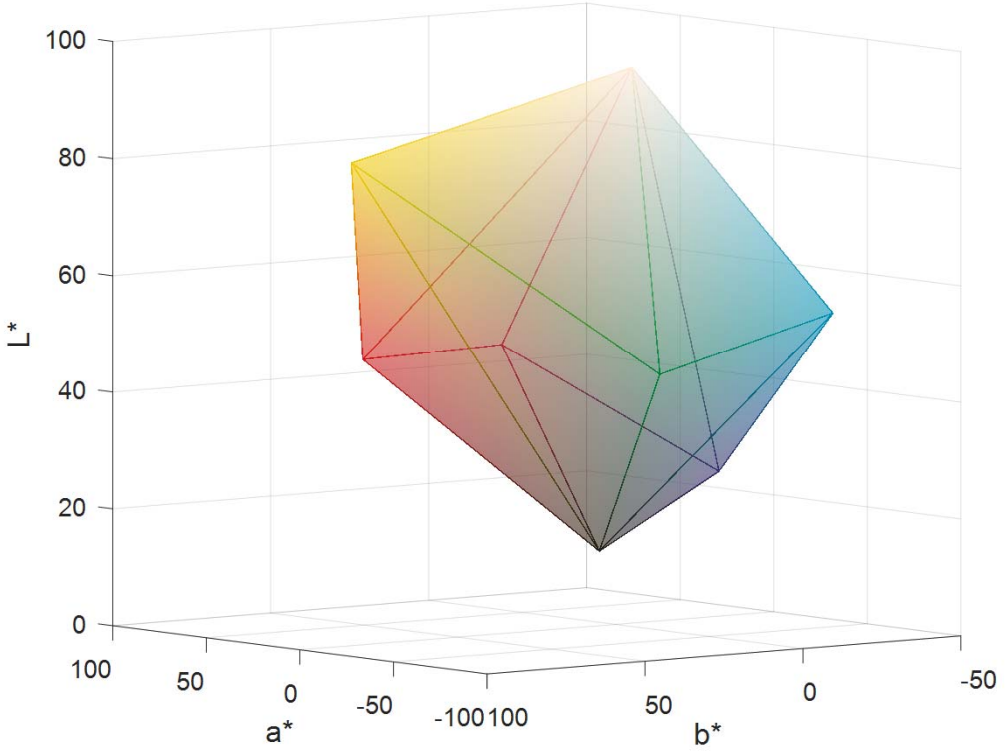
Byte Position	Field Length (bytes)	Content	Encoded as…
0..3	4	'gbd ' (7626420h) type signature	
4..7	4	Reserved, shall be 0	
8..9	2	Number of PCS Channels (P)	**uInt16Number**
10..11	2	Number of Device Channels (Q)	**uInt16Number**
12..15	4	Number of vertices (V)	**uInt32Number**
16..19	4	Number of faces (F)	**uInt32Number**
20..19+F*12	F*12	**Array of vertex IDs for each face**	**uInt32Number**
20+F*12.. 19+F*12+V*P*4	V*P	**Array of PCS coordinates for each vertex**	**float32Number**
20+F*12+V*P*4 … end	**V*Q**	**Array of device coordinates for each vertex**	**float32Number**

Encoding the gamut boundary

- A gamut boundary can be encoded as a list of vertices on gamut surface + a list of indices into the vertices list which form triangular faces on surface
- Vertices = Faces =

$$\begin{bmatrix} L_1a_1b_1 \\ L_2a_2b_2 \\ L_3a_3b_3 \\ L_4a_4b_4 \\ L_5a_5b_5 \\ .... \\ L_na_nb_n \end{bmatrix} \qquad \begin{bmatrix} p_1 & p_4 & p_2 \\ p_2 & p_4 & p_3 \\ p_3 & p_4 & p_5 \\ . & . & . \\ p_{n-2} & p_{n-1} & p_n \end{bmatrix}$$





