Calibration

2nd C

Presented by: David Hunter

Part 2: Demystifying Color

Agenda: Second C- Calibration

- Overview of 5 C's of Color Management
- Quantify Color Differences
- Review the 1st C- Capturing your Data
- Overview of 2nd C- Calibration
- Demonstration and Trial that you can use…

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Second of the 5 C's of Color Control

Capture — collect your data

Calibration- make printer 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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Quantifying Color Differences

Without Data- No Idea What is Happening

- Capture Data to understand Print Properties
- Choose measurement device based on need/price
- Conformance to Production Standard
- Measure print to understand salable vs waste

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How to Determine What is Waste?

Print that isn't Salable…

- What visual difference is too different for customer to accept?
  - 1= Proofer
  - 2= Digital Press
  - 3= Offset Press

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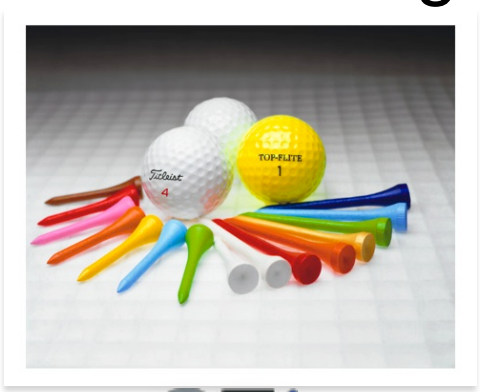
Quantify Differences- Print

What Type of Color Match?

- Match for specific individual brand colors: Spot Color

- Match between pages and or images: Process Color



Quantify Differences- Print

What Type of Color Match?

- Match for specific individual brand colors: Spot Color
  - **ΔE (delta E**) quantifies spot difference
  - Bigger the number, bigger the difference

- Match between pages and or images: Process Color
  - **E-Factor** (EF)- quantifies process color difference
  - Bigger the number, bigger the difference
  - Think ΔE for process colors, same relative difference

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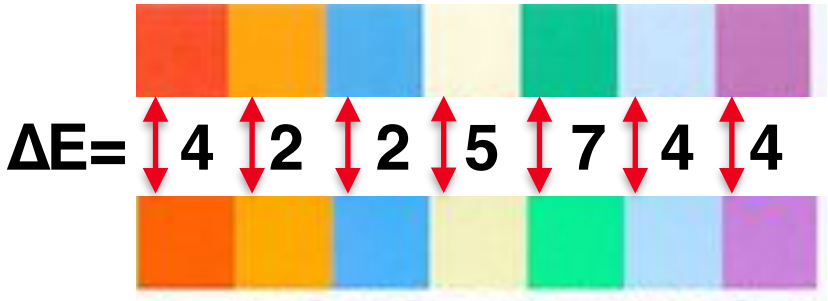
Printing Color, Quantify Differences

What Type of Color Match?

- Match for specific individual brand colors: Spot Color



- Match between pages and or images: Process Color

Technical Definition: E-Factor

95% of colors are within that delta E

- Used to quantify page, and image differences (not spot)
- Requires at least 60 different patch color definitions
- Compares the patch definitions and sort highest delta E
  - *95% worst delta E is the E-Factor*
  - *CRF at 95th percentile ΔE 2000*
  - *Defined in G7 Color Space tolerances and TR016*
- Co-relates great with spot color delta E differences
- Lower the number= Closer color match, better match

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Printing Color, Need to Understand Boundarys

Know if Print is "Salable"

- In play vs. out of bounds
- Tribal Knowledge related to customer expectations
  - *If no history, no tribal knowledge- large risk for loss*
- Quantify Print Result using Metric for Color Difference
  - *Eliminates human subjectivity, people see color differently*
  - *Single color comparison use: delta E (ΔE)*
  - *Pictures and Documents use: E-Factor*
- Lower the number= Closer color match, better match

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Review of 1st C- Capturing Data

Without Data- No Idea What is Happening

- Capture Data to understand Print Properties
- Choose measurement device based on quality/price
- Measure printer to understand what is normal…
- Conformance to Production Standard EF

EF = 2.9

EF = 0.7

EF = 0.25

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Calibration Agenda

Important C- without Consistency- No Color Matching

- Stabilize the process!!!!
- How to determine how much and what type of process control
- How to quantify printing device variations?
- How to build calibration schedules
- Is Calibration enough?

