Color Control Fundamentals

Color Basics

Presented by: David Hunter

Defining Color Values

Agenda

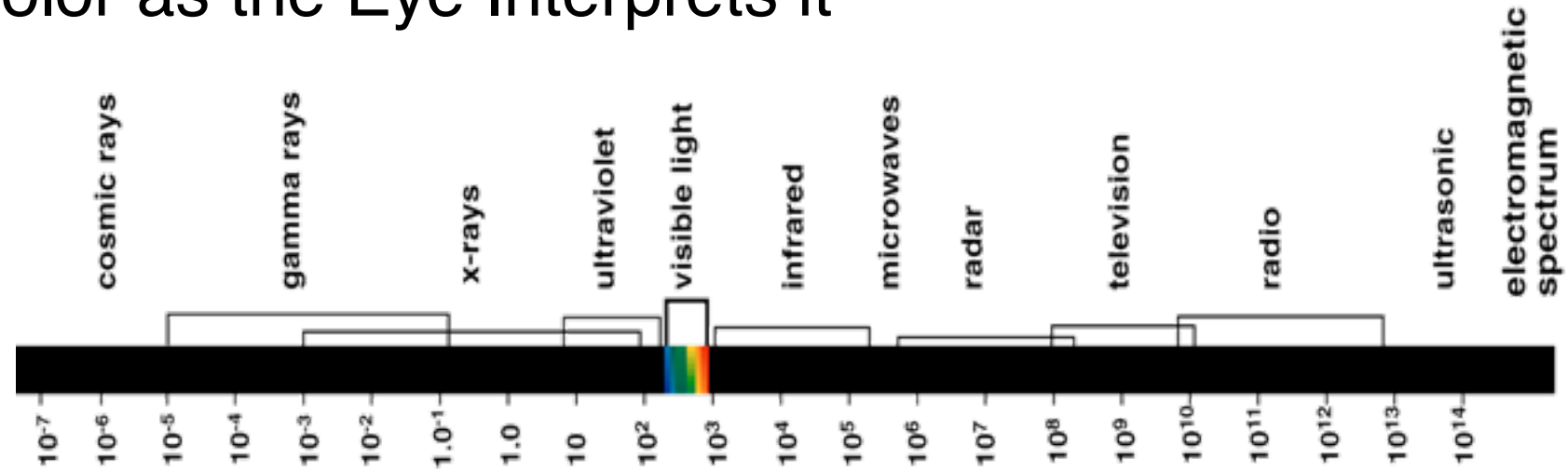
- Color as the Eye Interprets it
- Rendering color value as a number
- Spectral Data
- CIE-Lab
- Mapping to Prints, and known Spots

ChromaChecker

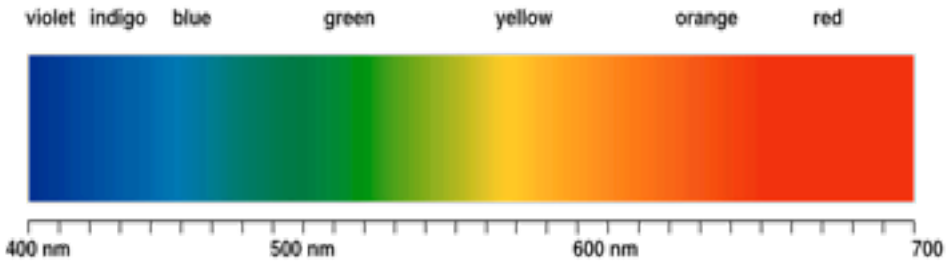
Defining Color Values

Electromagnetic Spectrum

- Color as the Eye Interprets it



R•O•Y•G•B•I•V



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No Light

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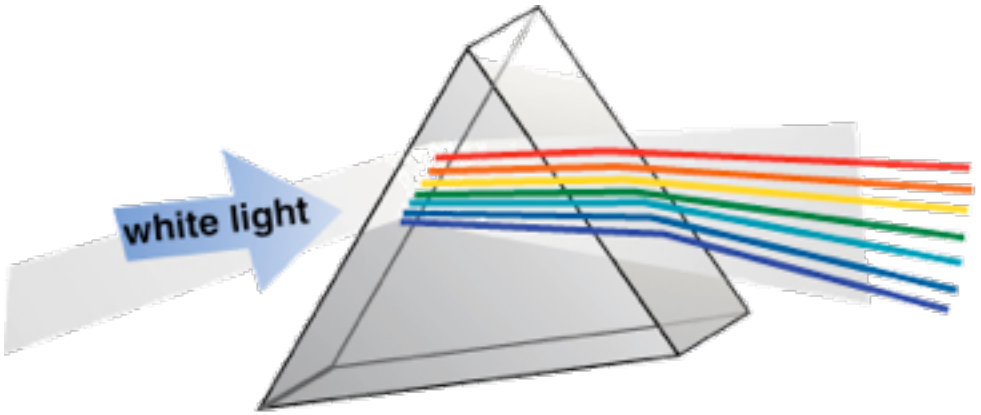
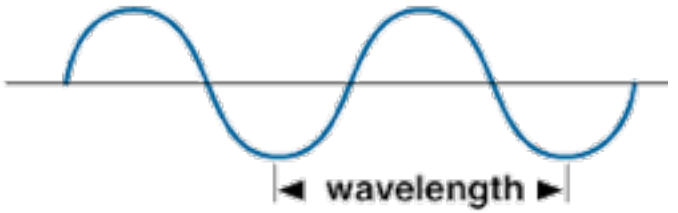
Need Light Source (Illuminant)

Prism

- White Light- Composed of all colors of spectrum
- Black Light?





