An Evaluation of the Effect of Instrument Geometry on Color Management for Printed Textiles

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- Rochester Institute of Technology
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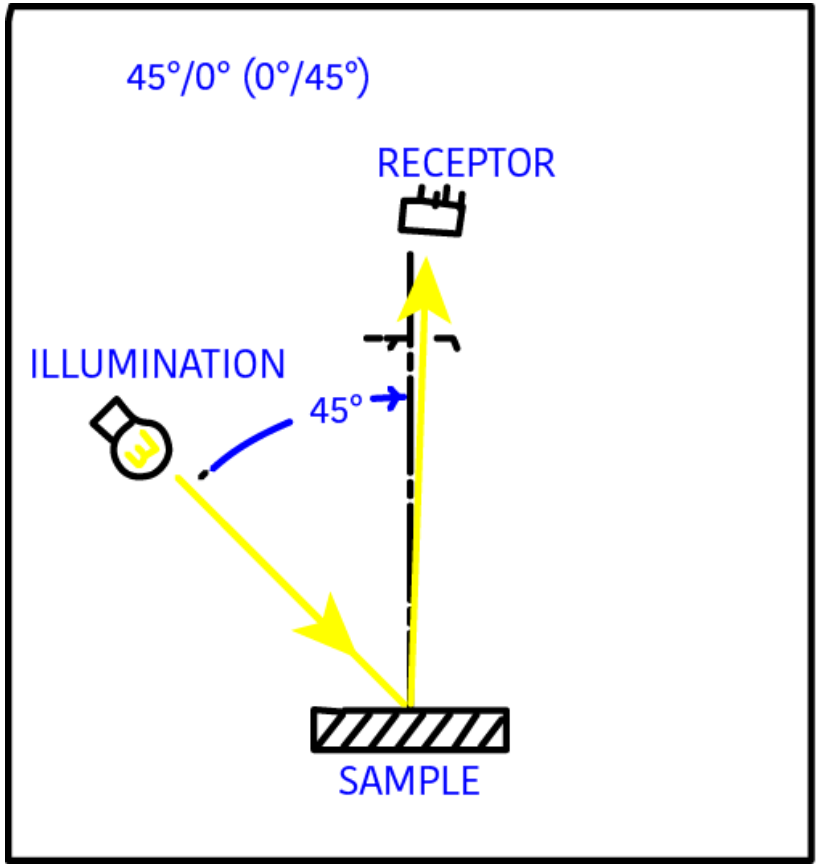
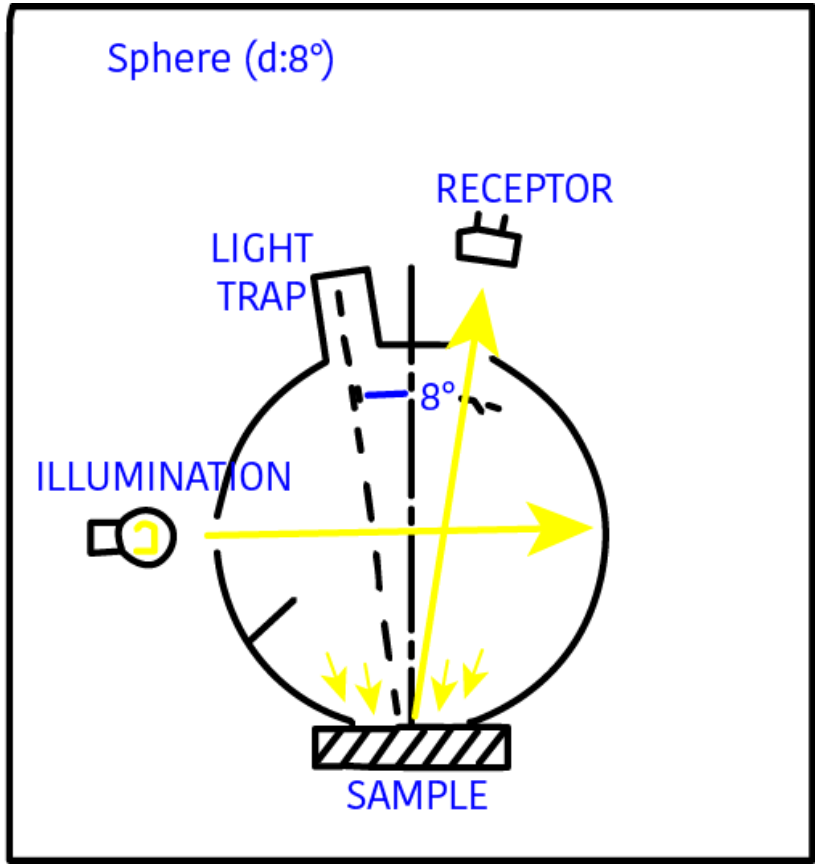
Sphere vs 45°


45°/0° (0°/45°)
RECEPTOR
ILLUMINATION
45°
SAMPLE


Sphere (d:8°)
RECEPTOR
LIGHT
TRAP
8°
ILLUMINATION
SAMPLE

Nature of ICC Profiling

- Numerous Patches Measured to Create a Profile
  - *Typically, 100's to 1,000's*
- Automated Spectrophotometers Typically Utilized
  - *Relative vs. Absolute*
- No Known Automated Sphere Device Specifically for this Purpose

Automated Patch Readings?

Analyses

Quantitative Analysis	Qualitative Analysis
Numeric Gamut Volume	Visual Gamut Volume
Round-Trip Profile	Visual Gamut Shapes
Spot Readings	

Variables

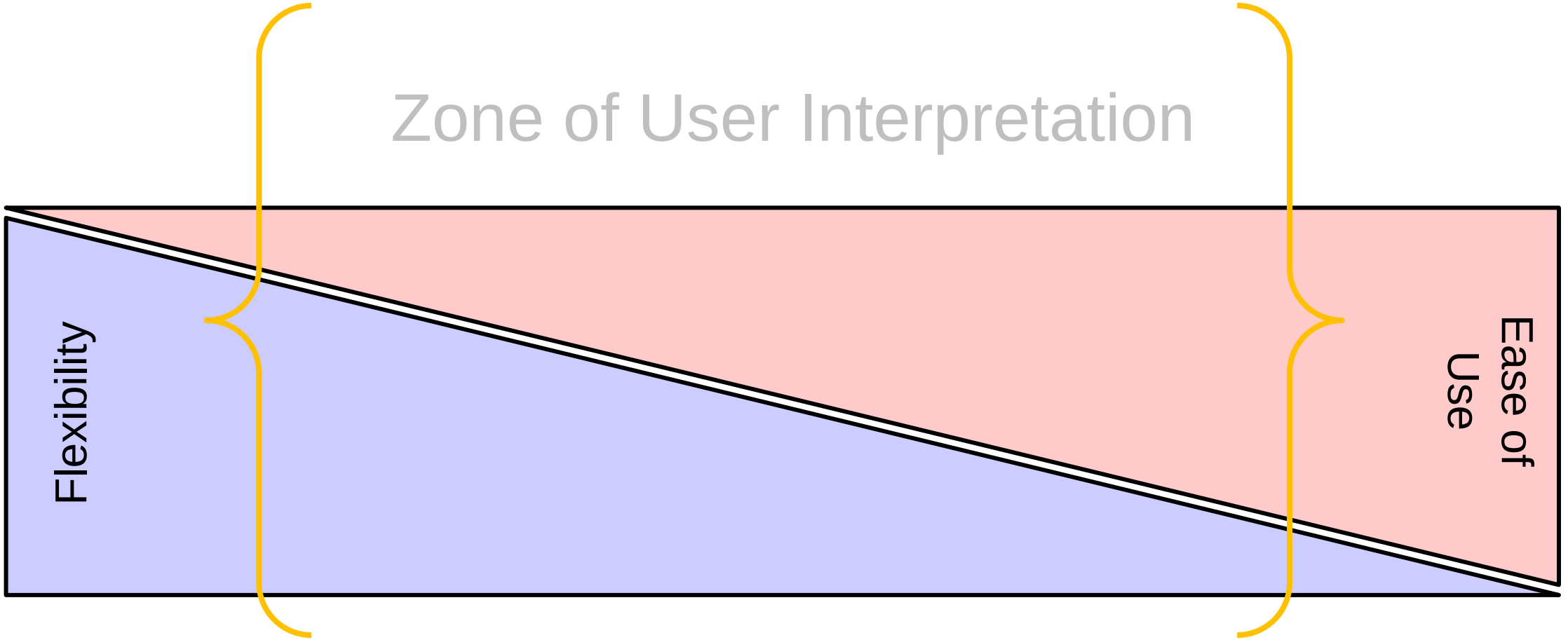
Instruments		
45°	Sphere: Specular Excluded	Sphere: Specular Included

