Consistent Colour Appearance assessment method

CIE TC 8-16, W Craig Revie

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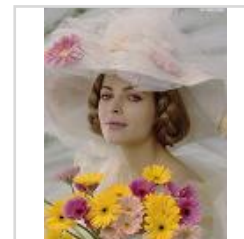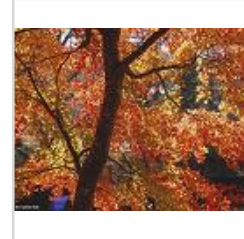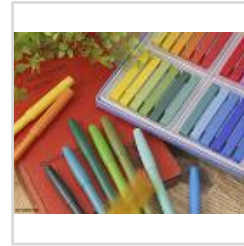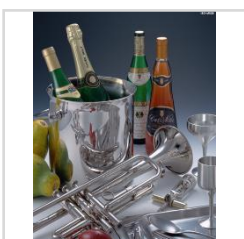## 2 Scope

To study and report on sets of reproductions of the same source image that have a consistent colour appearance and are most similar to a reference reproduction, including recommending assessment methods that measure the similarity of reproductions of an image with different colour gamuts, for printed images on substrates with approximately similar characteristics in a fixed viewing environment. Only the effect 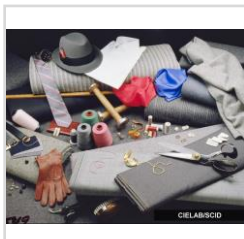of colour reproduction on appearance will be considered by this TC and so the assessment will be performed using hard copy or soft copy proofing.

To propose a metric which can measure consistency of colour appearance.

CIE TC8-16 Assessment of Consistent Colour Appearance

- Identification of resources
  - Reference images (available to all members of CIE TC8-16 – details on COLLTOOL)
  - Reference print gamuts (see http://www.color.org/resources/r8-13/CCA-gamuts.xalter)
  - Reference display (details from BenQ)
  - Reference proofing system
  - Uniform colour space
- Image preparation
- Viewing conditions
- Psychophysical assessment
- Measurement assessment

Candidate images (ISO 12640 SCID)
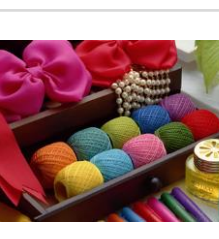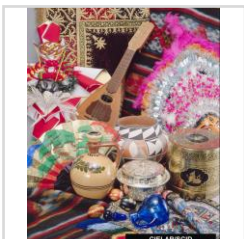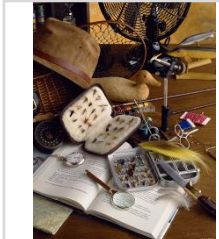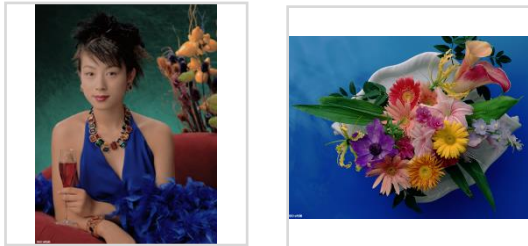
ISO12640-2 sRGB SCID

ISO12640-3 CIELAB SCID

ISO12640-4 AdobeRGB SCID

Roman16 images

01_highkey 02_midtone 03_lowkey 04_cyan 05_magenta 06_yellow
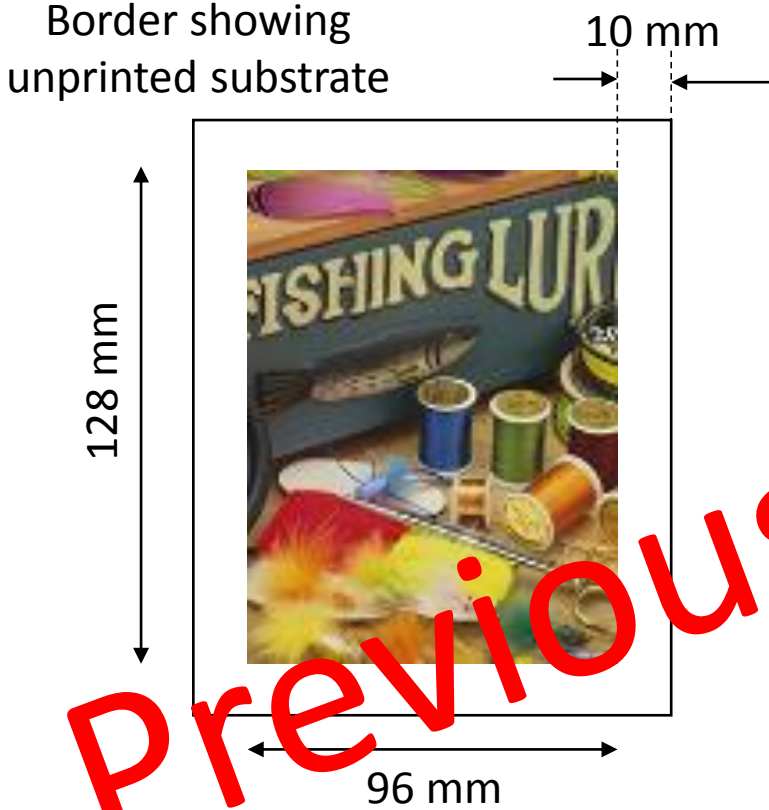07_red 08_green 09_blue 10_olive 11_brown
12_pastel 13_coloured
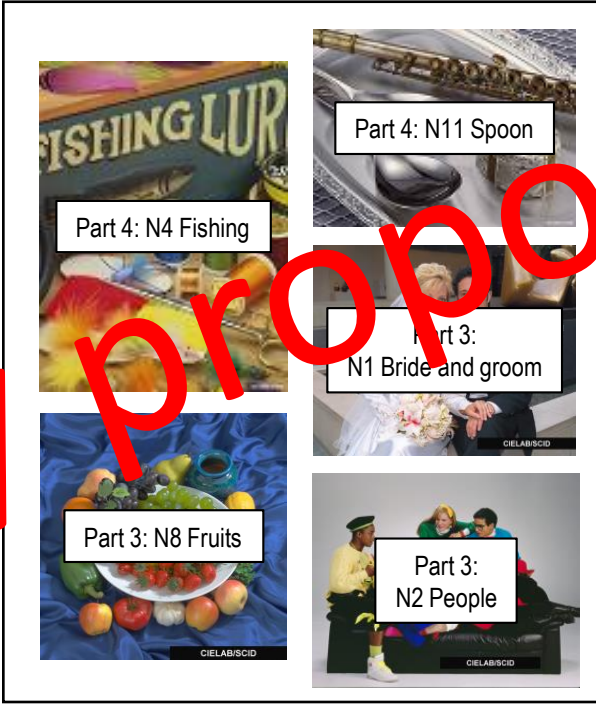01_highkey_BW 02_midtone_BW 03_lowkey_BW