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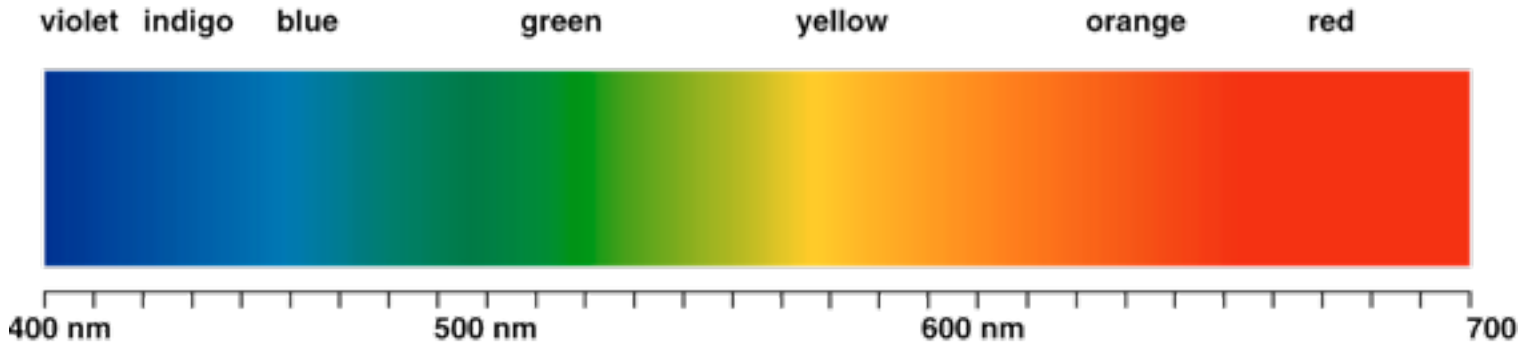
Spectral Definition

One Color

- 380-720 NM
- 10 NM increments
- 32 numbers represent one color
- Can predict result of new light source
- Easily Convert to CIE-Lab



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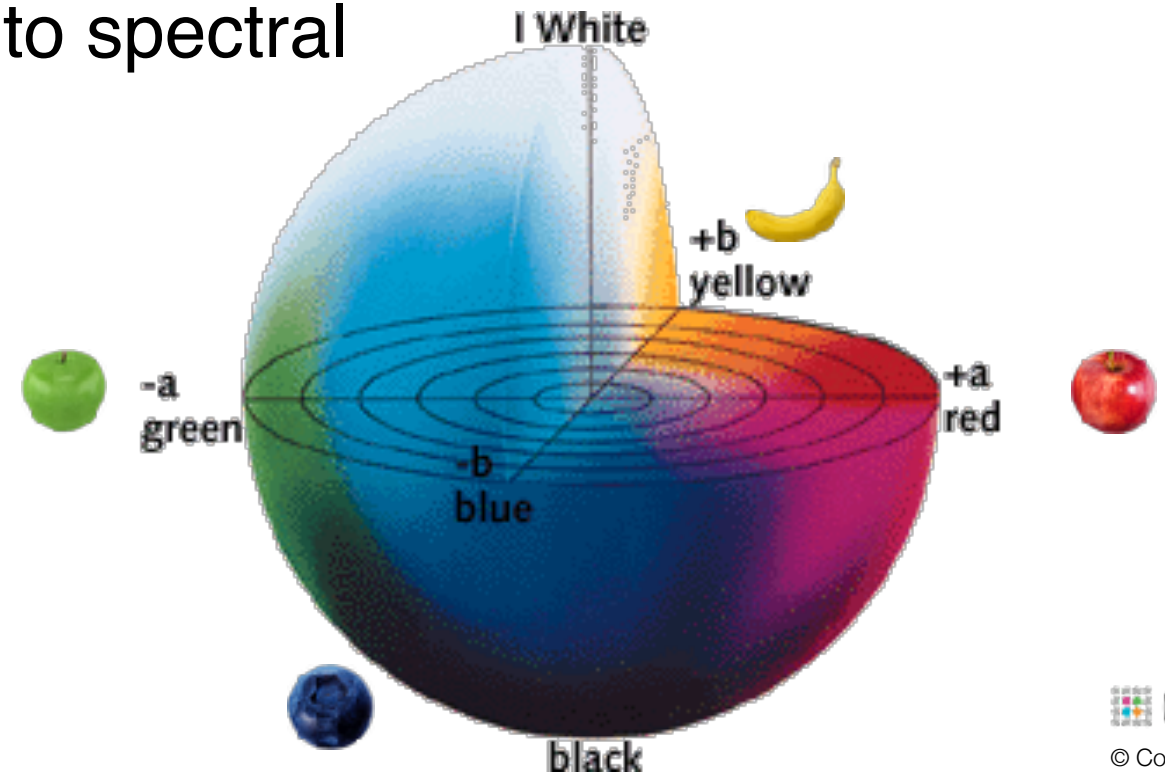
CIE-Lab Definition