Substrates	
Ultra-Cotton (UC) High Texture / Low Gloss	Samba Less Texture / Higher Gloss

Materials

Measuring Instruments:	X-Rite eXact (45°)	Konica Minolta CM700D (Sphere)	Legacy: X-Rite SP62 (Sphere)	Legacy: X-Rite 939 (0/45°)
Software:	X-Rite i1 Profiler (i1 Publish)	Legacy: X-Rite ColorPort	Legacy: X-Rite (Gretag Macbeth) ProfileMaker	Chromix ColorThink Pro
Hardware:	ColorScout A+ (x,y Table)	Vutek GS 3250 Inkjet Printer, UV Curable Ink		

Flexibility and Ease of Use: Inverse Relationship



Flexibility and Ease of Use: Inverse Relationship

Flexible, but Hard to Use

- Customizable
- Onus of responsibility on user

Closed, but Easy to Use

- Great – So Long as User is Lockstep with Engineer's Indented Purpose
  - *Includes Specific Application and Workflow*
- "Was not designed for that"

It's a Good Thing that the Journey *IS* the Destination

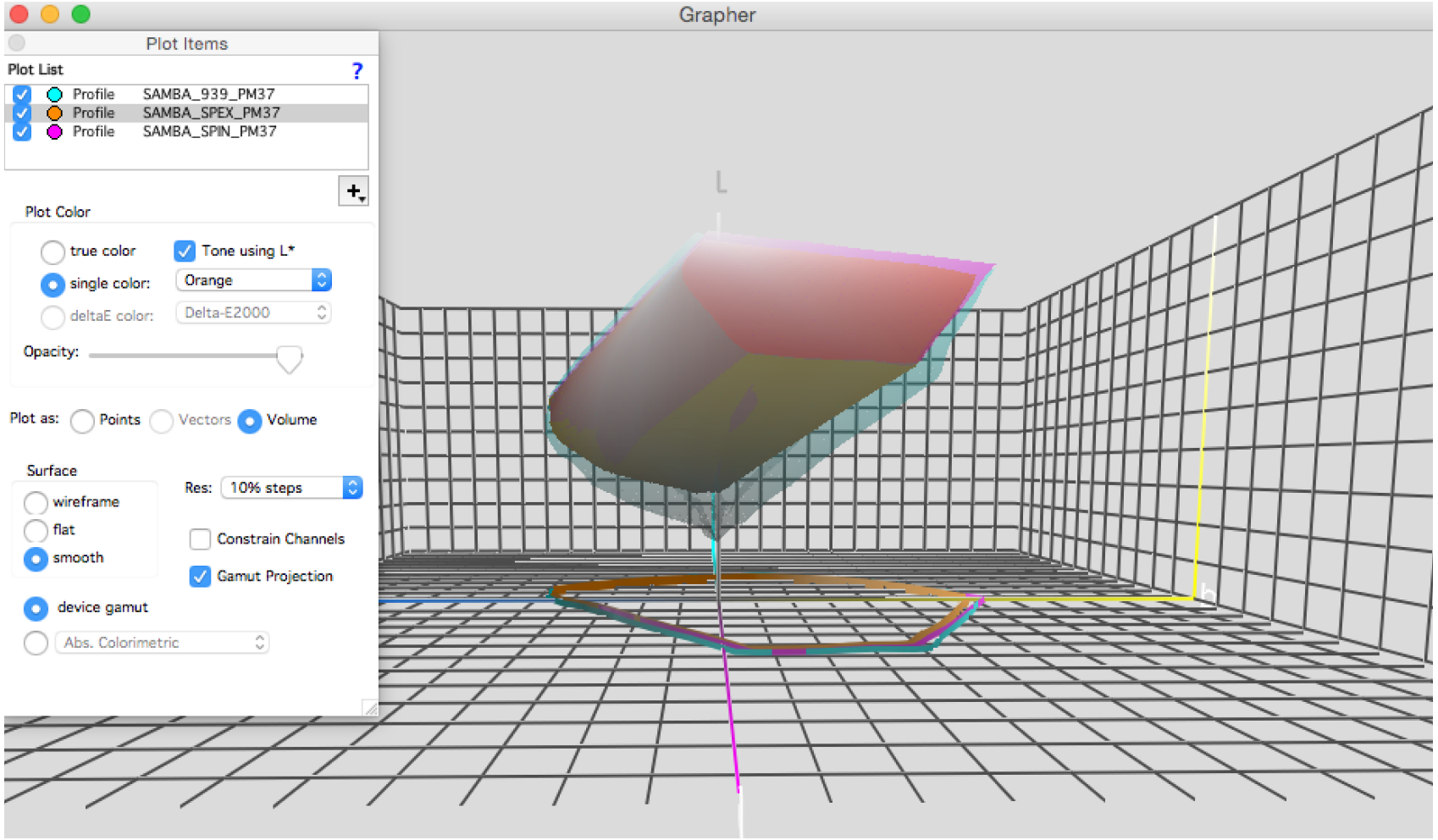
- Initial Spherical Readings Would Not Build Profile with i1 Profiler (i1 Publish) Software
- Forced to Turn to Legacy Solutions
  - *X-Rite ColorPort Direct Support for X-Rite SP64*
  - *X-Rite ColorPort Direct Support for ProfileMaker*
  - *Good Thing I Held on to that Motorola-Based iMAC*

Quantitative: Numeric Gamut Volumes

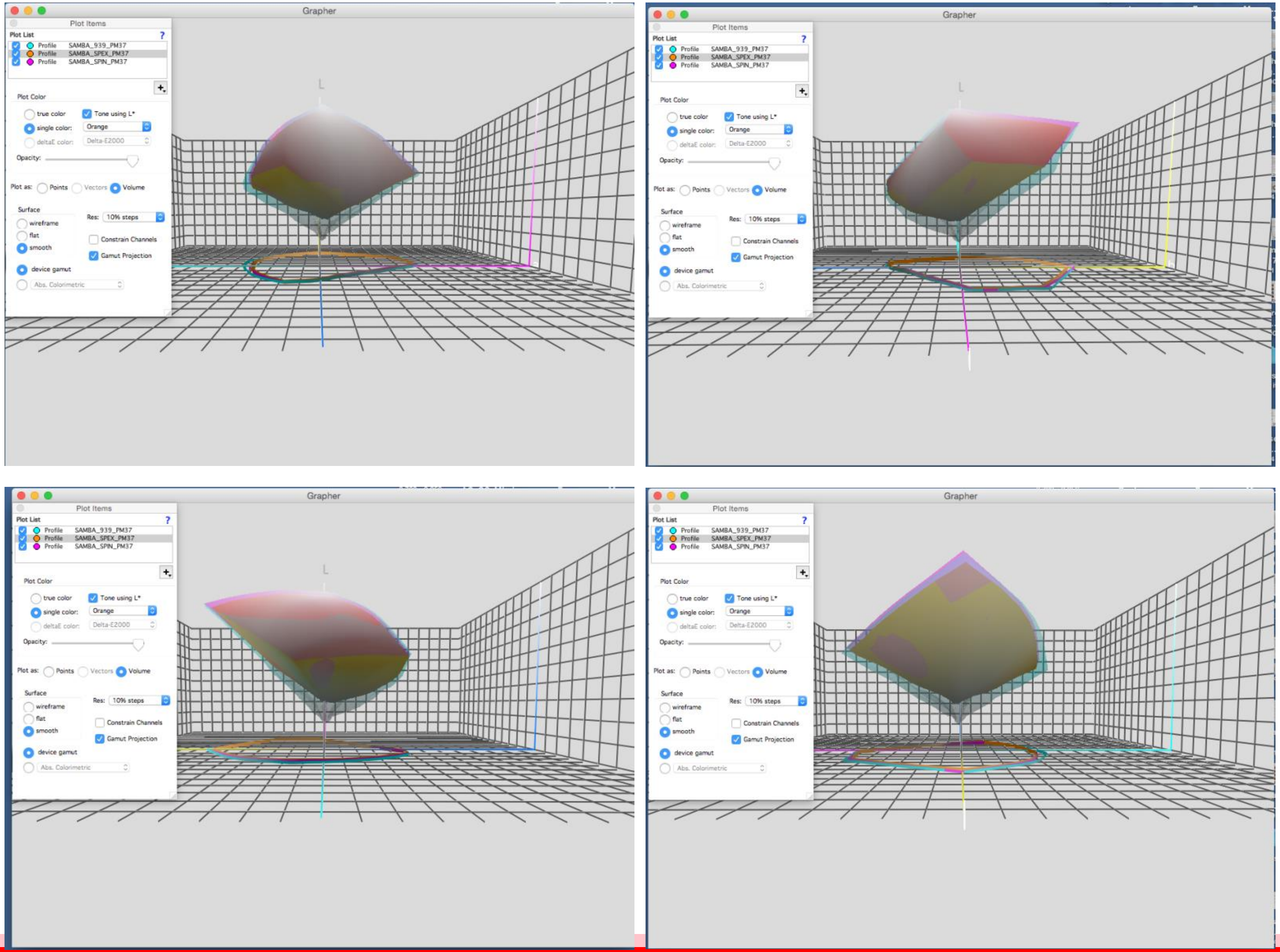
SAMBA	
45°	250,155
Sphere Specular Excluded	195,429
Sphere Specular Included	210,523

