Gamut Analysis XCMYK

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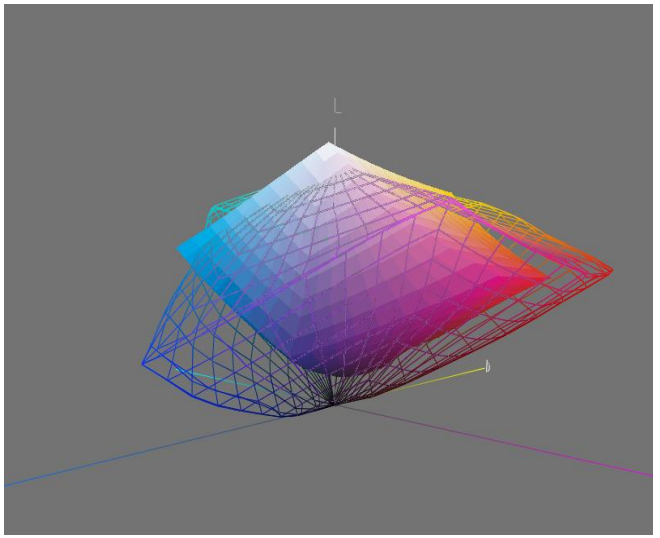
Background

- **XCMYK** – new expanded gamut **4-color** printing process
- Standard **ISO 12647-2 compliant CMYK** inks can be used
  - with higher ink film thickness
  - non-traditional screening e.g. FM
- XCMYK dataset and ICC profile – Idealliance[1]

Gamut Metrics – relative coverage

- We often need to compare two or more color gamuts
- The **absolute 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**

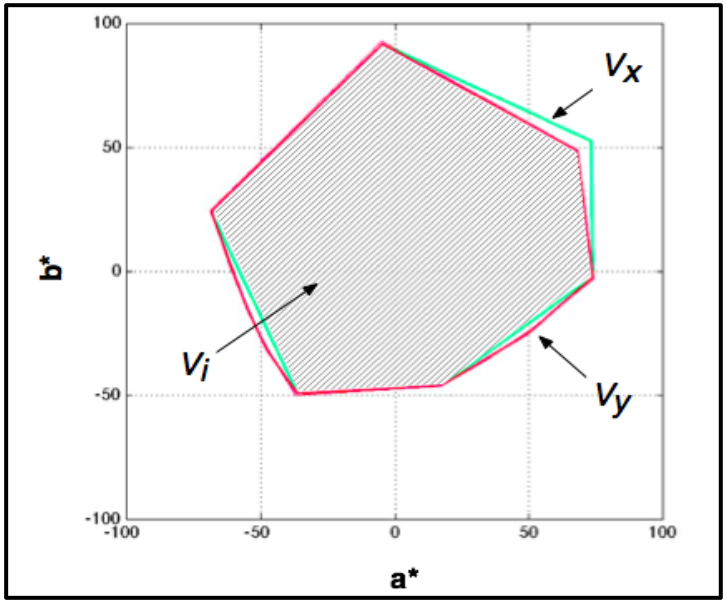


Gamut Comparison Index (GCI)

- GCI[2] – objective metric to **quantify the difference between two gamuts**

- GCI between two gamuts shows **how closely they match** – similar to ΔE

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



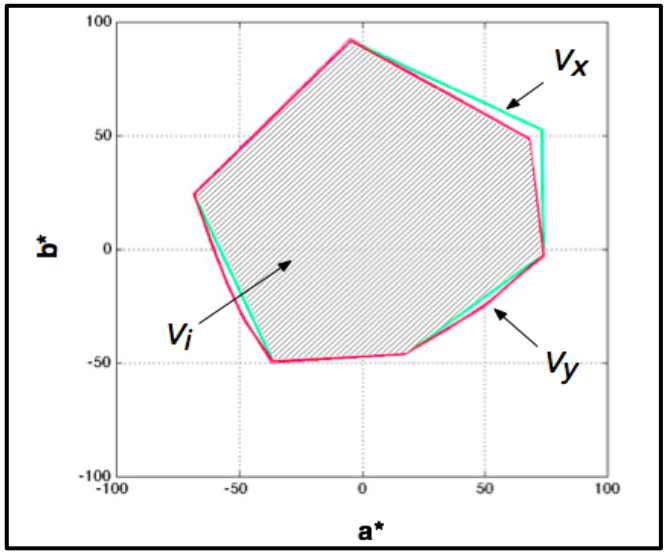
V_x : gamut volume of the medium x

V_y : gamut volume of the medium y

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

Gamut Metrics – relative coverage

- $[V_i / V_x]$: how much of gamut x is **covered** by gamut y
- $[V_i / V_y]$: how much of gamut y is **covered** by gamut x
- $[(V_x - V_i) / V_x]$: how much of gamut x is **outside** the gamut y
- $[(V_y - V_i) / V_y]$: how much of gamut y is **outside** the gamut x
- $[V_x / V_y]$: ratio of gamut x to gamut y