One Color

- 3 numbers, L* lightness, a* red/green axis, b* yellow/blue
- Illuminant dependent- Only good for 1 Light source
- Can't convert to spectral



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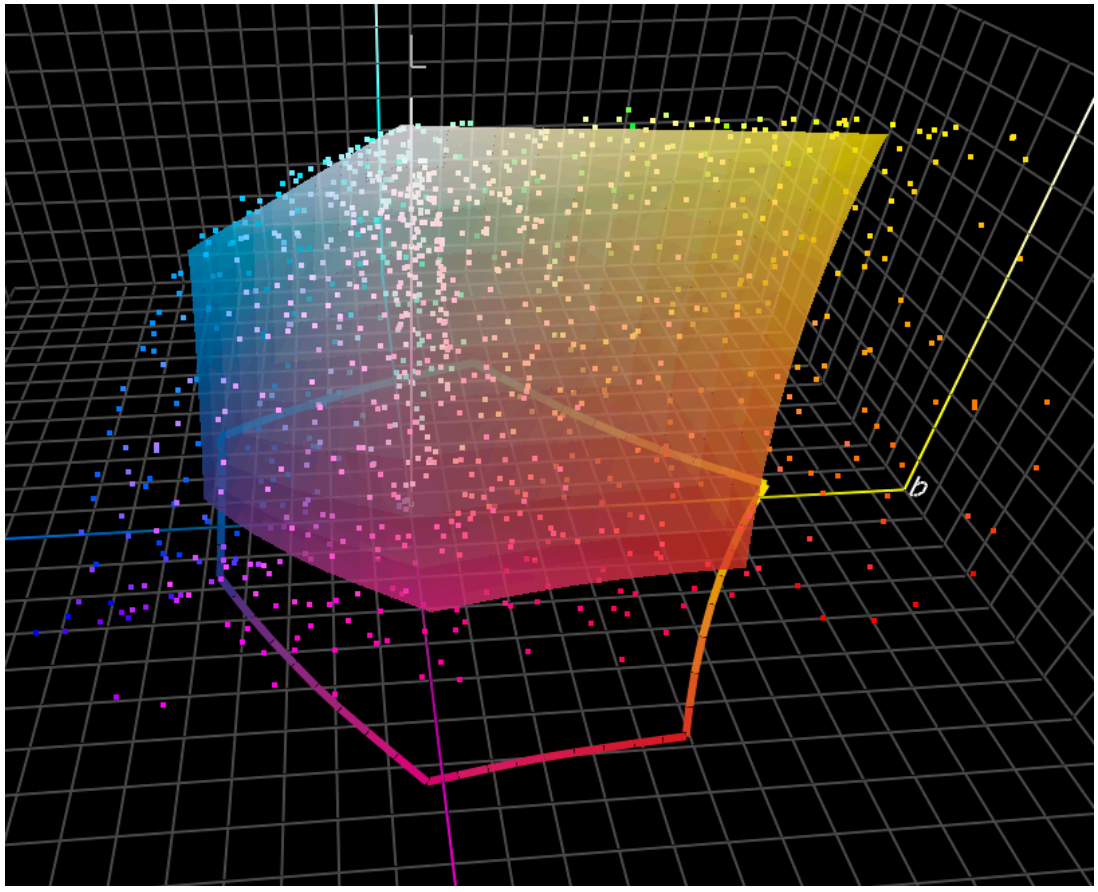
Define Printing Gamut and Measured Colors

GRACoL Print Gamut and PMS Colors

- 58% of colors within 2ΔE(00)



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Summary

Light Affects Color

- Spectral definition is more desired for defining colors
- CIE-Lab is still valuable for editing, correcting colors
- Spectral Prediction for Spots/Tints/Profiles is future

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Color Control Fundamentals

5 C's Color Control

Presented by: David Hunter

STEPS TO DEFINING PROCESS DISCIPLINE

How to meet or exceed E-Factor?