Ultra Cotton	
45°	253,231
Sphere Specular Excluded	236,232
Sphere Specular Included	224,914

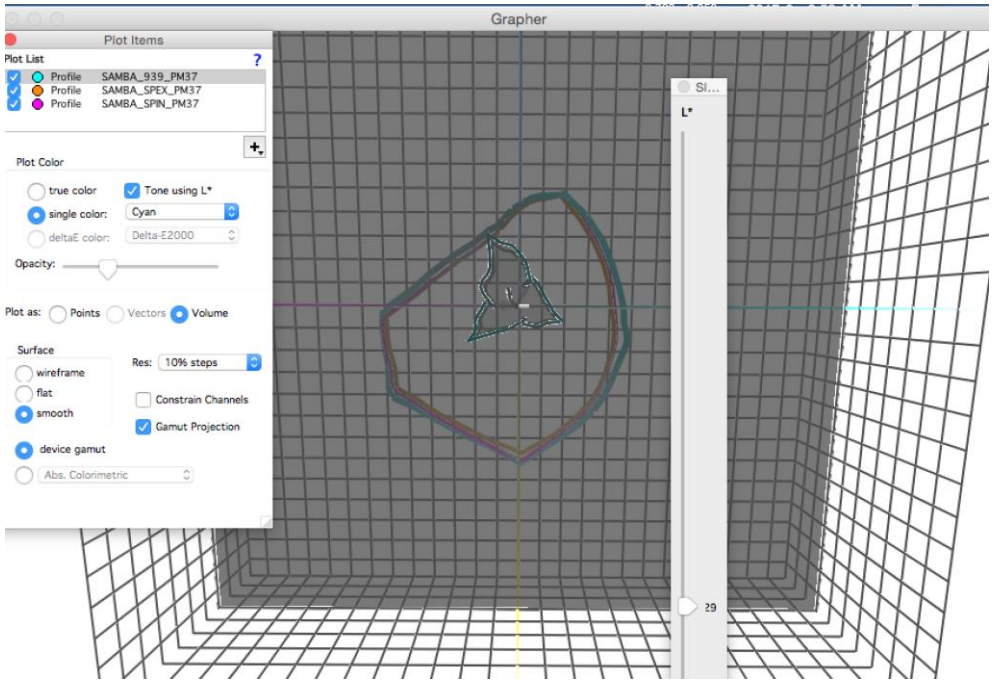
Qualitative: Visual Gamut Volumes - SAMBA