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Calibration and Process Control

- **Definition of Process Control**

  Ensuring a device/**process** is predictable, stable, and consistently operates at a **target** level of performance, with only normal variation…

- **But, what's the definition of…**

  Target *level of Performance?* ***Normal*** *variation?*

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Calibration: How Often

It Depends on…

- Expectations for Salability
  - *Tighter the expectations, the more often calibration performed*
  - *More calibration equals more cost (less production, more downtime)*
- Rate of drift of Device
  - *Different devices have different characteristics*
  - *Temperature and humidity influences on print performance*
  - *Variation of consumables: substrates, inks, toners, blankets*
- Need to Test Rate of Drift using **Conformance** Software
  - *Reports drift over time in E-Factor*

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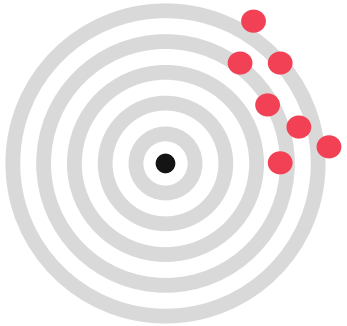
Calibration: How Often?

It Depends: Target Level of Performance/Normal Variation

- Target Performance relates to Expectations for Salability
  - *Tighter the expectations, the more often calibration performed*

- What is “normal” variation or rate of change for each device?
  - *Variation of consumables/substrates, and Temp/Humidity changes*



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Calibration: How Often?

It Depends: Target Level of Performance/Normal Variation

- Target Performance relates to Expectations for Salability
  - *Tighter the expectations, the more often calibration performed*

EF = 6

EF = 2

- What is “normal” variation or rate of change for each device?
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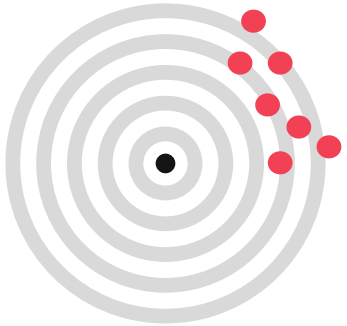

EF = 7

EF = 3

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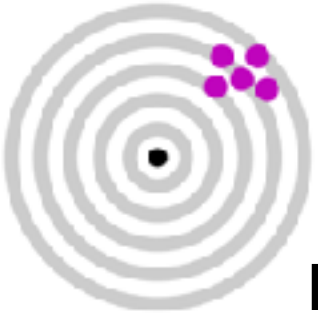
Calibration: How Often?

Target Level of Performance > Normal Variation= Success

EF = 6

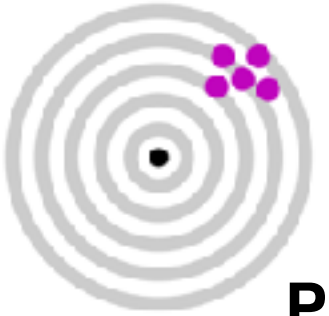


EF = 3

Expectations **Printed Results**

Target Level of Performance < Normal Variation= Failure

EF = 2



EF = 3

Expectations **Printed Results**

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How Often to Calibrate?

Calibration Once a Week- Normal Variation…

- Print color page every day/hour/minute over time
- Quantify E-Factor Difference of the prints over time
- Include Calibration schedule to understand if it needs more

EF = 5 EF = 7 EF = 5

Monday **Tuesday** **Wednesday** **Thursday**

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Calibration for Workflow

Required to ensure Precision (Consistency)

- Calibration for Digital Printing devices (to itself)
  - *Usually built into RIP for output device*
  - *Brings printer back to known, reproducible condition*
- Calibration for Measurement Instruments
- Platesetter- Ensure repeatability over time
- *Optionally*- Calibrate Printing device to G7 condition
  - *Adjust gray balance and NPDC to hit G7 Gray criteria*
  - *ChromaChecker can perform this*

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Calibration is Required for Consistency

- **No consistency, no control**
- Calibration stabilizes & brings device back to “normal"
- If device constantly “drifting”, no hope of color accuracy

No Precision

LOW ACCURANCY
LOW PRECISION

LOW ACCURANCY
HIGH PRECISION

Precision

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Quantify Printer Variation

Understanding what is “normal” printer variation

- What types of printer variation?
- What affects printer variation?
- What variables need to be considered and controlled?
  - *Depends on print technology*
- What metric can we use to determine consistency?
- How to monitor your printer consistency?