5 C's of Color Control

Capture — assess instrumentation capabilities

Calibration — make device consistent to itself & over time

Characterization — define device gamut and create profile

Conversion — map one gamut to another in the workflow

Conformance — verify new results and meet expectations

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Definitions

Device Consistency

- Precision
- Process Control- G7
- Shared Visual Appearance
- Delta E metrics for CMYK solids

Device Matching

- Accuracy
- Color Conformance- EF
- Color Match
- E-Factor metrics for pages

LOW ACCURANCY
HIGH PRECISION

HIGH ACCURANCY
LOW PRECISION

HIGH ACCURANCY
HIGH PRECISION

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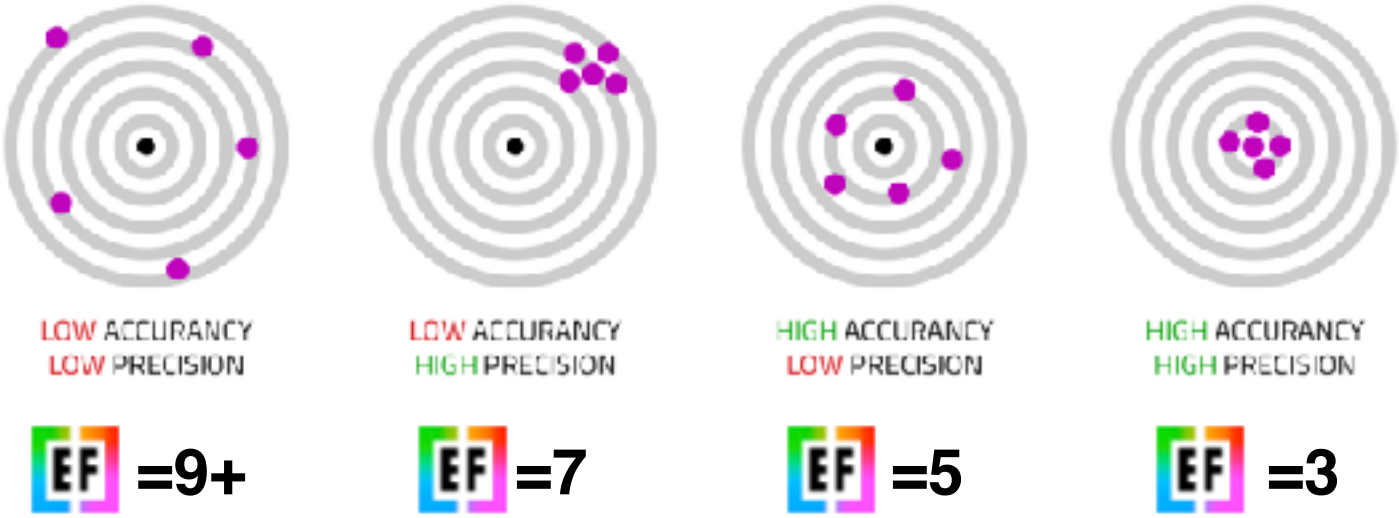
Transition from Graphic Arts to Manufacturing

Taking Raw Materials & Creating Products that Consistently Meet Customer Expectations

- **Maximum Color Match Requires**- Optimum process control, tighter metrics, optimum color conformance, lower EF



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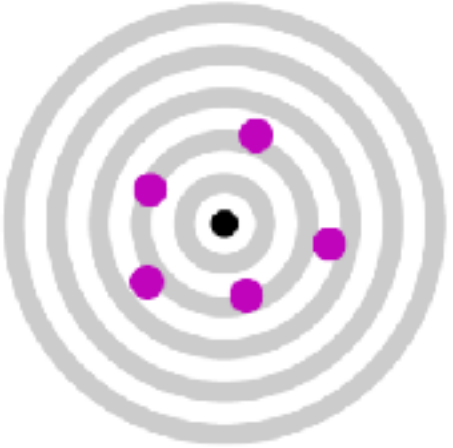
5 C's determine Quality of Color Match

Need Good Components for all 5 C's to have best color

- Precision and Accuracy achieved with all 5
- Might not need all 5 C's depending on your Expectations

No Color Control

Capture & Calibration



+ G7 Curve

+Characterization & Conversion

ChromaChecker

5 C's determine Quality of Color Match

Need Good Components for all 5 C's to have best color

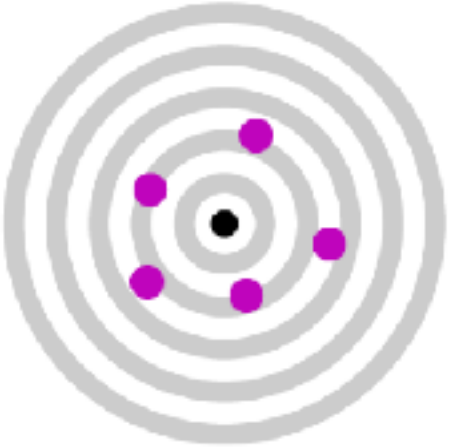
- Precision and Accuracy achieved with all 5
- Might not need all 5 C's depending on your Expectations

No Color Control

=9+

Capture & Calibration

=7



+ G7 Curve

=5

+Characterization & Conversion

=3

Color Control Fundamentals

First of the Five C's:

Capture

Presented by: David Hunter

STEPS TO DEFINING PROCESS DISCIPLINE

How to meet or exceed E-Factor?