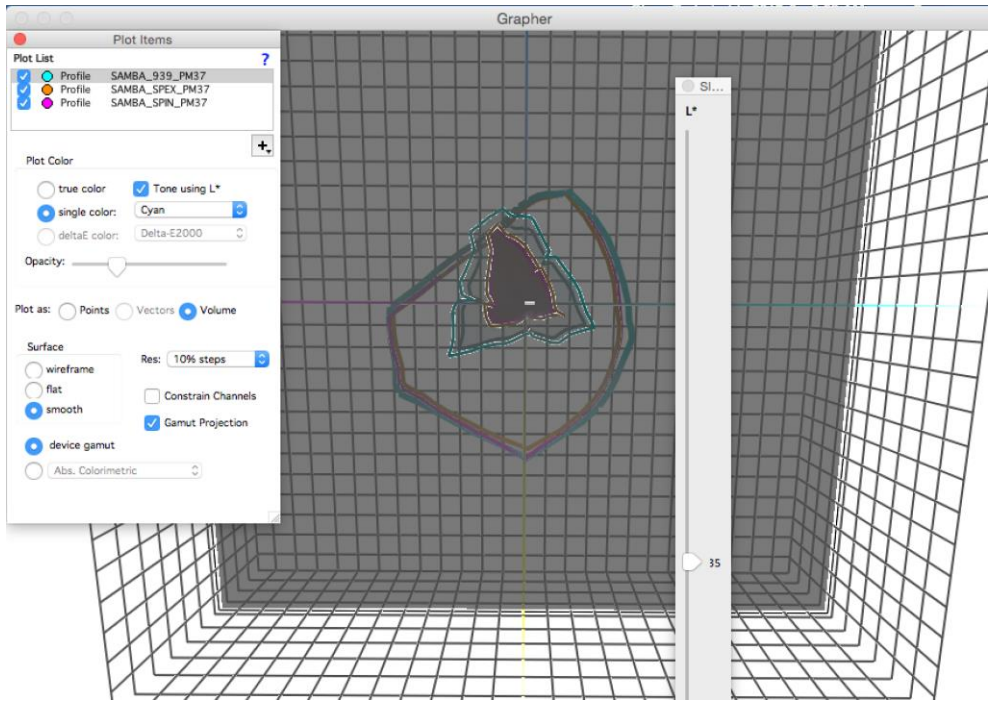


Qualitative: Visual Gamut Volumes - SAMBA

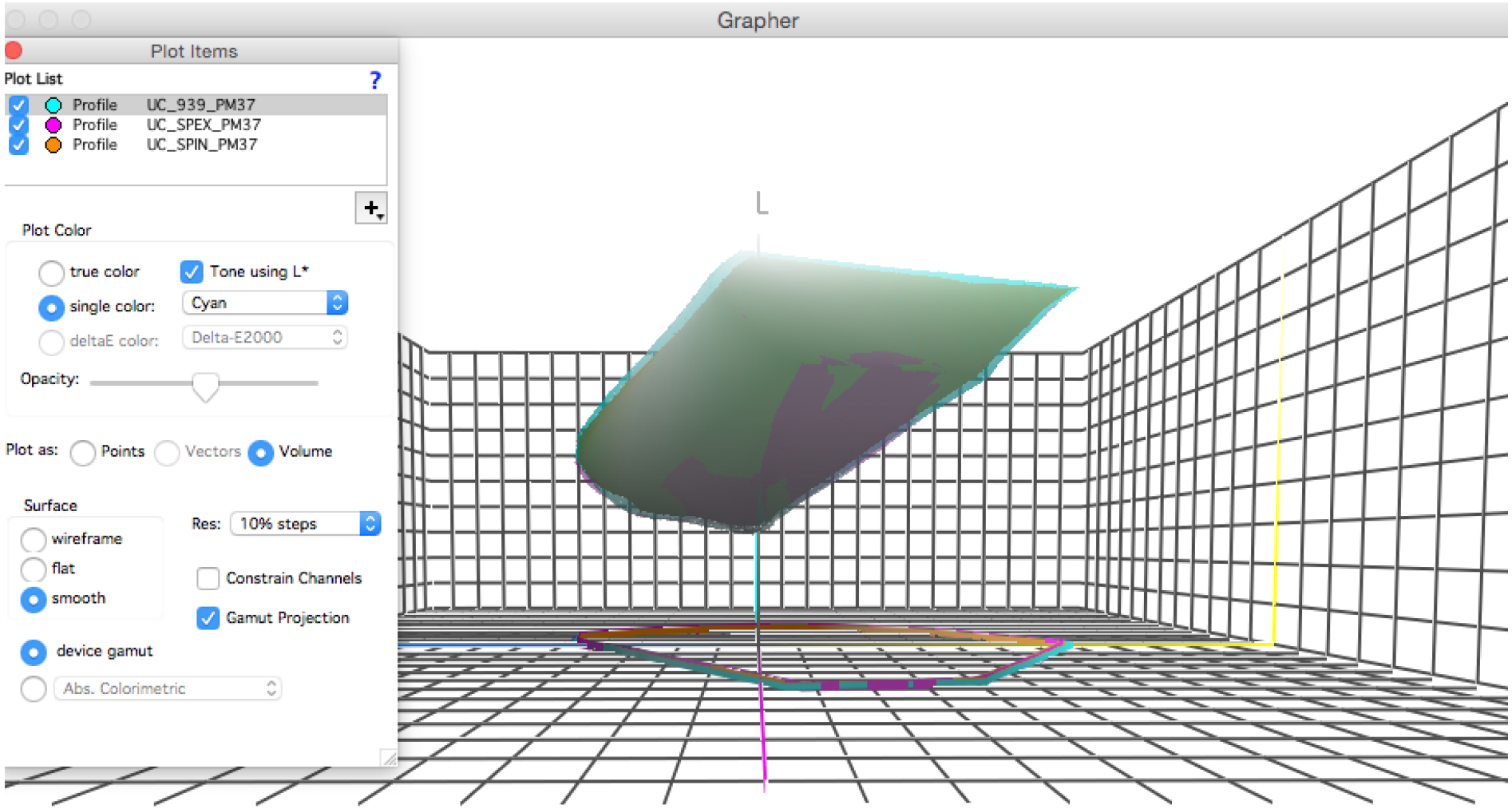


Qualitative: Visual Gamut Volumes – SAMBA L* Slice





Qualitative: Visual Gamut Volumes – Ultra Cotton