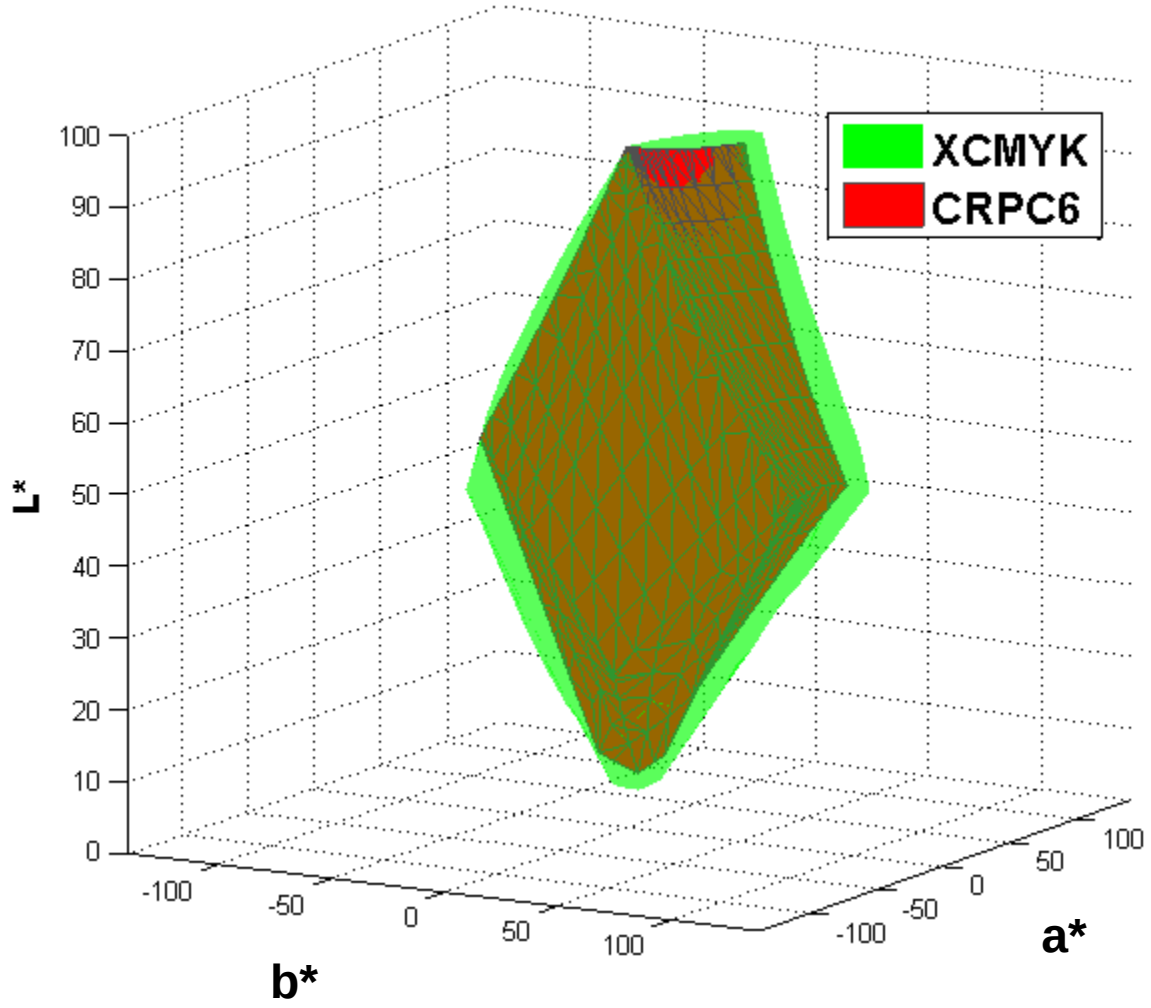


Gamut Metrics[2]