First of the 5 C's of Color Control

Capture — assess instrumentation capabilities

Calibration — make device consistent to itself & over time

Characterization — define device gamut and create profile

Conversion — map one gamut to another in the workflow

Conformance — verify new results and meet expectations

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Capture Data with Measurement Instruments

Quantify color with multiple capabilities








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Capture- Selecting a Measurement Device

Factors to Consider

- Ease of use- measuring single color? More?
- Level of automation (auto patch/ bar code)
- Substrate material thickness/transparency
- Aperture Size per printed line screen
- Textured material
- Other measurement devices to match
- Cost

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Capture with Manual Measurements

Manually measure one color at a time

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Capture with Single Strip Measurements

Measure color bar, patch size dependent on instrument

- Calibration (process control) and Conformance applications

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Capture with Automated Target Measurements

Automated x, y measuring large targets

- Characterization (ICC Profile) targets
- Predefined locations with i1iO
- Bar code incorporated with target for automatic routing

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Capture- Determining Which Device is Required

Considerations based on E-Factor

- Tighter the expectations the more critical the accuracy
- Precision- repeatability/consistency
- Accuracy- in relation to “Master” instrument
- Not always directly related to price

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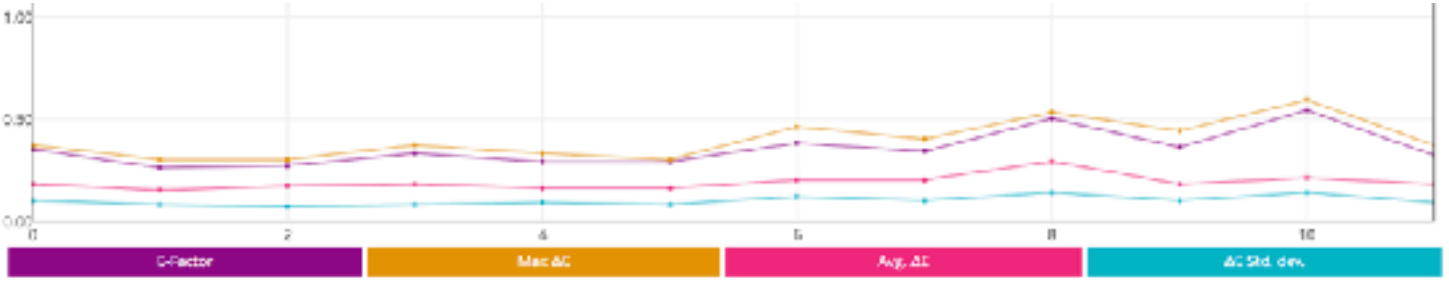
Capture- How Precise is an Instrument?

Data from measuring 42 patch target twelve times

- Exposes state of “exactness” and “repeatability”



File list:

	Measurement	Created	Baseline	Worst patches	Max. ΔE	Avg. ΔE	EF		
☐	I1_XA2_AA000_14.txt		Autogenerated baseline 2018-03-01 09:06:xx		0.37	0.18	0.32	✓	
☐	I1_XA2_AA068_13.txt		Autogenerated baseline 2018-03-01 09:06:44		0.59	0.21	0.56	✓	
☐	I1_XA2_AA000_12.txt		Autogenerated baseline 2018-03-01 09:06:xx		0.44	0.18	0.36	✓	
☐	I1_XA2_AA068_11.txt		Autogenerated baseline 2018-03-01 09:06:44		0.53	0.29	0.50	✗	
☐	I1_XA2_AA000_10.txt		Autogenerated baseline 2018-03-01 09:06:xx		0.45	0.20	0.34	✓	
☐	I1_XA2_AA068_9.txt		Autogenerated baseline 2018-03-01 09:06:44		0.46	0.20	0.38	✓	
☐	I1_XA2_AA000_8.txt		Autogenerated baseline 2018-03-01 09:06:xx		0.30	0.15	0.29	✓	
☐	I1_XA2_AA068_7.txt		Autogenerated baseline 2018-03-01 09:06:44		0.33	0.16	0.29	✓	
☐	I1_XA2_AA000_6.txt		Autogenerated baseline 2018-03-01 09:06:xx		0.37	0.18	0.33	✓	

Average: .37

i1Pro1

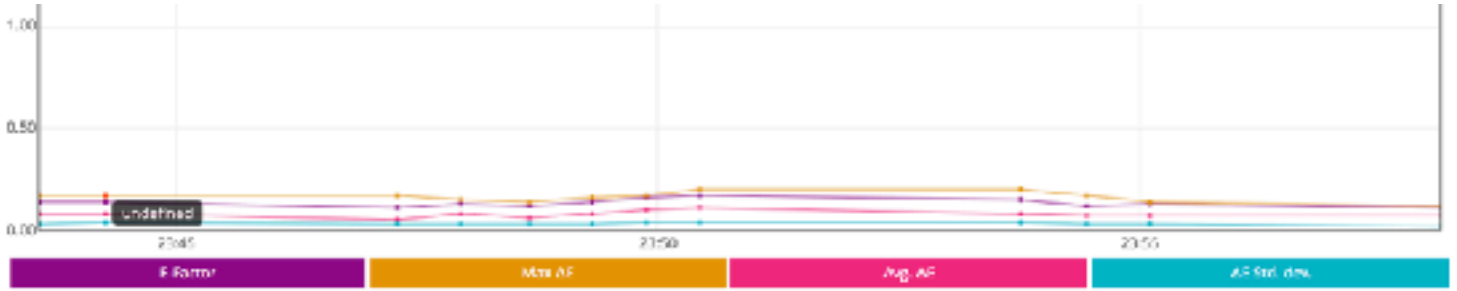
Discontinued

ChromaChecker

Capture- How Precise is an Instrument?