Although not representative of typical imagery these images may be better than the ISO set for some purposes, for example when it is important to see what is happening in particular parts of the colour gamut
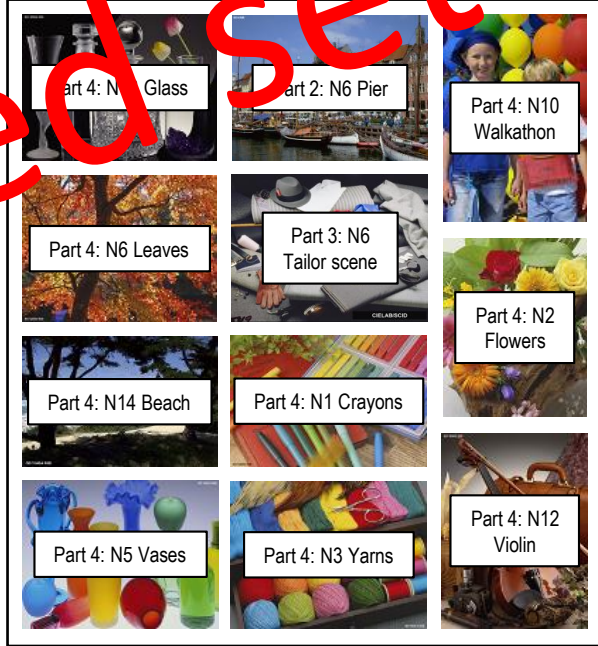
Candidate images (ISO 12640 SCID)

Border showing unprinted substrate

10 mm

128 mm

96 mm

Images should be printed at approximately the same size

Part 4: N4 Fishing

Part 4: N11 Spoon

Part 3: N1 Bride and groom

Part 3: N8 Fruits

Part 3: N2 People

Primary image set

Part 4: N Glass

Part 2: N6 Pier

Part 4: N10 Walkathon

Part 4: N6 Leaves

Part 3: N6 Tailor scene

Part 4: N14 Beach

Part 4: N1 Crayons

Part 4: N2 Flowers

Part 4: N5 Vases

Part 4: N3 Yarns

Part 4: N12 Violin

Secondary set

Previously proposed set

See http://www.color.org/resources/r8-13/CCA_test.xalter

Proposed revision: primary image set

128 x 96 mm

128 x 102.4 mm

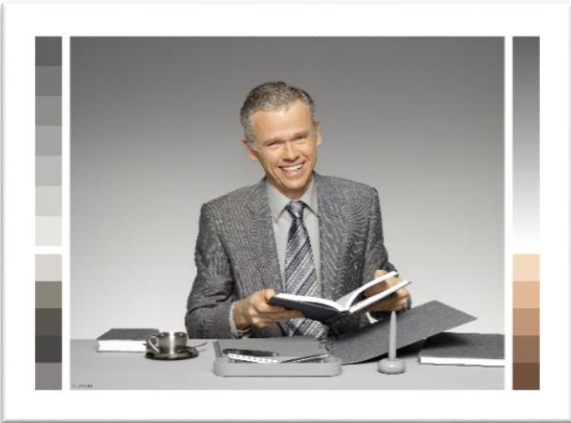*Suggested dimensions*
Images scaled so that longest edge is 146 mm
including border