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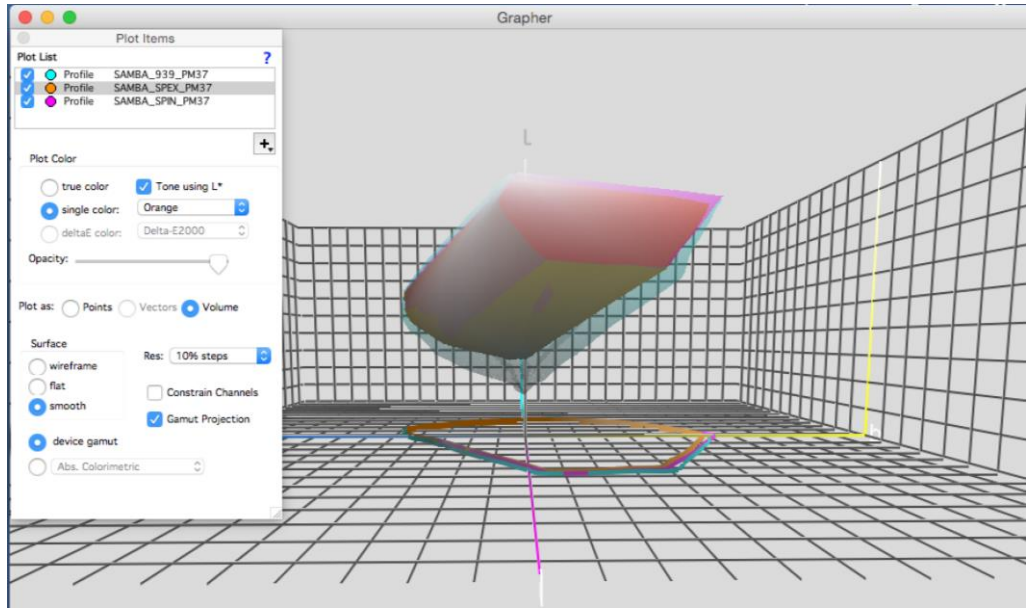
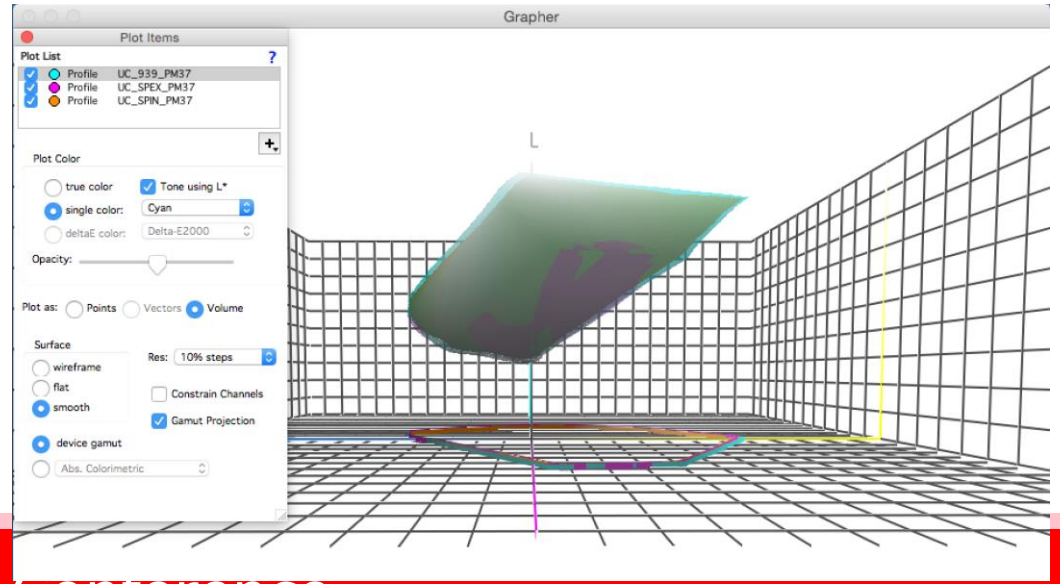
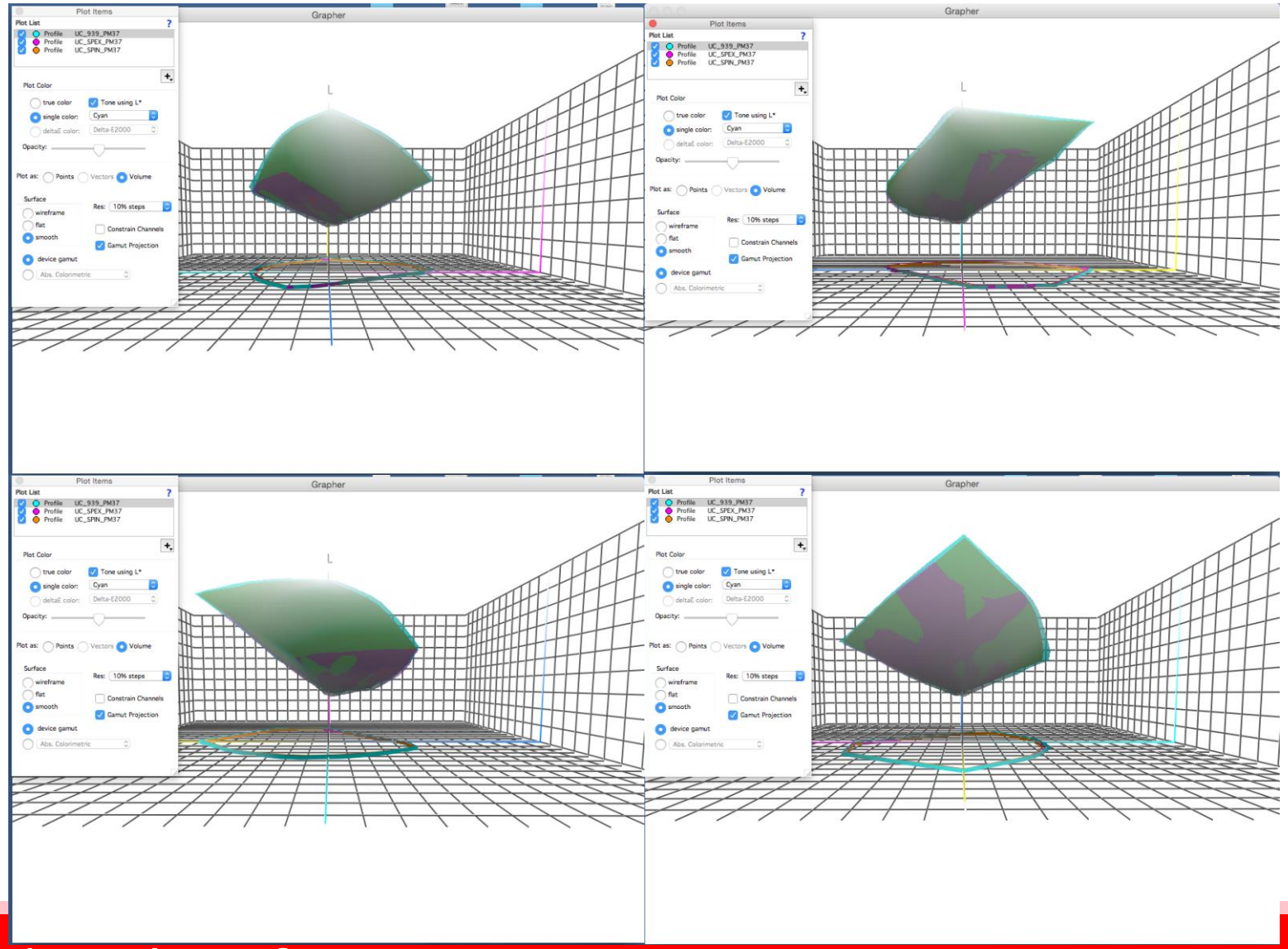
Qualitative: Visual Gamut Volumes – SAMBA vs. Ultra Cotton