Data from measuring 42 patch target twelve times

- Exposes state of “exactness” and “repeatability”



File list

	Measurement	Created	Baseline	Worst patches	Max ΔE	Avg ΔE	EF	%	
☐	PR NTVerifier_Export_2017_09_05_09h58s08.txt				0.12	0.07	0.11	✓	
☐	PR NTVerifier_Export_2017_09_05_09h55m06.txt				0.14	0.07	0.13	✓	
☐	PR NTVerifier_Export_2017_09_05_09h54s27.txt				0.12	0.07	0.12	✓	
☐	PR NTVerifier_Export_2017_09_05_09h53s16.txt				0.20	0.09	0.15	✓	
☐	PR NTVerifier_Export_2017_09_05_09h50s26.txt				0.20	0.11	0.17	✓	
☐	PR NTVerifier_Export_2017_09_05_09h49s53.txt				0.17	0.10	0.16	✓	
☐	PR NTVerifier_Export_2017_09_05_09h48s19.txt				0.16	0.08	0.14	✓	
☐	PR NTVerifier_Export_2017_09_05_09h46s40.txt				0.14	0.06	0.12	✓	
☐	PR NTVerifier_Export_2017_09_05_09h42s57.txt				0.15	0.09	0.13	✓	

Average: .14

i1Pro2

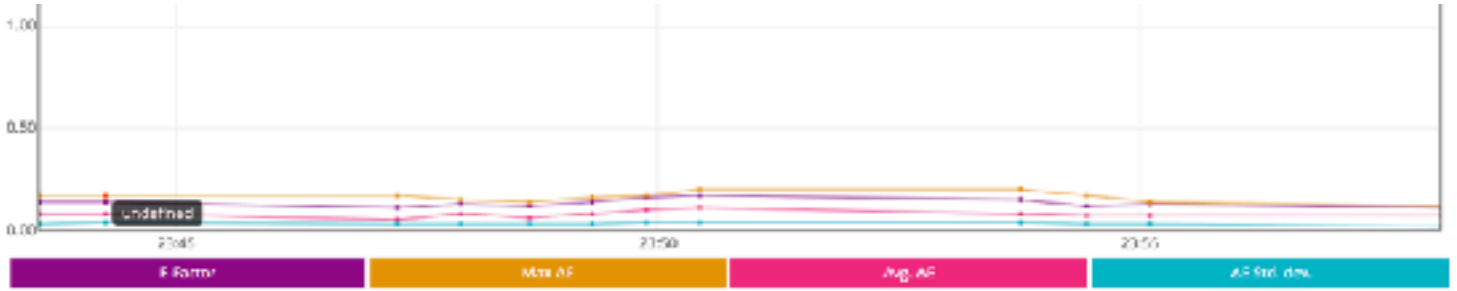
Discontinued

ChromaChecker

Capture- How Precise is an Instrument?

Data from measuring 42 patch target twelve times

- Exposes state of “exactness” and “repeatability”



File list

	Measurement		Created	Baseline	Worst patches	Max ΔE	Avg ΔE	EF	%	
☐	PR NTVerifier_Export_2017_09_05_09h58s08.txt	Ms	2017-09-05 21:58:08	i1_SN807_M0		0.12	0.07	0.11	✓	🔍
☐	PR NTVerifier_Export_2017_09_05_09h55s06.txt	Ms	2017-09-05 21:55:06	i1_SN807_M0		0.14	0.07	0.13	✓	🔍
☐	PR NTVerifier_Export_2017_09_05_09h54s37.txt	Ms	2017-09-05 21:54:37	i1_SN807_M0		0.12	0.07	0.12	✓	🔍
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☐	PR NTVerifier_Export_2017_09_05_09h46s53.txt	Ms	2017-09-05 21:46:53	i1_SN807_M0		0.17	0.10	0.16	✓	🔍
☐	PR NTVerifier_Export_2017_09_05_09h46s19.txt	Ms	2017-09-05 21:46:19	i1_SN807_M0		0.16	0.08	0.14	✓	🔍
☐	PR NTVerifier_Export_2017_09_05_09h46s40.txt	Ms	2017-09-05 21:46:40	i1_SN807_M0		0.14	0.06	0.12	✓	🔍
☐	PR NTVerifier_Export_2017_09_05_09h42s57.txt	Ms	2017-09-05 21:42:57	i1_SN807_M0		0.15	0.09	0.13	✓	🔍