128 x 128 mm
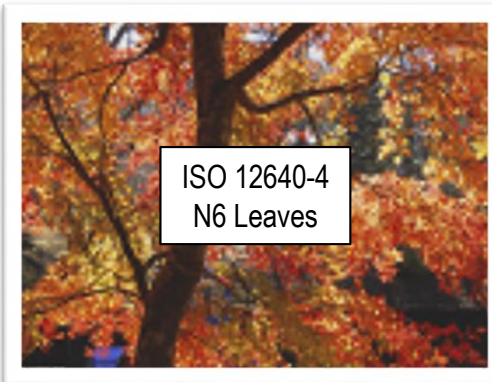
128 x 96 mm

96 x 128 mm

146 x 105.93 mm

146 x 105.93 mm

146 x 105.93 mm

146 x 105.93 mm

Proposed revision: primary image set

ISO 12640-2 N6 Pier
128 x 96 mm

ISO 12640-3 N1 Bride and groom
128 x 102.4 mm

ISO 12640-3 N8 Fruits
128 x 128 mm

ISO 12640-4 N6 Leaves
128 x 96 mm

ISO 12640-4 N12 Violin
96 x 128 mm

Suggested dimensions
Images scaled so that longest edge is 146 mm including border

Roman16 02_midtone
146 x 105.93 mm

Roman16 07_red
146 x 105.93 mm

Roman16 09_blue
146 x 105.93 mm

Roman16 10_olive
146 x 105.93 mm

Proposed revision: secondary set

128 x 102.4 mm

128 x 102.4 mm

128 x 96 mm

128 x 96 mm

128 x 96 mm

96 x 128 mm

96 x 128 mm

85.11 x 128 mm

128 x 96 mm

128 x 96 mm

128 x 84.8 mm

146 x 105.93 mm

146 x 105.93 mm

146 x 105.93 mm

146 x 105.93 mm

Proposed revision: secondary set

ISO 12640-3 N2 People — 128 x 102.4 mm
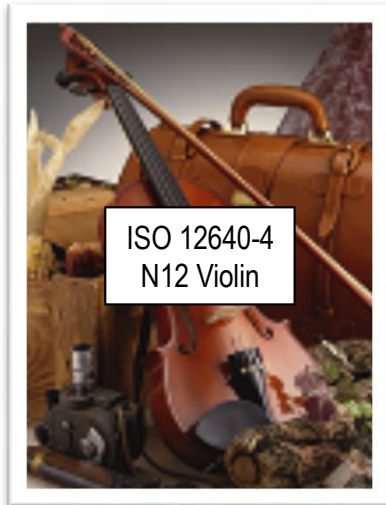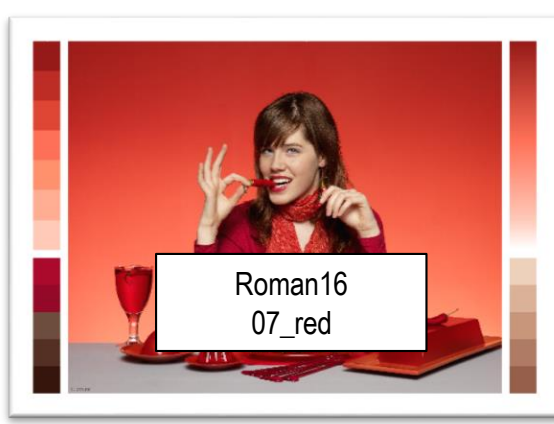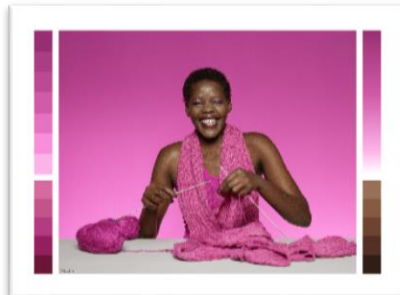
ISO 12640-3 N6 Tailor scene — 128 x 102.4 mm