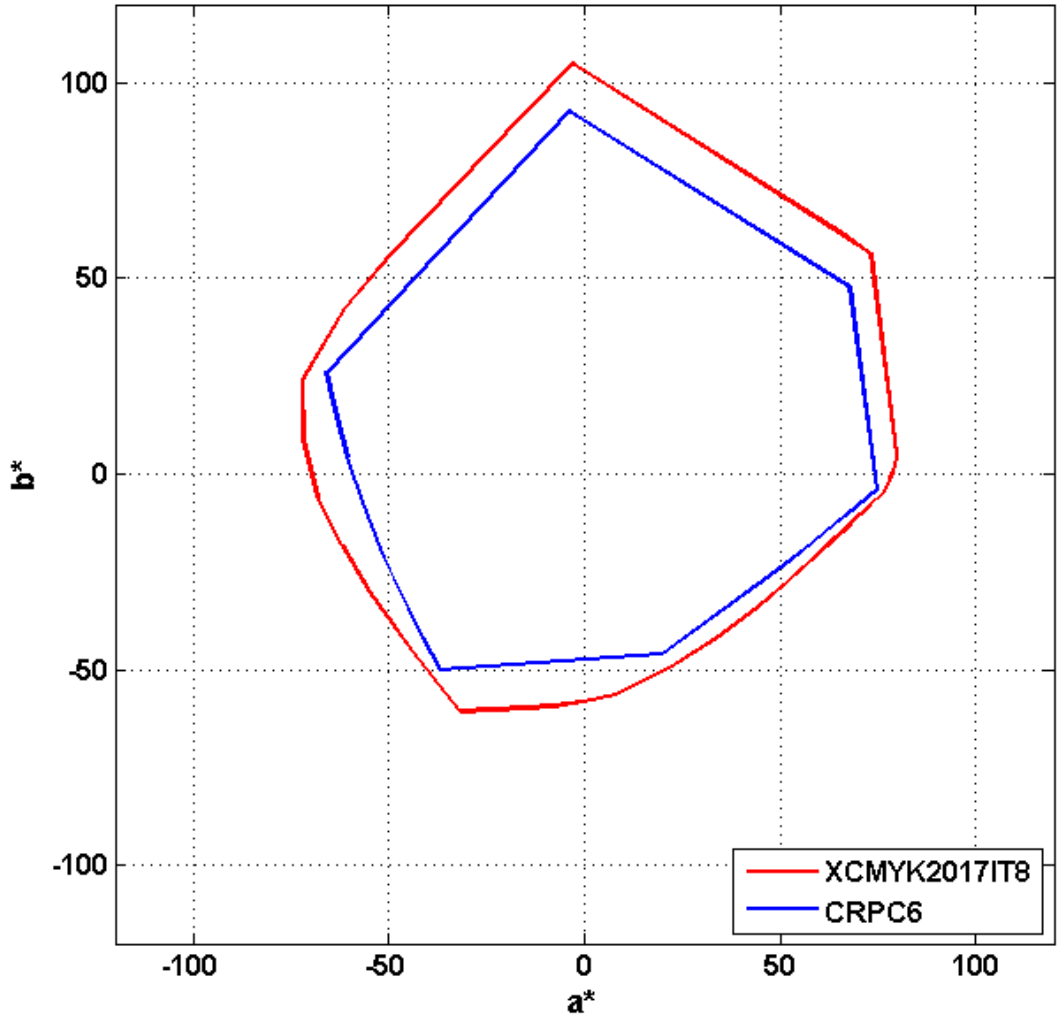
Datasets and method

- Reference gamut – **XCMYK2017IT8**
  - GRACoL2013_CRPC6[3]
  - FOGRA51[4]
  - Proofer gamut – example Epson9900
  - 7c Expanded Gamut CMYKOGV – Press1 & Press2
- Gamut volume calculation method – Alpha-shapes