Average: .14

i1Pro3

$1,500

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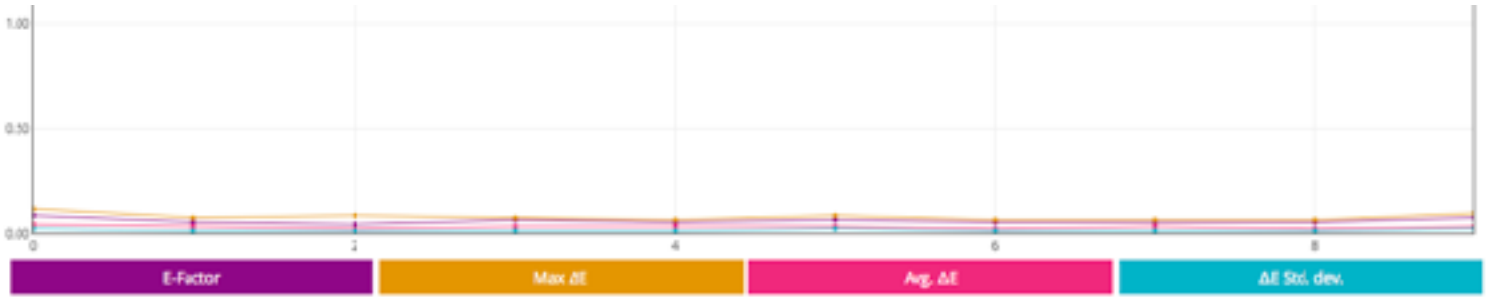
Capture- How Precise is an Instrument?

Data from measuring 42 patch target twelve times

- Exposes state of “exactness” and “repeatability”



File list

	Measurement	Created	Baseline	Worst patches	Max. ΔE	Avg. ΔE	EF		
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☐	PRINTVerifier_Export_2017_11_08_20h33s57.txt	MD	2017-11-08 20:33:57	Autogenerated baseline 2017-11-08 20:35:11		0.16	0.03	0.05	✓	
☐	PRINTVerifier_Export_2017_11_08_20h32s54.txt	MD	2017-11-08 20:32:54	Autogenerated baseline 2017-11-08 20:35:11		0.06	0.03	0.05	✓	
☐	PRINTVerifier_Export_2017_11_08_20h32s13.txt	MD	2017-11-08 20:32:13	Autogenerated baseline 2017-11-08 20:35:11		0.06	0.02	0.05	✓	
☐	PRINTVerifier_Export_2017_11_08_20h30s07.txt	MD	2017-11-08 20:30:07	Autogenerated baseline 2017-11-08 20:35:11		0.08	0.03	0.06	✓	
☐	PRINTVerifier_Export_2017_11_08_20h21s58.txt	MD	2017-11-08 20:21:58	Autogenerated baseline 2017-11-08 20:35:11		0.06	0.03	0.05	✓	
☐	PRINTVerifier_Export_2017_11_08_20h20s55.txt	MD	2017-11-08 20:20:55	Autogenerated baseline 2017-11-08 20:35:11		0.07	0.03	0.06	✓	
☐	PRINTVerifier_Export_2017_11_08_20h20s07.txt	MD	2017-11-08 20:20:07	Autogenerated baseline 2017-11-08 20:35:11		0.08	0.02	0.04	✓	
☐	PRINTVerifier_Export_2017_11_08_20h19s16.txt	MD	2017-11-08 20:19:16	Autogenerated baseline 2017-11-08 20:35:11		0.07	0.03	0.05	✓	

Average: .05

eXact

$5500

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Capture- Is Instrument Precise Enough?

E-Factor- Expectations

- Instrument Gauge Factor
- Every Manufacturing Industry has IGF
- ChromaChecker introduces to Print Industry
- Workflow Tolerance:
  - % of precision + cross instrument variation
  - allocate down to 20% to instrument variation

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Capture- Interpreting the Data

“Stacking” Effect of Multiple Devices

- Multiple instruments measuring same color: Deviation
- Instrument use different technology, lighting, math
- With two Instruments double numbers, three= triple…
- Interpretation of data reveals:
  - (2) i1Pro1 = .74, then workflow = 3.7
  - (2) i1Pro2 = .28, then workflow = 1.40
  - (2) eXact = .10, then workflow = 0.50

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Capture- Interpreting the Data

“Stacking” Effect of Multiple Instruments

- Measuring same color differently results in Deviation
- FAIL customer tolerance before print page 1

Create Profile Instrument A

Verify Profile Instrument B **Fails!**

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Capture- Interpreting the Data

"Stacking" Effect of Multiple Instruments

- Measuring same color differently results in Deviation
- FAIL customer tolerance before print page 1

=Match=

~~=Match=~~

Compare to Press?
Instrument C

Fails ALSO!

Create Profile
Instrument A

Verify Profile
Instrument B

Fails!

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Capture- How Accurate is an Instrument?