ISO 12640-4 N1 Crayons — 128 x 96 mm

ISO 12640-4 N3 Yarns — 128 x 96 mm

ISO 12640-4 N5 Vases — 128 x 96 mm

ISO 12640-4 N2 Flowers — 96 x 128 mm

ISO 12640-4 N4 Fishing — 96 x 128 mm

ISO 12640-4 N10 Walkathon — 85.11 x 128 mm

ISO 12640-4 N11 Spoon — 128 x 96 mm

ISO 12640-4 N13 Glass — 128 x 96 mm

ISO 12640-4 N14 Beach — 128 x 84.8 mm

01_highkey — 146 x 105.93 mm

03_lowkey — 146 x 105.93 mm

04_cyan — 146 x 105.93 mm

05_magenta — 146 x 105.93 mm

Candidate print gamuts

Candidate profiles for Consistent Colour Appearance assessment

Legend:
- CGATS21_CRPC1.icc
- Uncoated_Fogra47L_VIGC_260.icc
- PSRgravureMF
- PSR_SC_STD_V2_PT
- SC paper (ECI)
- Japan Web Coated (Ad)
- Coated FOGRA39 (ISO 12647-2:2004)
- ColorMaster_v2_expandV4(smoothed)papertint-3_v1_exported_U400_K100_G80
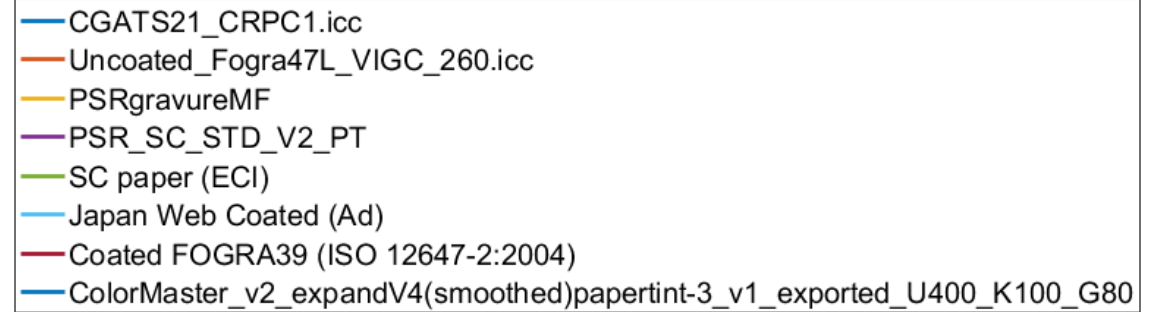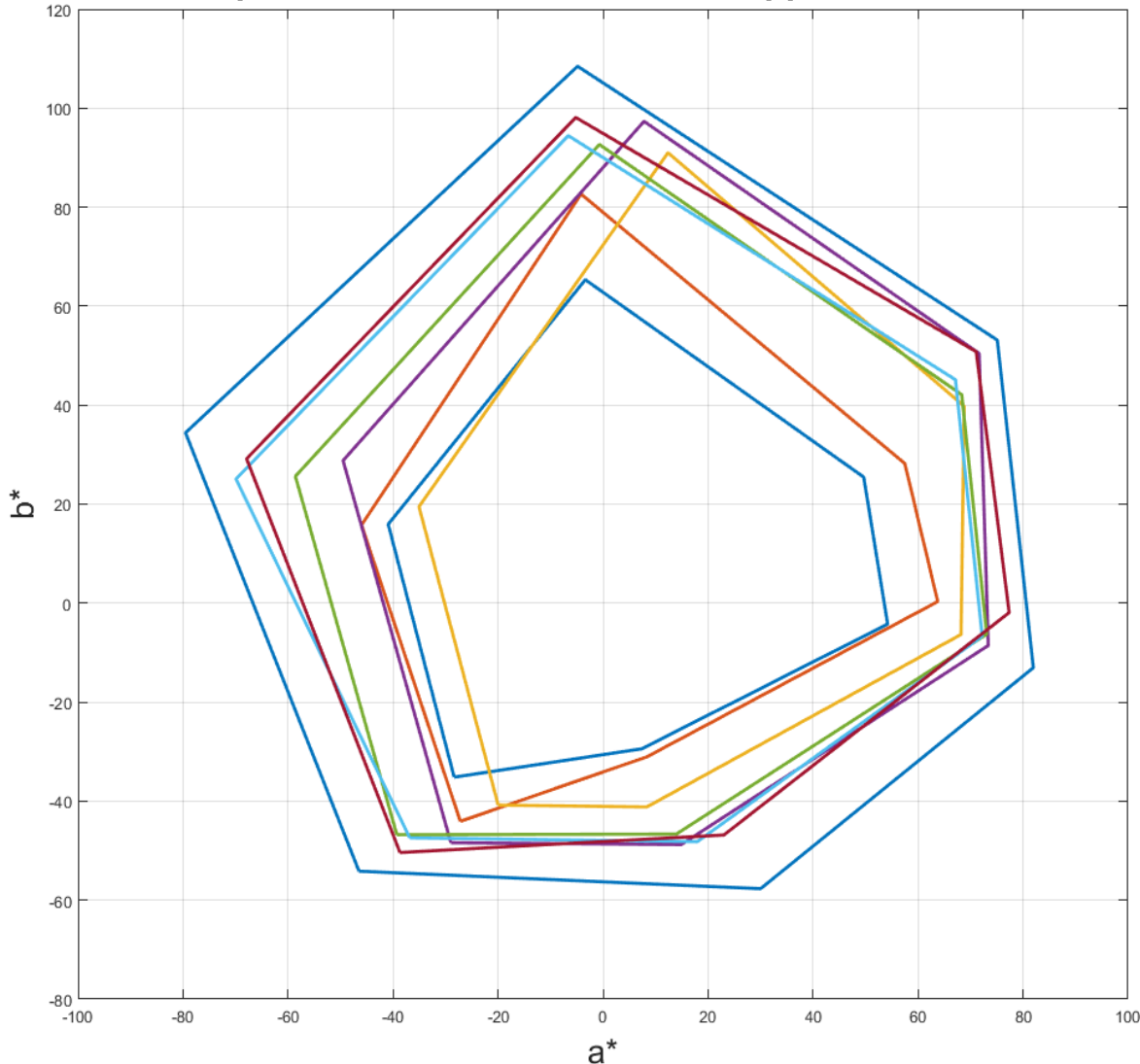
CGATS21 CRPC1: ICC profile registry
Uncoated Fogra47L: ICC profile registry
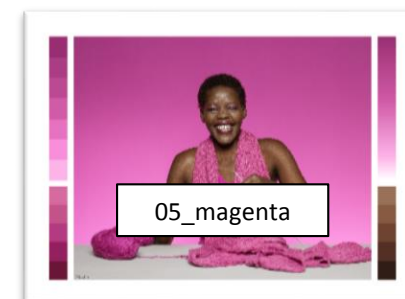PSR Gravure MF: ECI web site
PSR SC STD V2 PT: ECI web site
SC paper (ECI): ICC profile registry
Japan Web Coated (Ad): Adobe web site
Coated FOGRA39: Adobe web site
ColorMaster / Fogra53-5: Fogra web site