XCMYK vs. GRACoL2013 CRPC6



XCMYK vs. GRACoL2013 CRPC6



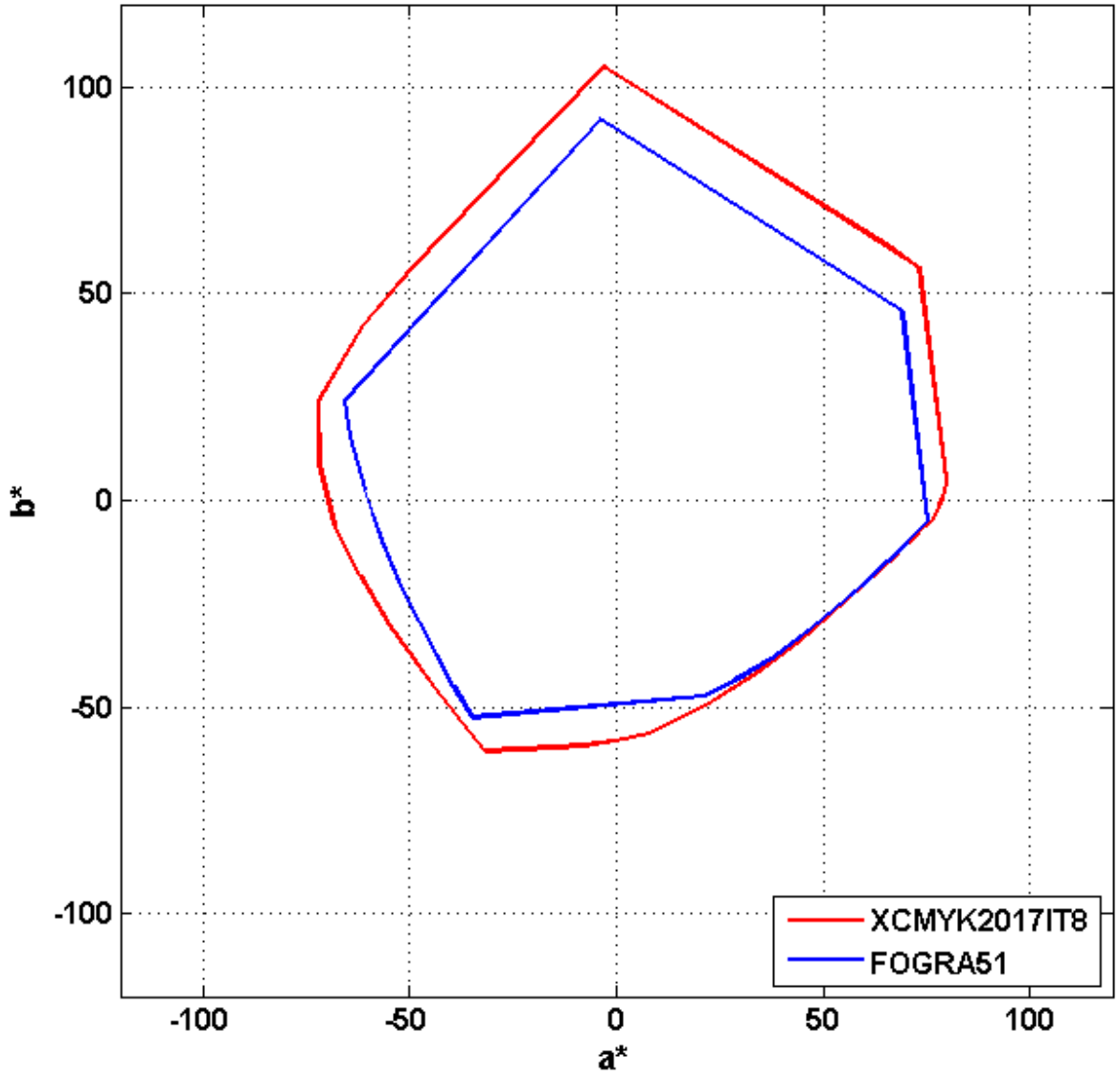
XCMYK vs. GRACoL2013 CRPC6

Volume of XCMYK2017IT8	569984
Volume of CRPC6	389309
Volume of intersection	388425
GCI	0.68
Volume ratio of XCMYK2017IT8 to CRPC6	**1.46**
Fraction of XCMYK2017IT8 covered by CRPC6	68.15%
Fraction of CRPC6 covered by XCMYK2017IT8	**99.77%**
Fraction of XCMYK2017IT8 lying outside CRPC6	31.85%
Fraction of CRPC6 lying outside XCMYK2017IT8	0.23%
Absolute difference in volumes	180675