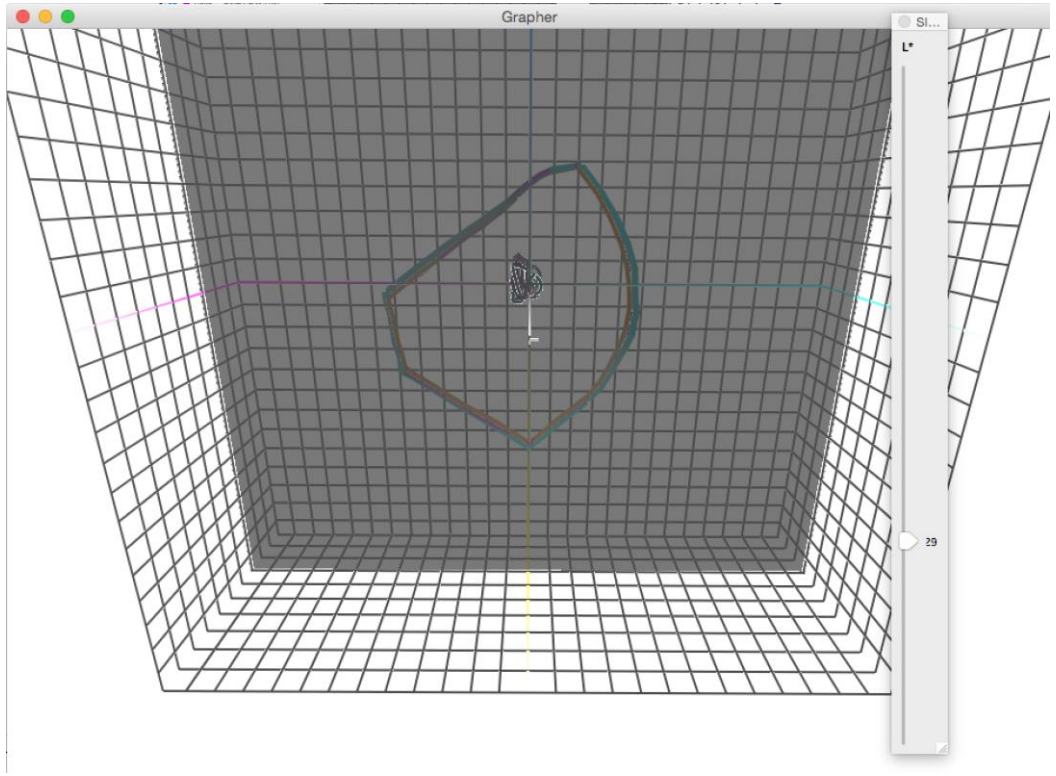


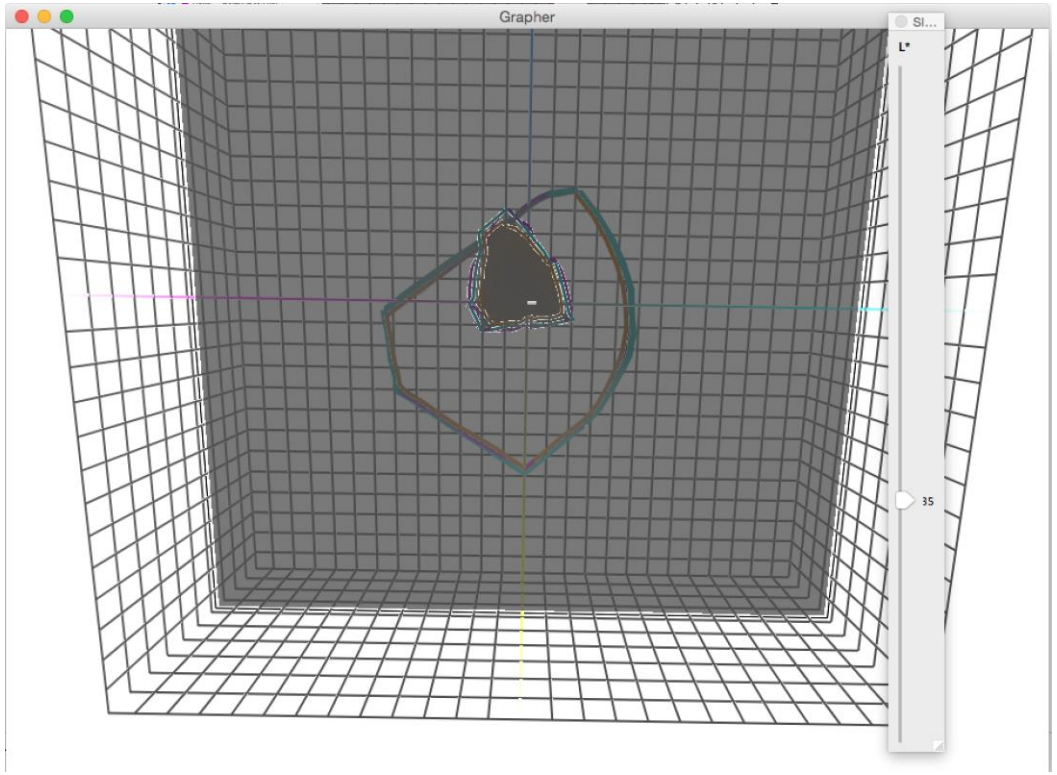


Qualitative: Visual Gamut Volumes – Ultra Cotton



Qualitative: Visual Gamut Volumes – Ultra Cotton
L* Slice





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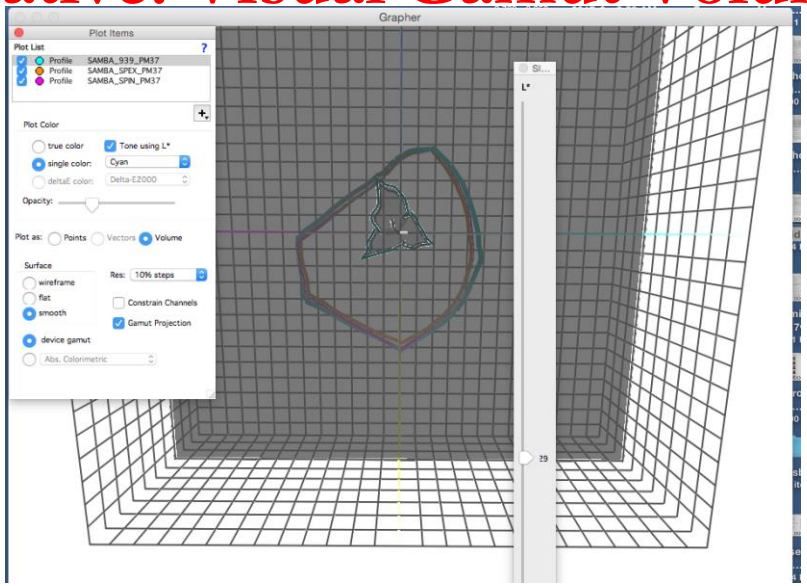
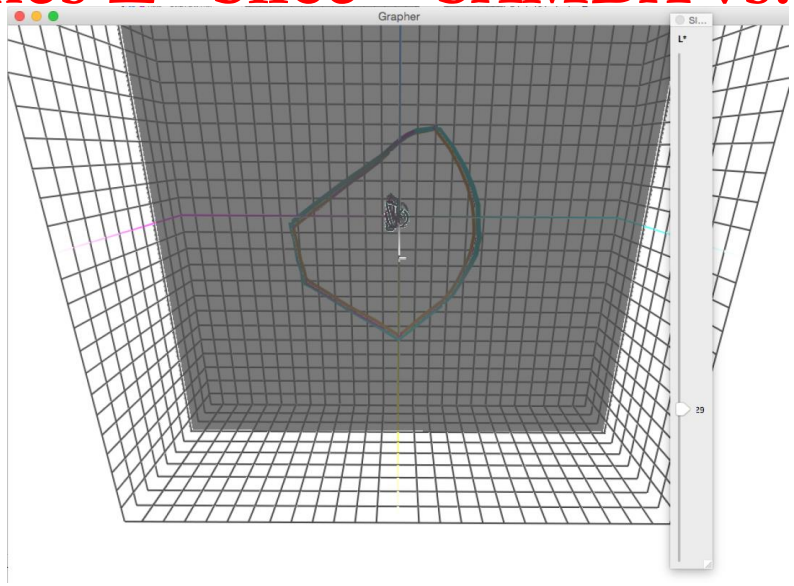
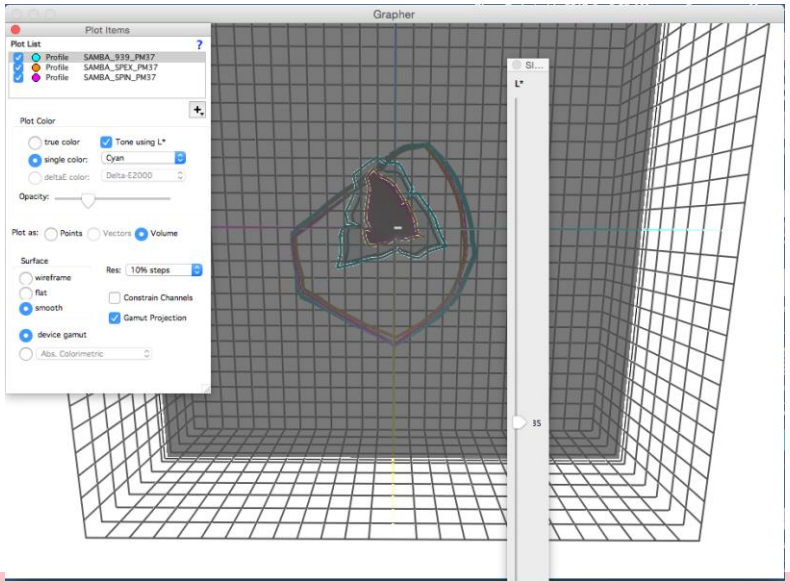
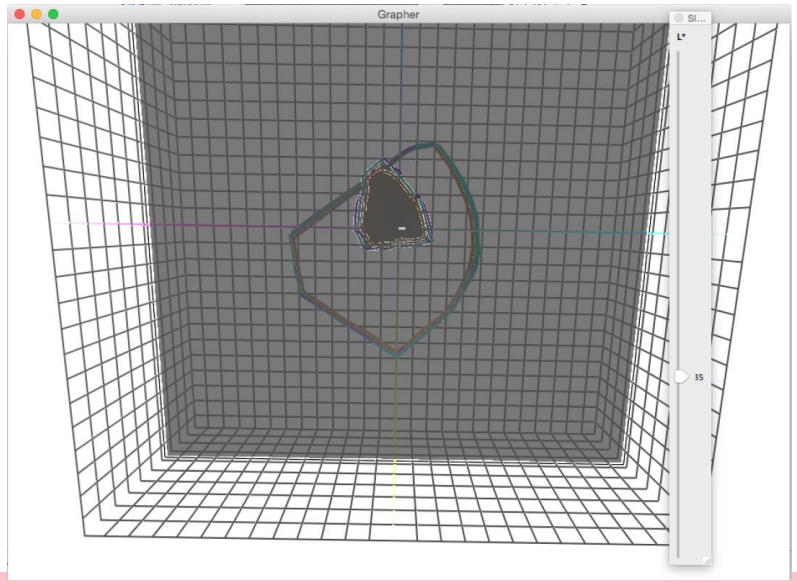
Qualitative: Visual Gamut Volumes L* Slice – SAMBA vs. Ultra Cotton









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Directionality Spot Readings: Eight Readings at 45° Increments

	SAMBA SUBSTRATE		
$\bar{x}$	0/45°	SPEX	SPIN
L*	93.18	92.63	92.76
a*	1.94	1.49	1.38
b*	-5.71	-3.66	-3.62
C*	6.03	3.95	3.88
h°	288.76	292.18	290.93
Range			
DL*	0.64	0.3	0.28
Da*	0.07	0.12	0.15
Db*	0.37	0.22	0.2
DC*	0.36	0.19	0.19
DH*	0.07	0.12	0.12
S			
DL*	0.22	0.1	0.1
Da*	0.02	0.04	0.05
Db*	0.13	0.07	0.06
DC*	0.12	0.06	0.06
DH*	0.02	0.04	0.04

	Ultra Cotton Substrate		
$\bar{x}$	0/45°	SPEX	SPIN
L*	93.51	92.94	93.05
a*	1.98	1.46	1.35
b*	-5.59	-3.12	-3.09
C*	5.93	3.45	3.37
h°	289.44	294.99	293.66
Range			
DL*	0.39	0.2	0.19
Da*	0.07	0.08	0.11
Db*	0.31	0.1	0.12
DC*	0.3	0.1	0.14
DH*	0.05	0.04	0.05
S			
DL*	0.13	0.08	0.07
Da*	0.02	0.03	0.04
Db*	0.1	0.04	0.04
DC*	0.1	0.04	0.05
DH*	0.02	0.02	0.01

Directionality Spot Readings: Rich Black (100, 85, 85, 0)

SAMBA SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	24.76	32.51	33.96
a*	-4.35	-1.33	-1.13
b*	0.8	0.31	0.23
C*	4.43	1.37	1.16
h°	169.61	166.88	168.52
Range			
DL*	1.61	0.13	0.21
Da*	1.13	0.19	0.16
Db*	0.25	0.11	0.09
DC*	1.08	0.17	0.14
DH*	0.25	0.07	0.06
S			
DL*	0.55	0.05	0.07
Da*	0.39	0.06	0.5
Db*	0.09	0.04	0.04
DC*	0.38	0.5	0.04
DH*	0.08	0.03	0.02