Note: it is not intended that these profiles should be used for rendering directly to CMYK. The associated characterisation data may be used directly but with some care the A2B1 tables (Absolute Intent) can be used to determine the colour produced by each CMYK combination

Reference printing gamuts

http://www.color.org/resources/r8-13/CCA-gamuts.xalter

Reference name	Characterisation data	ICC Profile
CGATS21-2-CRPC1	NPES **CGATS21-2-CRPC1.txt**	ICC profile registry **CGATS21_CRPC1.xalter**
FOGRA47	ICC characterisation data registry **FOGRA47L.txt**	ICC profile registry **Uncoated_Fogra47L_VIGC_300.xalter**
PSRgravureMF	ECI **eci_gravure_psr_v2_2009.zip** (PSRgravureMF_ECI2002.txt)	ECI **eci_gravure_psr_v2_2009.zip** (PSRgravureMF.icc)
ECI PSR SC STD V2	ECI **eci_gravure_psr_v2_2009.zip** (ECI_PSR_SC_STD_V2.txt)	ECI **eci_gravure_psr_v2_2009.zip** (PSR_SC_STD_V2_PT.icc)
SC_paper_eci	Only available from targ tag in ICC Profile	ECI **eci_offset_2009.zip** (SC_paper_eci.icc)
Japan Web Coated (Ad)	Not available (may be derived from A2B1 and MediaWhitePoint tags)	Adobe **detail.jsp?ftpID=4075** (JapanWebCoated.icc)
FOGRA39	ICC characterisation data registry **FOGRA39.txt**	ICC profile registry **Coated_Fogra39L_VIGC_300.xalter**
ColorMaster	Not available (may be derived from A2B1 and MediaWhitePoint tags).	Fogra **a-large-gamut-exchange-space.html**

Intended use
The set of reference printing gamuts is identified to enable exchange of results when assessing the effectiveness of Consistent Colour Appearance reproduction algorithms.

It is recommended that where possible the characterisation data is used as the primary reference, however, it is recognised that there may be some cases where it is more convenient to use the ICC Profile as a starting point.

In some cases no characterisation data is available. In these cases the A2B1 table data should be used.

Reference Display

- ## BenQ SW320 :

  - 32" IPS panel

  - UHD 4K Resolution (3840 * 2160) 16:9 ratio

  - 99% Adobe RGB coverage

  - Hardware Calibration capable

  - Special pricing for CIE TC8-16 TC research work.

- ## BenQ will work with TC to provide guidance on

  - calibration procedure

  - viewing environment

Reference proof printer

Would it be useful to have a recommendation
for a proof printer, ink set and substrate?
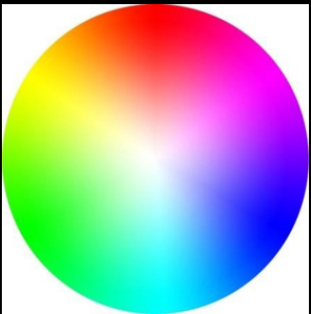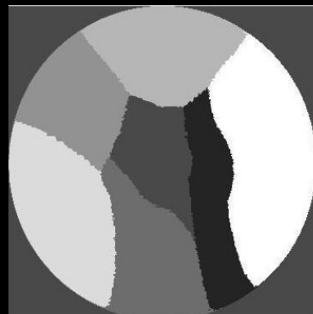

If so, how can we agree this?

Uniform colour space

Demonstration (Image Segmentation)

Segmentation (7 regions) using K-means clustering algorithm
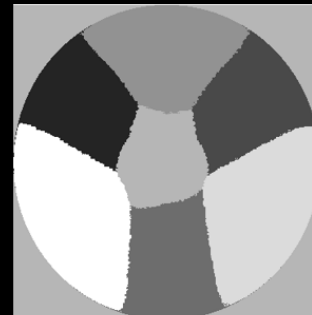
Original CIELAB CAM16-UCS
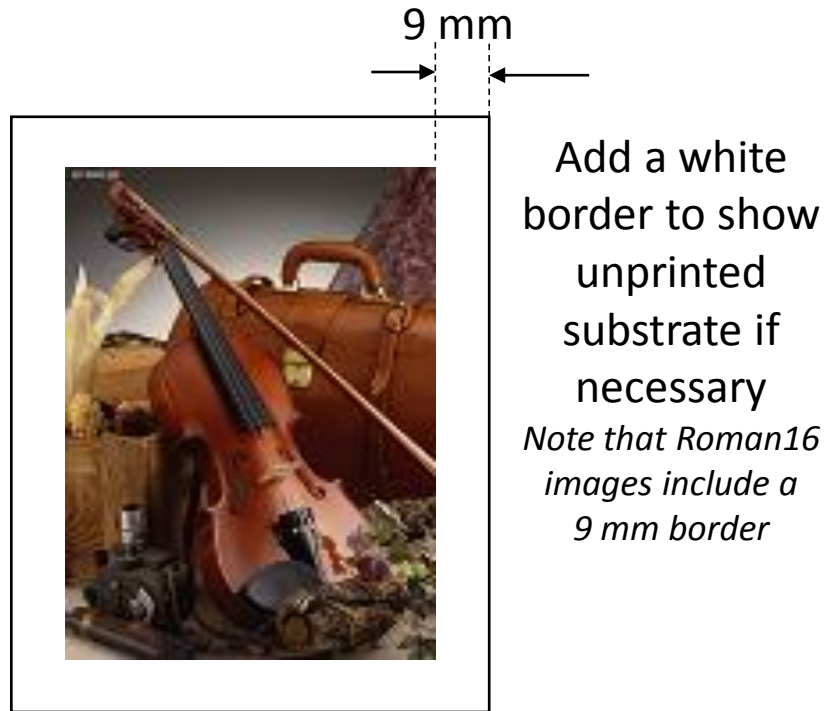
YC_bC_r IC_TC_P $J_za_zb_z$