XCMYK gamut is 46% bigger than CRPC6 gamut

All volumes in Cubic CIELAB units

XCMYK vs. FOGRA51

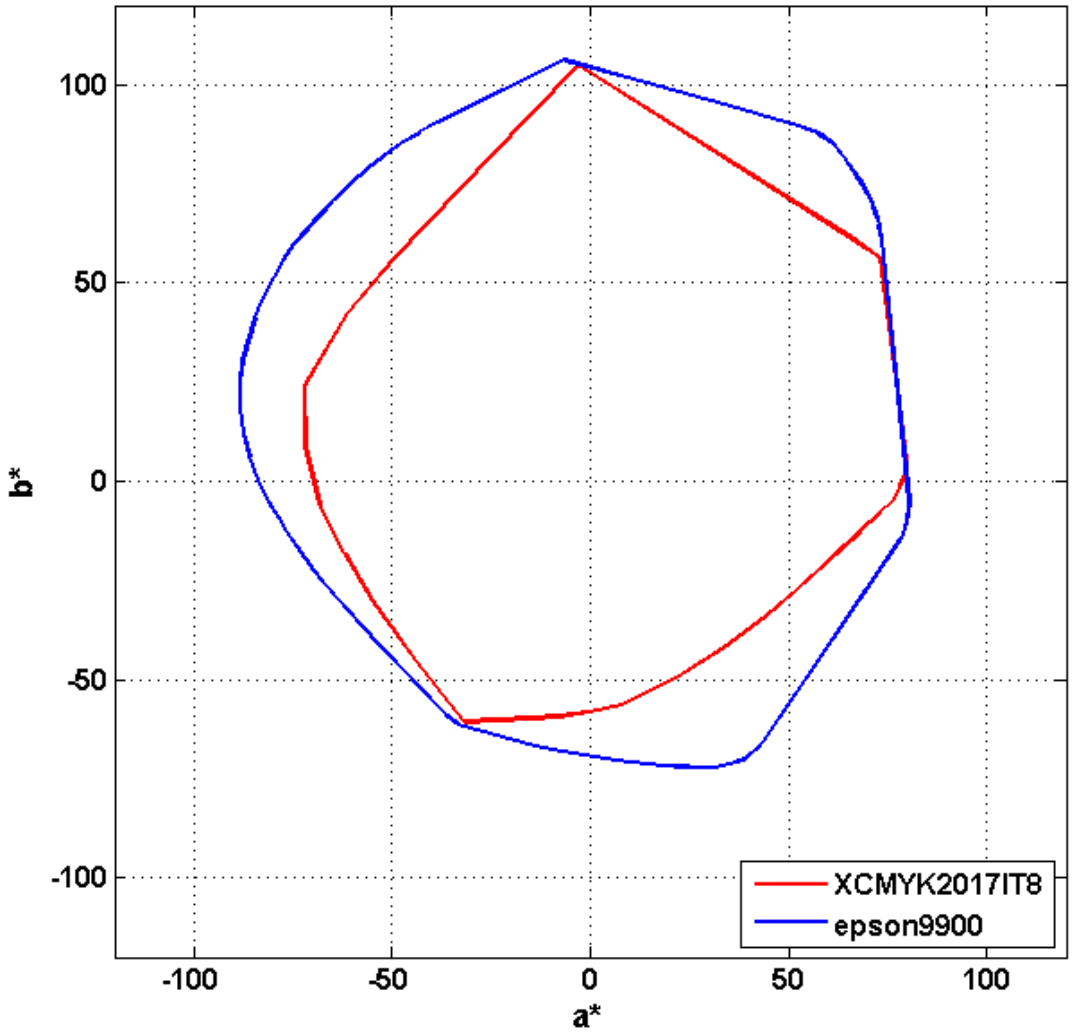


XCMYK vs. FOGRA51

Volume of XCMYK2017IT8	569984
Volume of FOGRA51	398546
Volume of intersection	397158
GCI	0.69
Volume ratio of XCMYK2017IT8 to FOGRA51	**1.43**
Fraction of XCMYK2017IT8 covered by FOGRA51	69.68%
Fraction of FOGRA51 covered by XCMYK2017IT8	**99.65%**
Fraction of XCMYK2017IT8 lying outside FOGRA51	30.32%
Fraction of FOGRA51 lying outside XCMYK2017IT8	0.35%
Absolute difference in volumes	171438

All volumes in Cubic CIELAB units

XCMYK vs. Proofer (Epson9900)



XCMYK vs. Proofer (Epson9900)