ULTRA COTTON SUBSTRATE			
$\bar{x}$	0/45°	SPEX	SPIN
L*	31.58	32.61	33.38
a*	-2.8	-1.9	-1.86
b*	1.09	0.56	0.48
C*	3.01	1.98	1.92
h°	158.8	163.61	165.64
Range			
DL*	2.17	0.21	0.27
Da*	0.62	0.25	0.18
Db*	0.7	0.14	0.14
DC*	0.74	0.22	0.15
DH*	0.29	0.1	0.09
S			
DL*	0.86	0.08	0.1
Da*	0.23	0.09	0.07
Db*	0.19	0.06	0.05
DC*	0.26	0.07	0.06
DH*	0.1	0.03	0.03

Directionality Spot Readings: 4x100 (100, 100, 100, 100)

SAMBA SUBSTRATE

$\bar{x}$	0/45°	SPEX	SPIN
L*	14.93	28.35	30.89
a*	0.89	1.38	1.38
b*	-0.06	0.23	0.23
C*	0.89	1.4	1.4
h	356.13	9.52	9.65
Range			
DL*	1.43	0.58	0.38
Da*	0.35	0.17	0.15
Db*	0.23	0.13	0.09
DC*	0.35	0.16	0.15
DH*	0.13	0.09	0.04
S			
DL*	0.43	0.19	0.15
Da*	0.11	0.06	0.05
Db*	0.07	0.04	0.03
DC*	0.11	0.05	0.05
DH*	0.04	0.03	0.01

ULTRA COTTON SUBSTRATE

$\bar{x}$	0/45°	SPEX	SPIN
L*	27.82	29.75	30.65
a*	1.17	1.33	1.29
b*	0	0.09	0.01
C*	1.17	1.34	1.29
h	359.87	3.68	0.32
Range			
DL*	1.92	0.38	0.49
Da*	0.3	0.1	0.08
Db*	0.51	0.07	0.08
DC*	0.3	0.09	0.08
DH*	0.26	0.04	0.05
S			
DL*	0.67	0.12	0.18
Da*	0.09	0.03	0.03
Db*	0.2	0.03	0.02
DC*	0.09	0.03	0.03
DH*	0.09	0.01	0.02

Directionality Spot Readings: Black (0, 0, 0, 100)

	SAMBA SUBSTRATE		
$\bar{x}$	0/45°	SPEX	SPIN
L*	34.36	35.57	36.14
a*	0.49	0.43	0.43
b*	-0.33	0.05	0
C*	0.59	0.43	0.43
h	325.74	7.17	0.38
Range			
DL*	0.67	0.16	0.04
Da*	0.06	0.05	0.06
Db*	0.22	0.07	0.07
DC*	0.1	0.05	0.06
DH*	0.13	0.03	0.03
S			
DL*	0.2	0.06	0.02
Da*	0.02	0.02	0.02
Db*	0.08	0.02	0.02
DC*	0.04	0.02	0.02
DH*	0.04	0.01	0.01

	ULTRA COTTON SUBSTRATE		
$\bar{x}$	0/45°	SPEX	SPIN
L*	33.03	33.04	33.62
a*	0.7	0.62	0.61
b*	0.63	0.9	0.8
C*	0.94	1.09	1.01
h	42.25	55.14	52.6
Range			
DL*	0.37	0.17	0.18
Da*	0.08	0.04	0.07
Db*	0.17	0.04	0.06
DC*	0.11	0.04	0.08
DH*	0.09	0.02	0.03
S			
DL*	0.13	0.07	0.06
Da*	0.02	0.01	0.03
Db*	0.06	0.01	0.02
DC*	0.03	0.01	0.03
DH*	0.03	0.01	0.01

Simulate Round-Trip Error

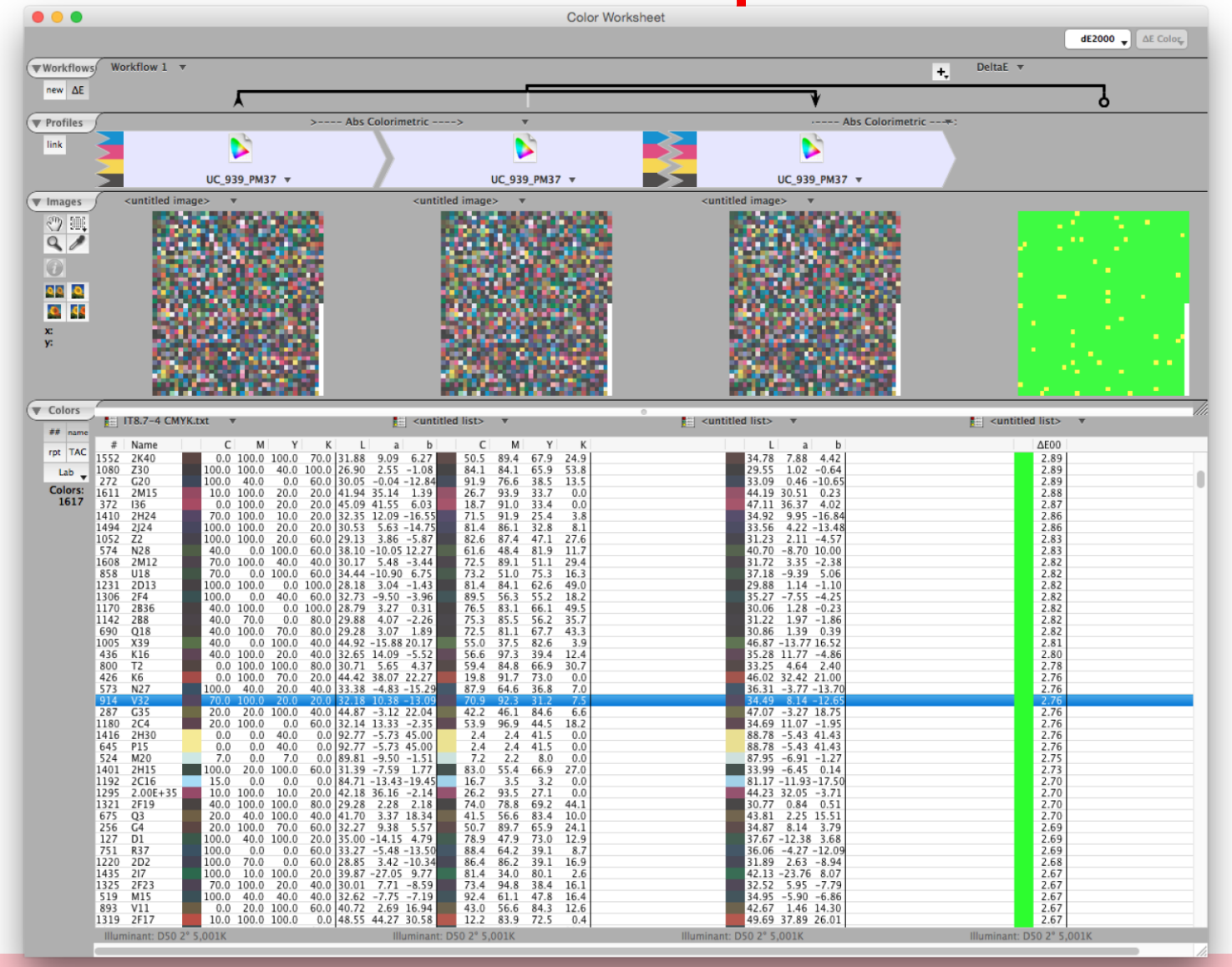
- Forward Transform (A to B)
  - *Device Color Space to Profile Connection Space*
- Inverse Transform (B to A)
  - *Profile Connection Space to Device Color Space*

Simulate Round-Trip Error

- CGATS TR016 Graphic Technology Printing Tolerance and Conformity Assessment
- T8.7/4 - 2005 Graphic technology - Input data for characterization of 4-color process printing

  (1,617 Patches)

Simulate Round-Trip Error



Simulate Round-Trip Error

- T8.7/4 - 2005 Graphic technology - Input data for characterization of 4-color process printing (1617 Patches)
- When Round-Tripped ΔE_{00} are Sorted Largest to Smallest, 81st Largest Value Represents 95th Percentile