15

$J_za_zb_z$ and CAM16-UCS papers are available from the CIE COLLTOOL area

IC_TC_P white paper is available from https://www.dolby.com/us/en/technologies/dolby-vision/ictcp-white-paper.pdf
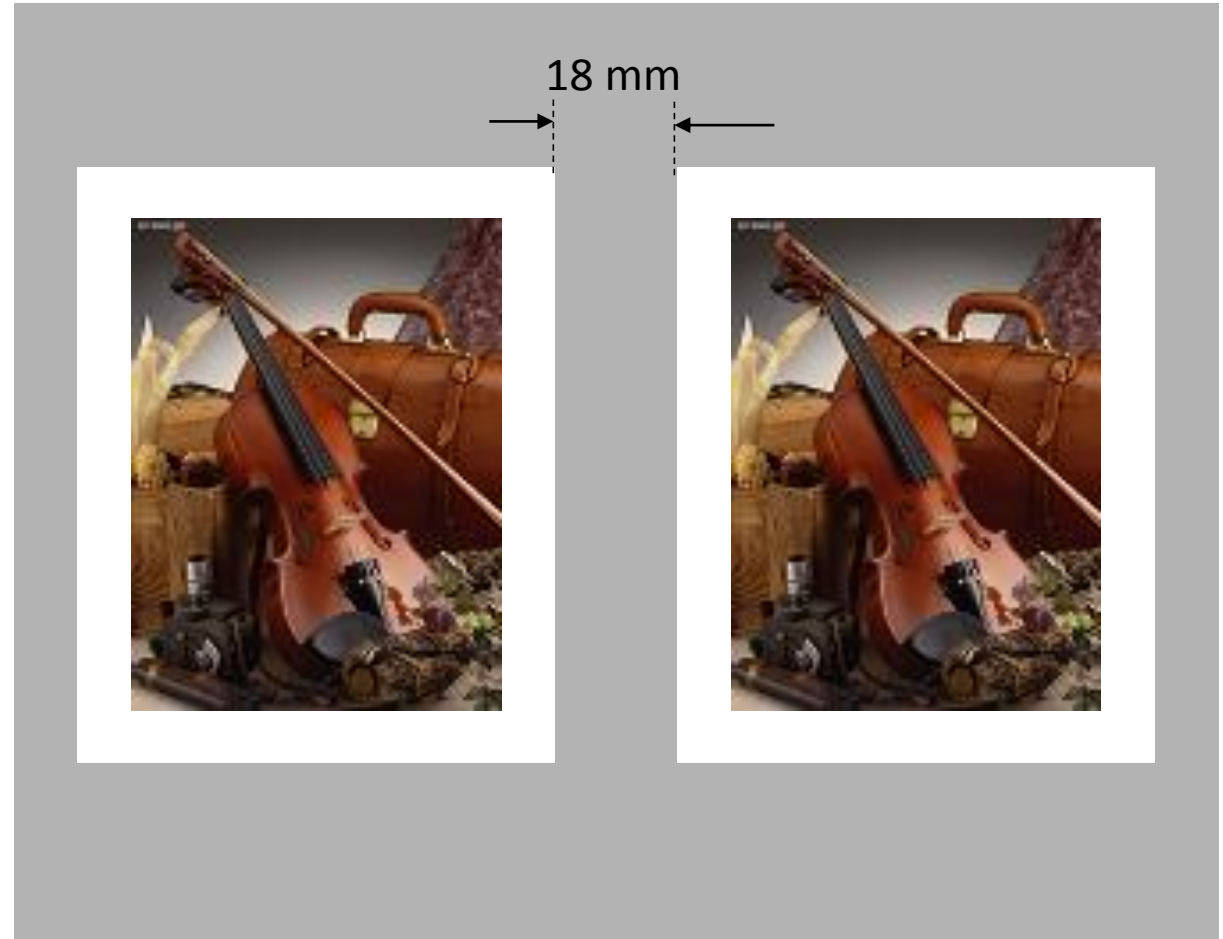
Given its ease of use and performance, perhaps $J_za_zb_z$ should be recommended