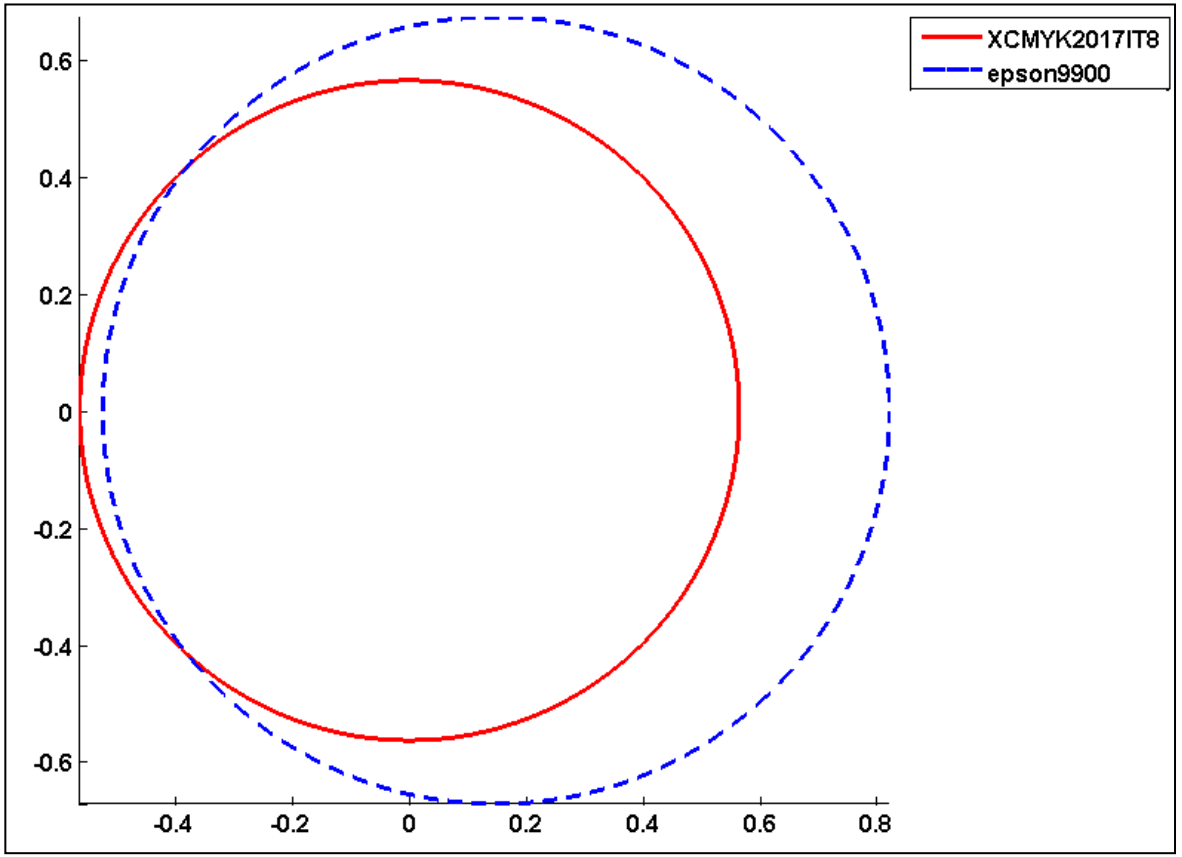
Volume of XCMYK2017IT8	569984
Volume of epson9900	810973
Volume of intersection	556411
GCI	0.67
Volume ratio of XCMYK2017IT8 to epson9900	0.70
Fraction of XCMYK2017IT8 covered by epson9900	**97.62%**
Fraction of epson9900 covered by XCMYK2017IT8	68.61%
Fraction of XCMYK2017IT8 lying outside epson9900	**2.38%**
Fraction of epson9900 lying outside XCMYK2017IT8	31.39%
Absolute difference in volumes	240990