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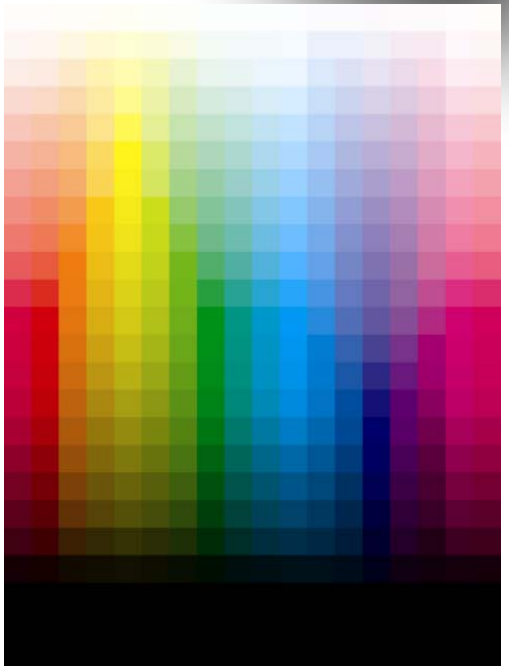
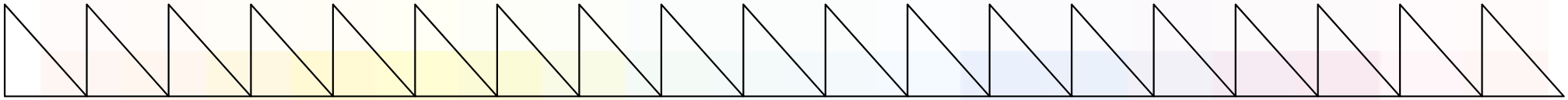
Extracting GBD from a profile

1) Assign profile to gamut boundary target (Green, 2002) and convert to CIELAB as destination with Colorimetric intent
2) Compute array of faces by stepping through patches in gamut boundary target (ensuring indices in each face are in clockwise order)
3) Write vertex and face arrays into GBD structure





Gamut comparison

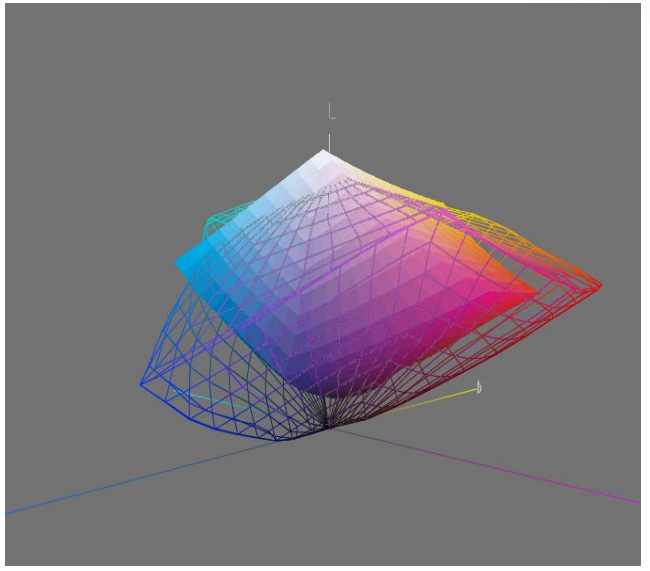
We often need to compare two or more colour gamuts