Proposed revision: image preparation

Background may be on print or display and so may not have a flat spectrum

9 mm

Add a white border to show unprinted substrate if necessary
Note that Roman16 images include a 9 mm border

Images should be printed at approximately the same size and original aspect ratio should be retained

18 mm

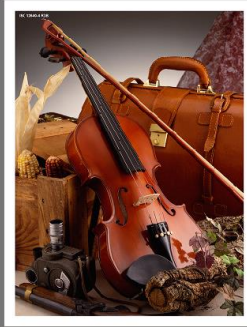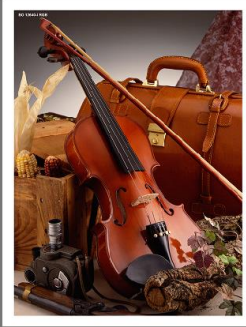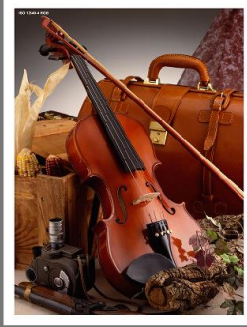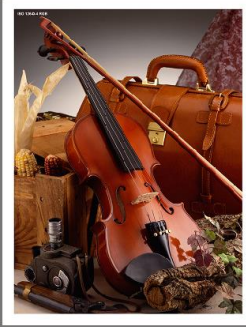Neutral (L* = 50) grey background, ideally ~ Munsell N5

Geometry for print or display

Geometry allows viewing of up to 8 reproductions including a reference (bottom right) on a 32 inch display

Control strips allow checking of display or proof print calibration
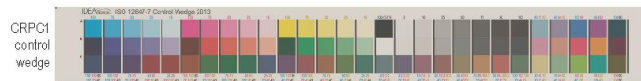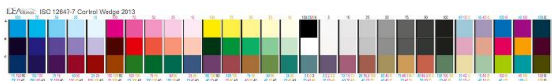
Use of print gamuts

Viewing environment

- ISO 3664:2009 Viewing conditions
- P2 viewing condition
- CIE Illuminant D50
- 500 lx +- 125 lx (same as ICC PCS)

- ISO 12646:2008 Display characteristics and viewing conditions
- ISO 14861:2015 Requirements for colour soft proofing systems
- Display colour gamut must be large enough to simulate all reference print gamuts

Hard copy proof

Soft copy proof

# Psychophysical assessment method

- This assessment method may be used to assess and compare rendering algorithms
  - is there a need for other assessment methods?
- Details of the assessment method need to be provided:
  - instructions for observers
- Can we compare the results of assessment on display with result of assessment of prints?

Measurement assessment
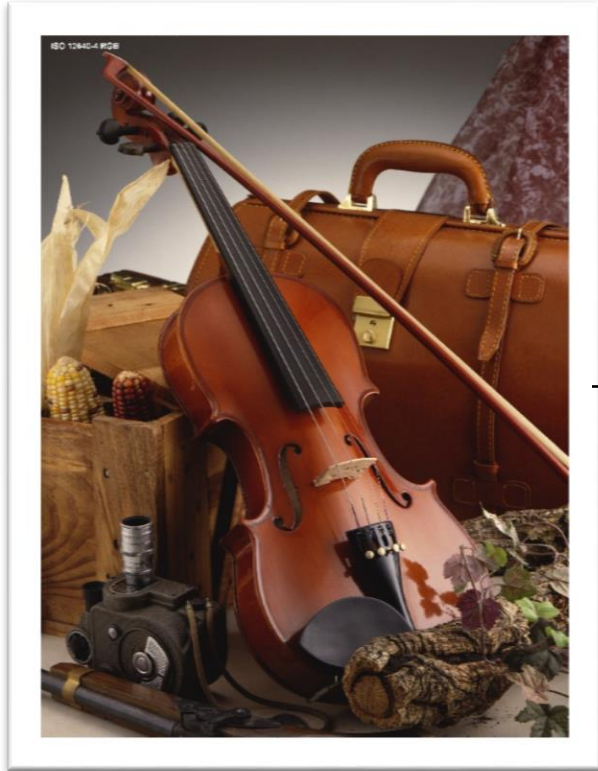
Original image
used for psychophysical
assessment
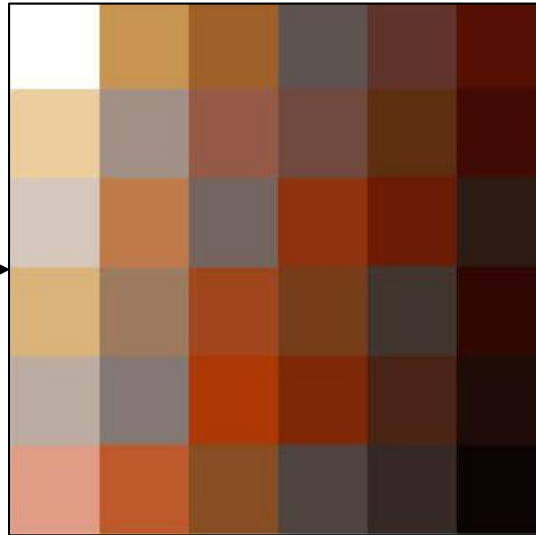
'Important' image colours
used for measurement
assessment