Proofer has insufficient gamut in some regions

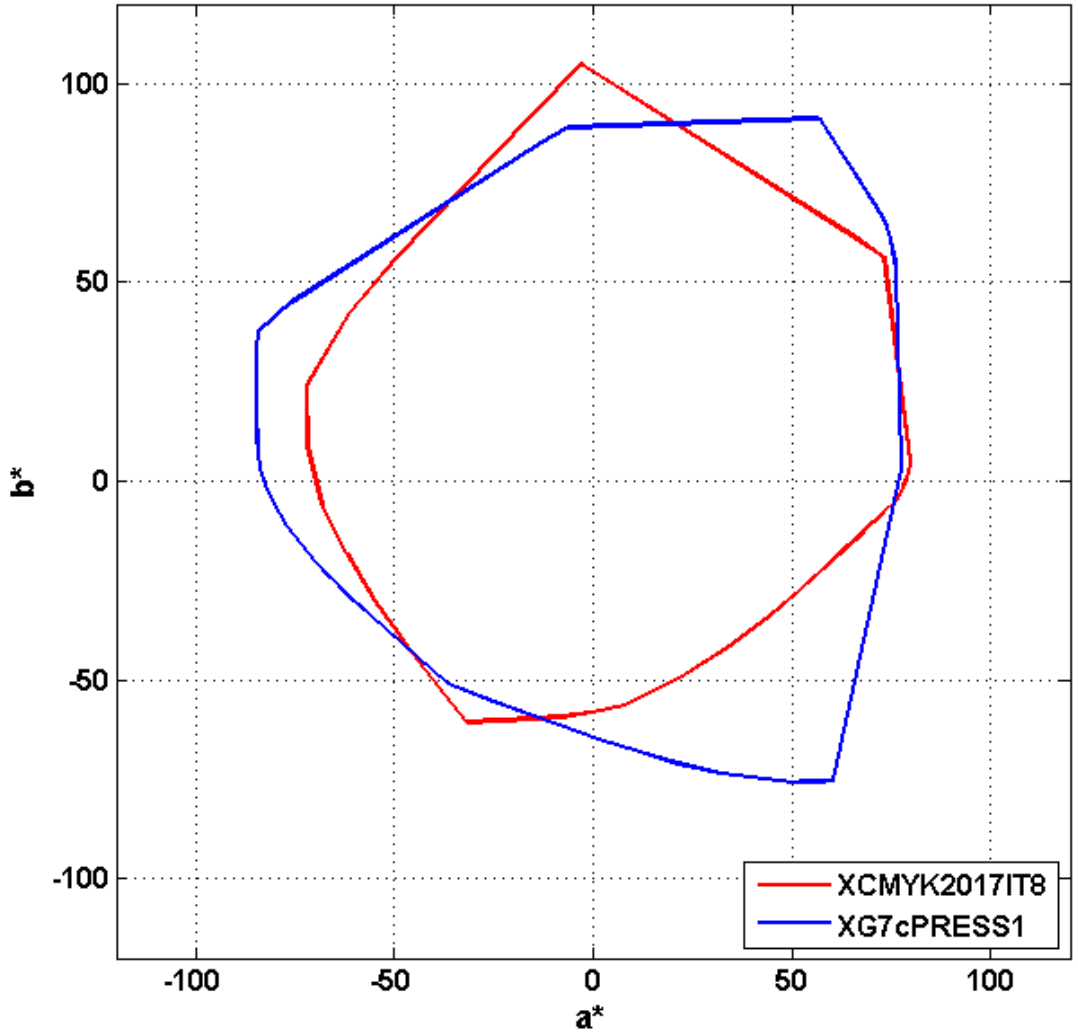
All volumes in Cubic CIELAB units

XCMYK vs. Proofer – Venn diagram

- **Volume-proportional idealized projection**
- Each circle = **relative volume** of individual gamut
- Areas of circles ≈ volumes of respective gamuts
- Intersection area of two circles ≈ volume of intersection of gamuts
- Depicts several gamut metrics in a simple diagram