Round-Trip Error Results

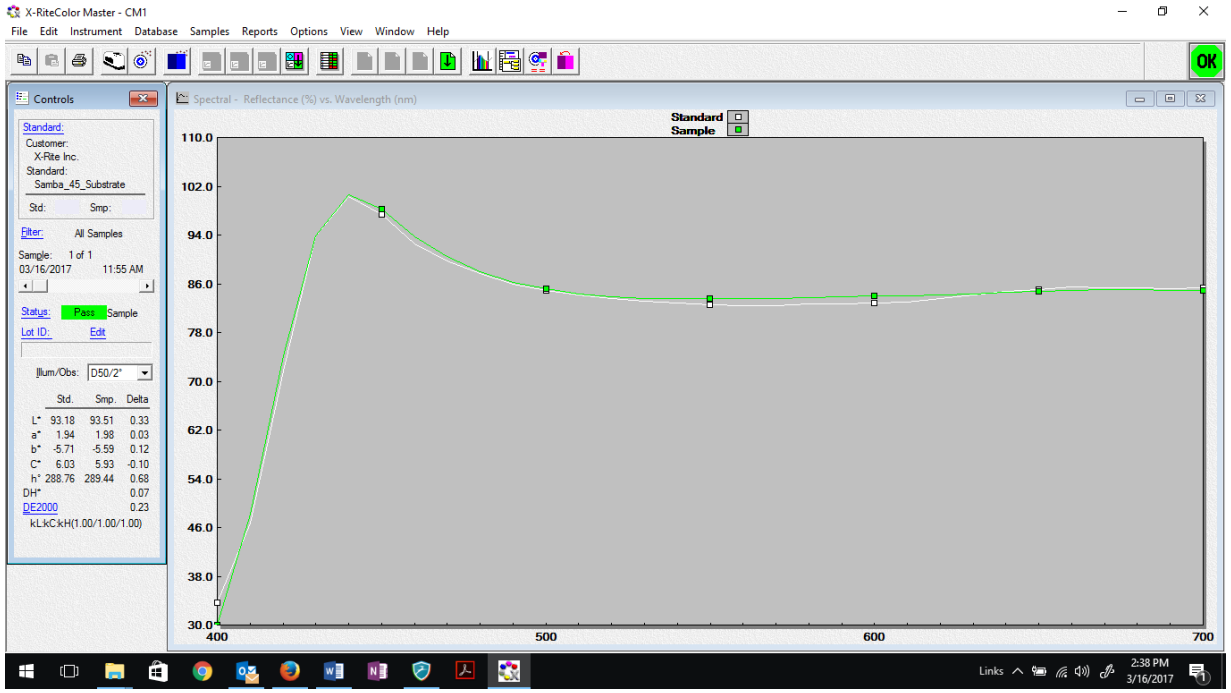
	SAMBA 95th Percentile ΔE_{00}	Ultra Cotton 95th Percentile ΔE_{00}
0/45°	5.31	2.76
Sphere Specular Excluded	2.64	2.69
Sphere Specular Included	2.61	2.71

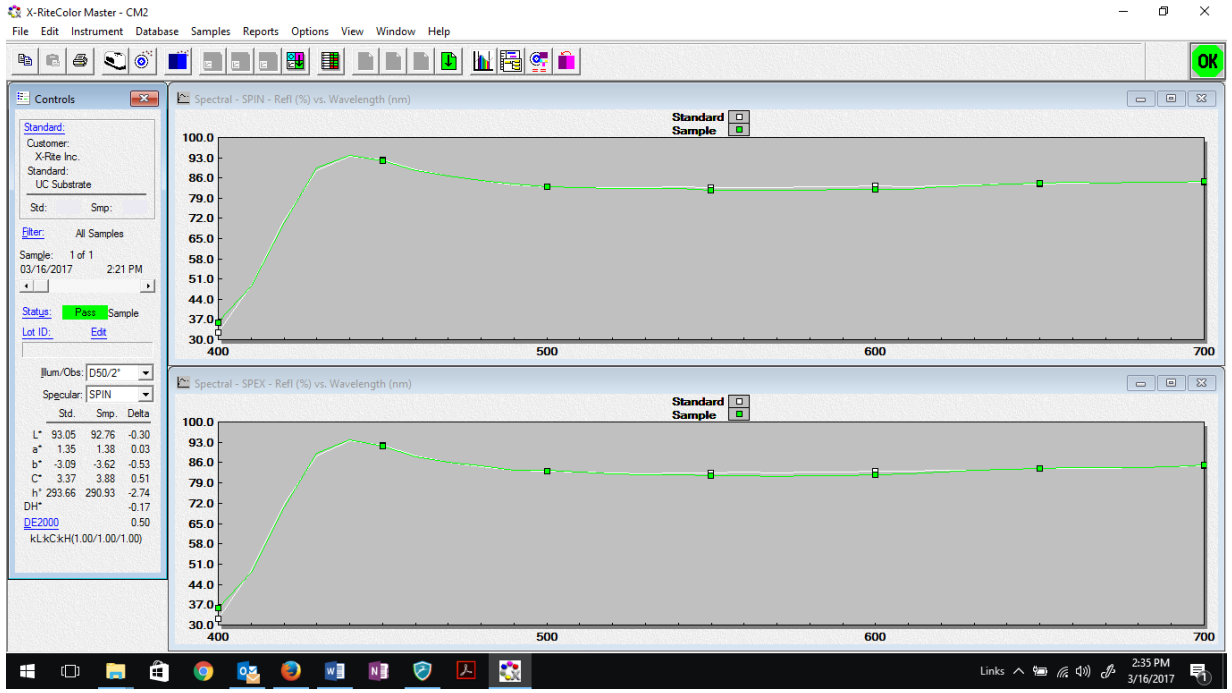
Conclusions/Implications

- Surface Qualities (e.g.: Gloss, "Sheen") Critical
- Directionality of Instrument Introduces Variance

Future Research

- Profiles Built at Differing Directionality (Instrument Orientation), Average
- Separate Texture from Other Surface Qualities
- Ink Limiting
- Other Profiling Solutions
- Control for OBAs


X-RiteColor Master - CM1
File Edit Instrument Database Samples Reports Options View Window Help
OK
Controls
Standard:
Customer:
X-Rite Inc.
Standard:
Samba_45_Substrate
Std: Smp:
Filter: All Samples
Sample: 1 of 1
03/16/2017 11:55 AM
Status: Pass Sample
Lot ID: Edit
Illum/Obs: D50/2°
Std. Smp. Delta
L* 93.18 93.51 0.33
a* 1.94 1.98 0.03
b* -5.71 -5.59 0.12
C* 6.03 5.93 -0.10
h° 288.76 289.44 0.68
DH* 0.07
DE2000 0.23
kL:kC:kH(1.00/1.00/1.00)
Spectral - Reflectance (%) vs. Wavelength (nm)
Standard
Sample
110.0
102.0
94.0
86.0
78.0
70.0
62.0
54.0
46.0
38.0
30.0
400
500
600
700
Links
2:38 PM
3/16/2017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OK
Controls
Standard:
Customer:
X-Rite Inc.
Standard:
UC Substrate
Std: Smp:
Filter: All Samples
Sample: 1 of 1
03/16/2017 2:21 PM
Status: Pass Sample
Lot ID: Edit
Illum/Obs: D50/2°
Specular: SPIN
Std. Smp. Delta
L* 93.05 92.76 -0.30
a* 1.35 1.38 0.03
b* -3.09 -3.62 -0.53
C* 3.37 3.88 0.51
h° 293.66 290.93 -2.74
DH* -0.17
DE2000 0.50
kL:kC:kH(1.00/1.00/1.00)
Spectral - SPIN - Refl (%) vs. Wavelength (nm)
Spectral - SPEX - Refl (%) vs. Wavelength (nm)
Standard
Sample
100.0
93.0
86.0
79.0
72.0
65.0
58.0
51.0
44.0
37.0
30.0
400
500
600
700
Links
2:35 PM
3/16/2017

Future Research –
Other Profiling Software Options, e.g.:

- Argyll Color Management
  - *http://www.argyllcms.com*
- basIC COLOR
  - *http://www.basiccolor.de/*
- FujiFilm ColorPath
  - *http://www.fujifilmusa.com/products/graphic_arts_printing/workflow-solutions/colorpath/*

Thank you

KONICA MINOLTA

CHROMIX

x-rite

PANTONE®

ColorThink Pro

Go 'whoa!' all over again.

2XL Imaging