The difference in gamut volumes alone is a poor indicator

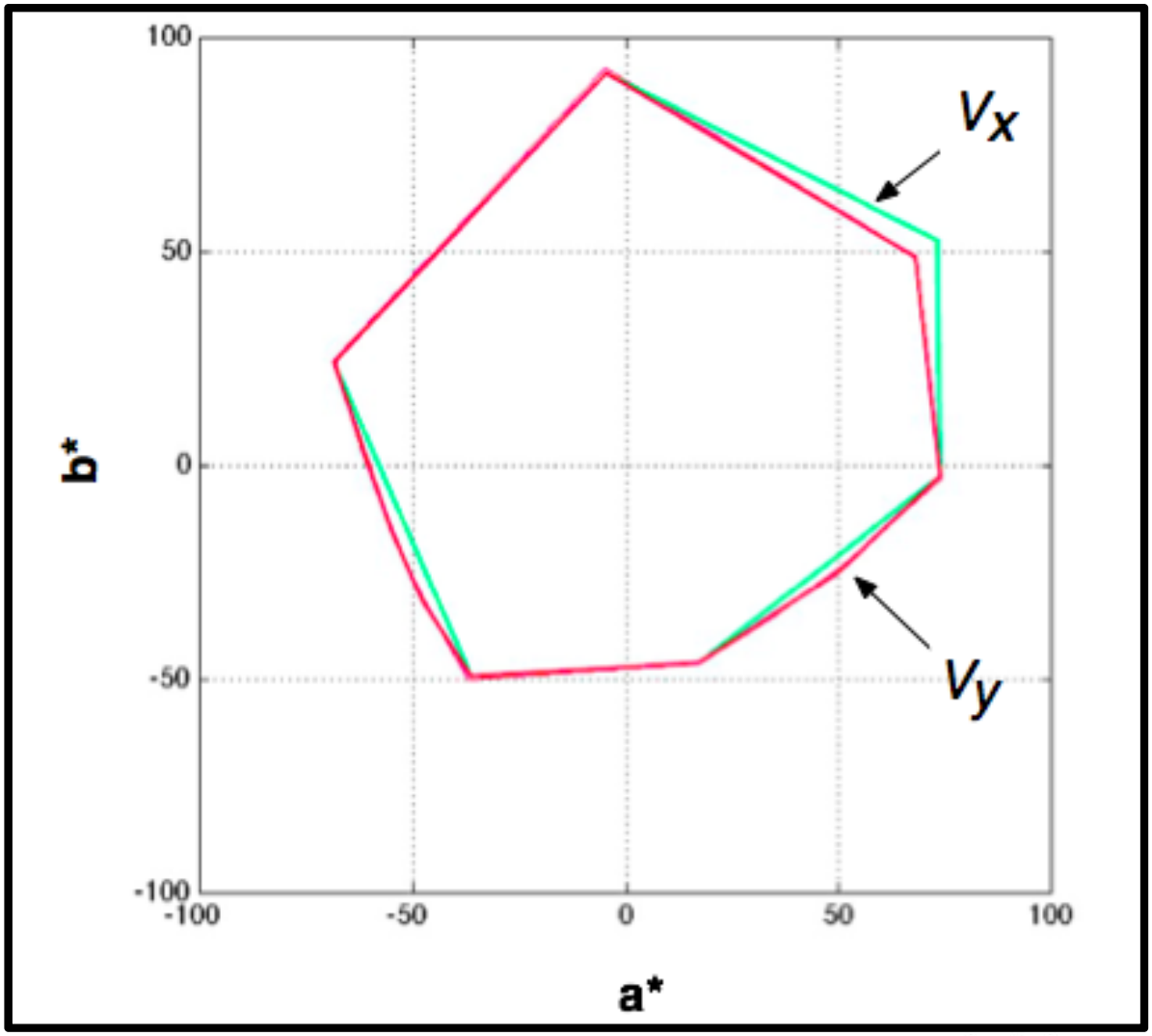
It can't tell if the gamuts intersect sufficiently to meet the reproduction aims

Two gamuts having the same volume may not coincide

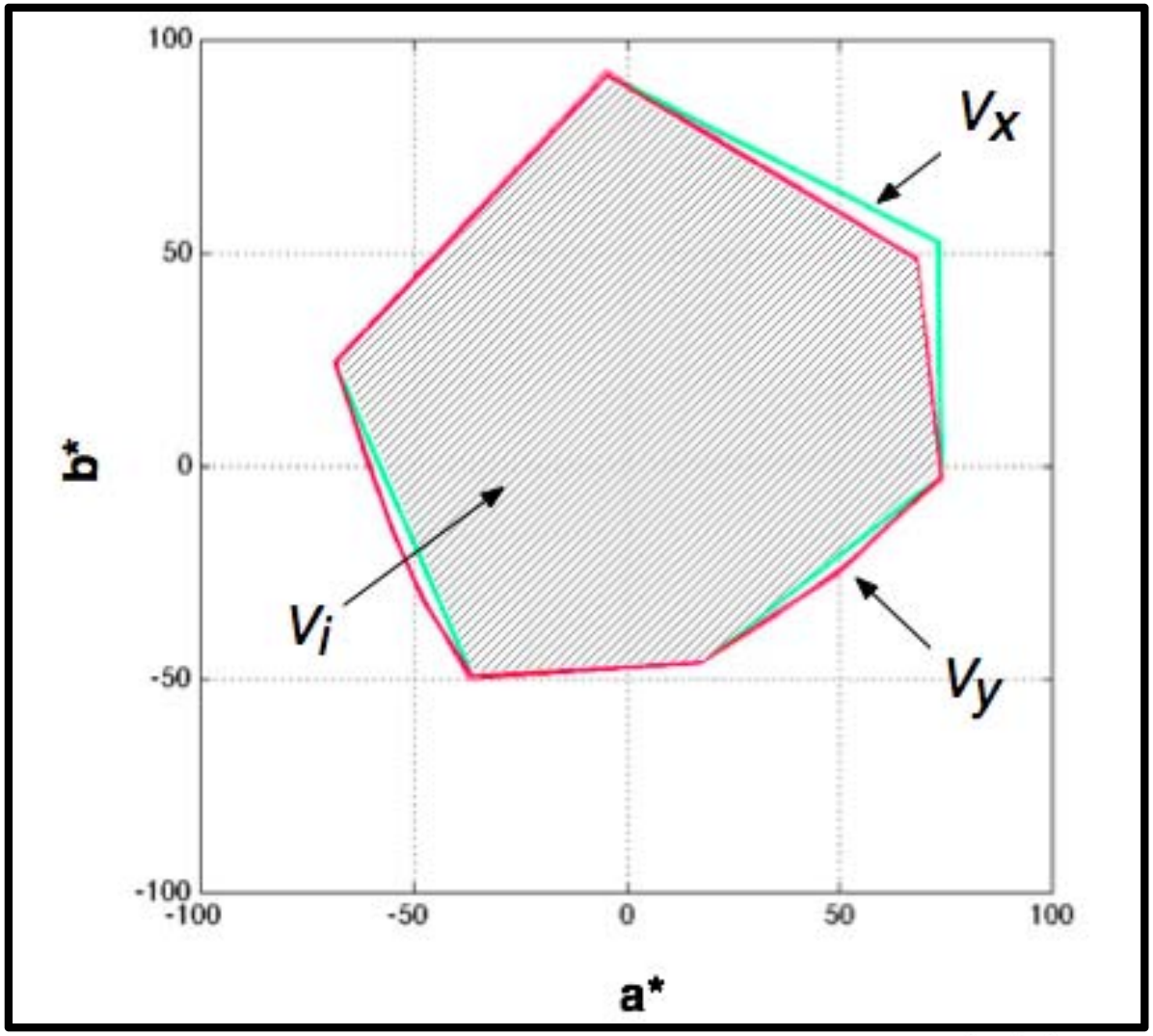
Metric needs to include both relative volume and intersection