XCMYK vs. CMYKOGV Press1



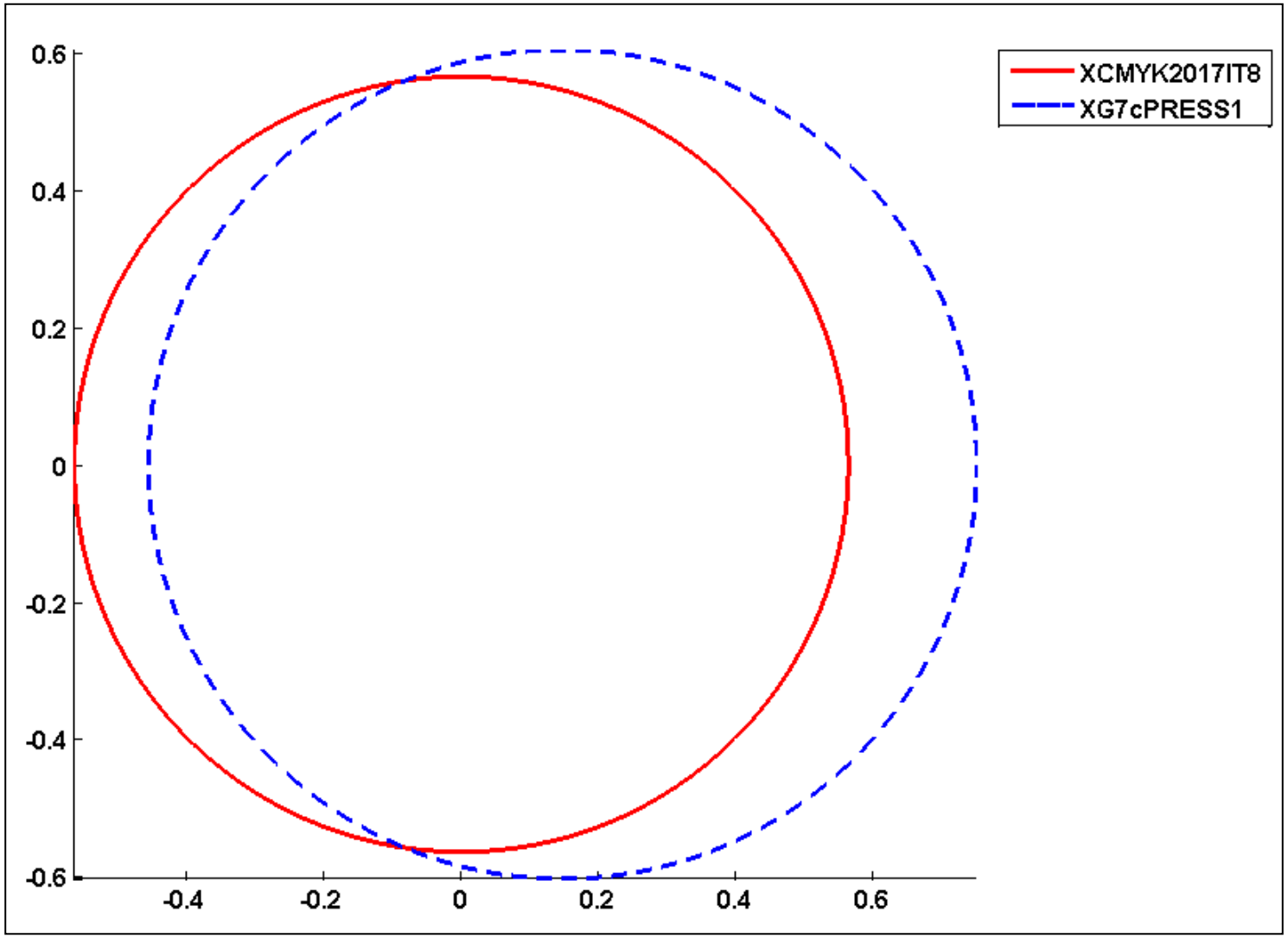
XCMYK vs. CMYKOGV Press1

Volume of XCMYK2017IT8	569984
Volume of XG7cPRESS1	652201
Volume of intersection	509642
GCI	0.70
Volume ratio of XCMYK2017IT8 to XG7cPRESS1	0.87
Volume ratio of XG7cPRESS1 to XCMYK2017IT8	**1.14**
Fraction of XCMYK2017IT8 covered by XG7cPRESS1	89.41%
Fraction of XG7cPRESS1 covered by XCMYK2017IT8	78.14%
Fraction of XCMYK2017IT8 lying outside XG7cPRESS1	**10.59%**
Fraction of XG7cPRESS1 lying outside XCMYK2017IT8	21.86%
Absolute difference in volumes	82217

CMYKOGV gamut (Press1) is only 14% bigger than XCMYK gamut

All volumes in Cubic CIELAB units

XCMYK vs. CMYKOGV Press1 - Venn diagram



Summary

- **XCMYK** provides significantly larger gamut **without adding any primary inks** to CMYK
- Before proofing, check if the **proofer gamut** is enough to match XCMYK – using gamut metrics
- Need to **harmonize with n-color printing process** (e.g. 7-color expanded gamut)
- **Gamut metrics** provide valuable information by quantifying **relative coverage & intersection** of two gamuts

References

1. XCMYK Expanded Gamut (2017). Available at https://www.idealliance.org/xcmyk/

2. Deshpande, K., Green, P., & Pointer, M. R. (2015). Metrics for comparing and analyzing two colour gamuts. *Color Research & Application*, *40*(5), 465-471.

3. GRACoL and SWOP Version 13 (2016). http://connect.idealliance.org/viewdocument/gracol-and-swop-version-13-1

4. FOGRA51 (2016). Characterization data for standardized printing conditions. Available at https://www.fogra.org/en/fogra-standardization/fogra-characterizationdata/fogra-characterizationdata-download/

Thank You!