Comparing how different devices measure color

- Exposes state of “correctness” and closeness to “bullseye”

	X-Rite i1 Pro 2 I1_SN307_M0	X-Rite SN317 eXact Exact_SN317_M0
X-Rite i1 Pro 1 Autogenerated baseline 2018-03-01 09:06:44	Workflow = 2.65 H = 1.20 Instrument = 0.53 H = 0.24 Harmonizer = 121% Max = 0.54 Avg. = 0.29	Workflow = 4.85 H = 1.20 Instrument = 0.97 H = 0.24 Harmonizer = 304% Max = 1.17 Avg. = 0.62
X-Rite i1 Pro 2 I1_SN307_M0		Workflow = 3.60 H = 0.95 Instrument = 0.72 H = 0.19 Harmonizer = 279% Max = 0.76 Avg. = 0.42

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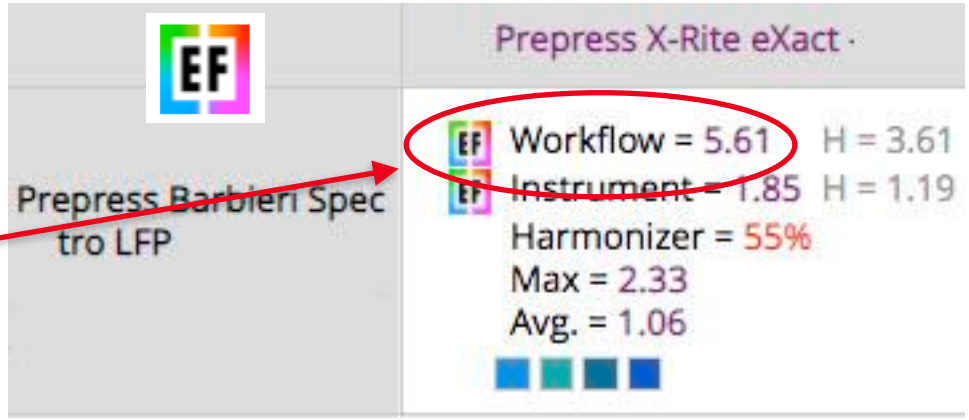
Capture- How Accurate is an Instrument?

Comparing how different devices measure color

- Exposes state of “correctness” and closeness to “bullseye



If E-Factor Workflow > Tolerance= **PROBLEM**

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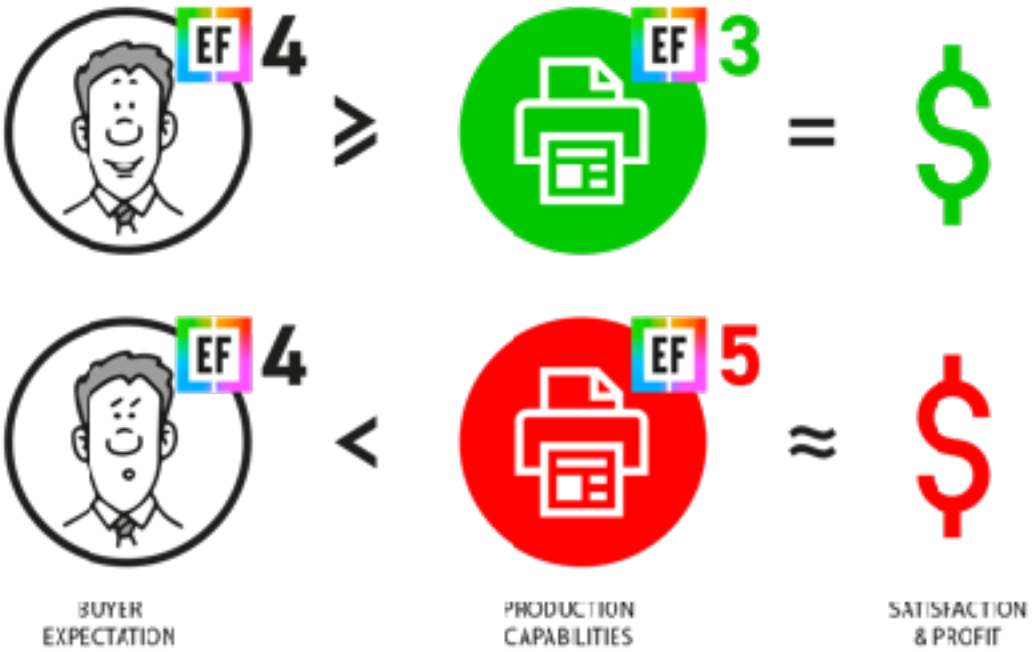
Capture- Instrument Differences affect Printer E-Factor

If Instrument differences > Tolerance

- Cause the Printer E-Factor to appear to FAIL
- Problem is Instrumentation Differences
- ChromaChecker can minimize this difference: Harmonization



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Summary: Capture Instrument

Application and Use Cases

- Multiple instruments measuring same color
- Understand: Capture instruments are different
  - *Even two units one serial number apart…*
- ChromaChecker Instrument Inspector
  - *Assess precision/accuracy each instrument*
  - *Warn when exceeds Tolerance Expectations*
  - *Can Harmonize to minimize differences*

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