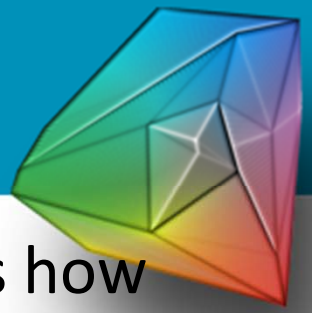
Gamut comparison index



Gamut comparison index



Gamut comparison index



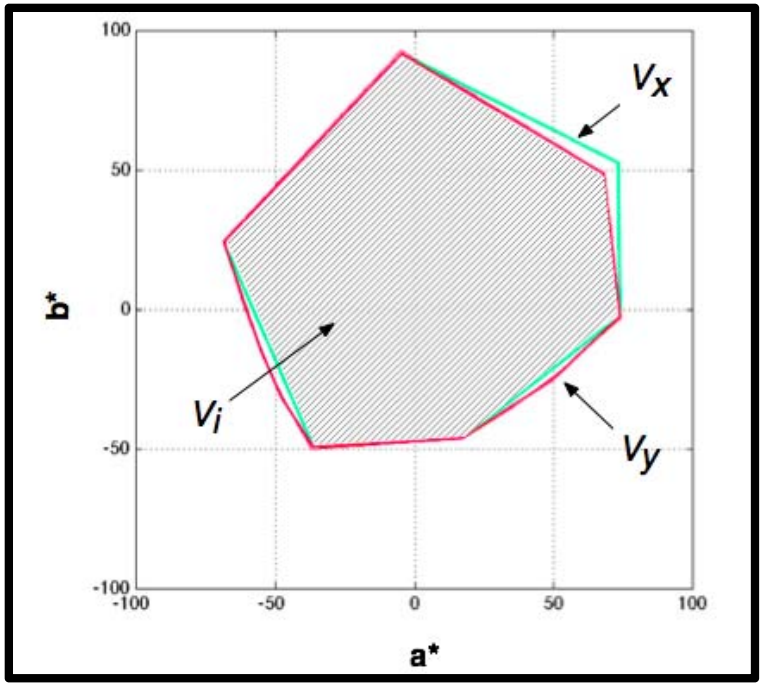
- Gamut comparison index between two gamuts shows how closely they match

$$GCI = \left(\frac{V_i}{V_x}\right)\left(\frac{V_i}{V_y}\right)$$

V_x : gamut volume of the medium *x*
V_y : gamut volume of the medium *y*
V_i : volume of intersection of the two gamuts ($V_x \cap V_y$)

Gamut comparison index

- (V_i / V_x) – how much of gamut x is outside the intersection
- (V_i / V_y) – how much of gamut y is outside the intersection



Summary

- The Perceptual Reference Medium Gamut is a rendering target for ICC v4 workflows
- It enables consistent and optimal mapping between source and destination encodings Perceptual intent
- Profiles are available to render to and from the PRMG
- PRMG compatibility can be easily evaluated
- ICC has introduced a new method of encoding the gamut boundary in iccMAX
- ISO, ICC and CIE are in the process of defining standard methods of describing a gamut boundary and comparing two gamuts

Thank you!