Image reconstructed using
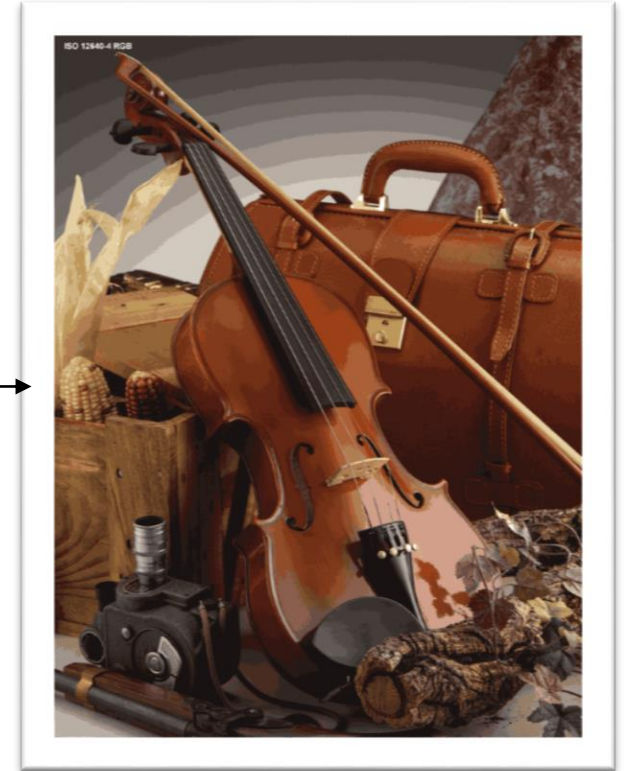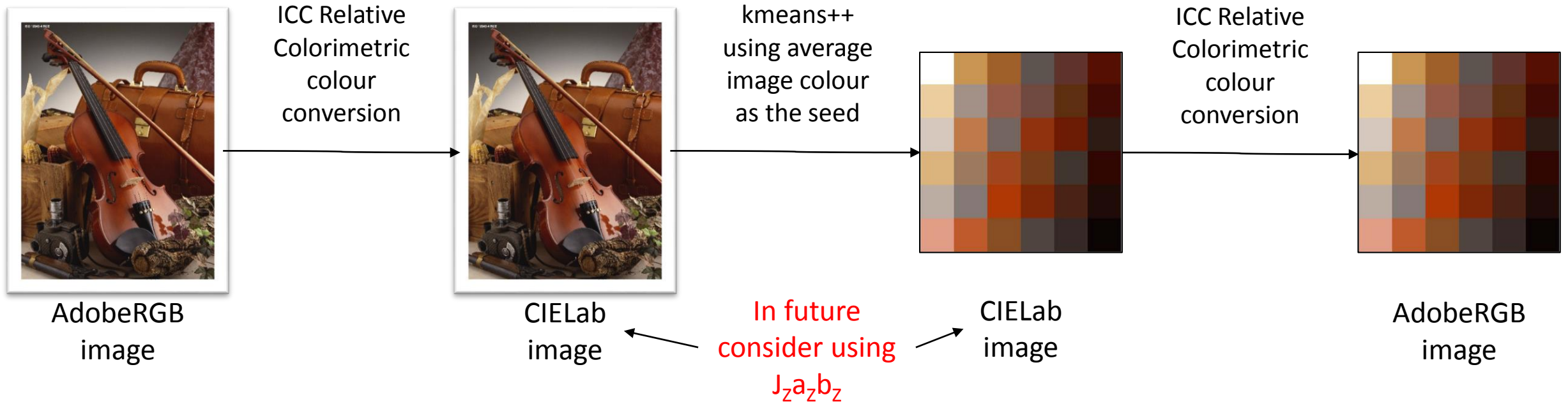the important image colours
as a confirmation

Algorithm details

AdobeRGB image → ICC Relative Colorimetric colour conversion → CIELab image → kmeans++ using average image colour as the seed → CIELab image → ICC Relative Colorimetric colour conversion → AdobeRGB image

In future consider using $J_z a_z b_z$

The kmeans++ algorithm is described in the following publications:

[1] J. B. MacQueen, "Some Methods for Classification and Analysis of MultiVariate Observations", in Proc. of the fifth Berkeley Symposium on Mathematical Statistics and Probability, L. M. L. Cam and J. Neyman, eds., vol. 1, UC Press, 1967, pp. 281-297.

[2] D. Arthur and S. Vassilvitskii, "k-means++: The Advantages of Careful Seeding", Technical Report 2006-13, Stanford InfoLab, 2006.

Measurement assessment

- Would it be useful to recommend an algorithm to extract the set of important colours from an image
    - This set of colours should be measured as part of any psychophysical assessment in order to provide a basis for subsequent analysis
- How many colours are necessary to describe an image?
    - I selected 36 as a compromise which produces a reasonable quality reconstruction image and can be measured relatively easily
    - See result for some of the reference images and the result using 64 colours
- A set of images that uses these colours could also be provided
- Would it be useful to have a MATLAB implementation?

Discussion of next steps