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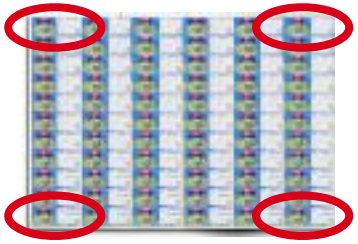
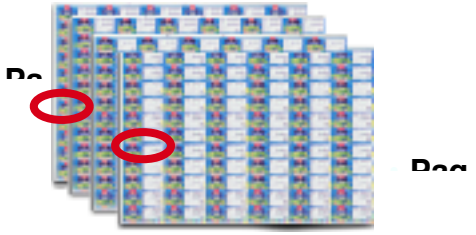
• Calibration- Schedule based on Variation

Three types of Variation:

1. Within page uniformity- Variation within one sheet



2. Between page repeatability- Variation from sheet to sheet;



3. Between job reproducability- Variation from job to job;

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What Affects Printer Consistency/Precision

What affects print variation of output

- Lack of preventative maintenance- run until it breaks mentality
- Consumable changes (paper/coatings/ink/toner)
- Volume of printed pages
- Temperature, Humidity, Dew Point variation

What procedures help compensate for variation

- Preventative maintenance schedules- Proactive assessment
- Calibration procedures and timing
- Goal is to bring device back to baseline condition

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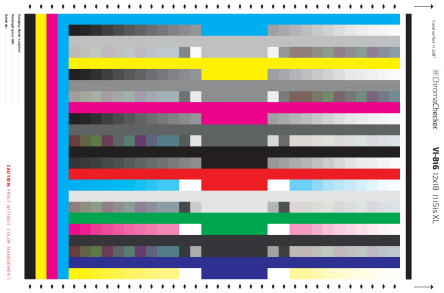
ChromaChecker Published Procedures

Assessing Normal Variation for any Print Technology

- Many variation issues are not disclosed, hard to tell
  - *Within page uniformity unacceptable*



  - *First 50 prints shift color with some print technologies*

50th print is 2 ΔE different from first print

- ChromaChecker Benchmark PDFs and directions

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Never Average Measurement Data w/o Compare

Every one states to Average…

- If one bad measurement- can wreck average
- Use Variation tool
- Understand differences are small, before average done
- When Averaging- need Ave and Max Error saved with file

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Quantify Printer Variation Summary

Critical to understand “normal” printer variation

- What types of printer variation? Within, between page/job
- What affects printer variation? Depends on print technology
- What variables need to be considered and controlled?
  - *Depends on print process*
- What metric can we use to determine consistency? EF
- How to monitor your printer consistency? Color Conformance!

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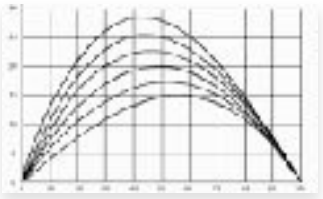
DIFFERENT TYPES OF CALIBRATION PROCEDURES

Dependent on Goal and Workflow

- Device Calibration — Make device consistent
  - Built into RIP, adjust tint ramps of CMYK to baseline

- G7 Calibration methodology
  - RIP/3rd software adjust CMYK tonality for gray balance and NPDC
  - Provides a “shared appearance” not color matching

- TVI Calibration methodology
  - RIP/3rd software adjust CMYK tonality for TVI match



ISO 12647-2 TVI Curves

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When to use which methodology?

- Ensure processes are consistent and calibrated:
  - Platesetter/Imagesetter is consistent
  - Printing process: consistent densities, and tonality (pressures)
- G7 Calibration methodology / TVI calibration methodology
  - RIP/3rd software adjust CMYK tonality for gray balance and NPDC
  - Creates new press curve (substrate based) add in workflow
  - Provides a “shared appearance” not color matching
  - Expected E-Factor to reference: between 4-6 if consumables good
  - If better match required — create ICC profile after press is G7

When to use which methodology?

- Ensure processes are consistent and calibrated:
  - Platesetter/Imagesetter is consistent
  - Printing process: consistent densities, and tonality (pressures)
- Create ICC Profiles for substrate types
  - Once printer is consistent - then create ICC Profile if necessary

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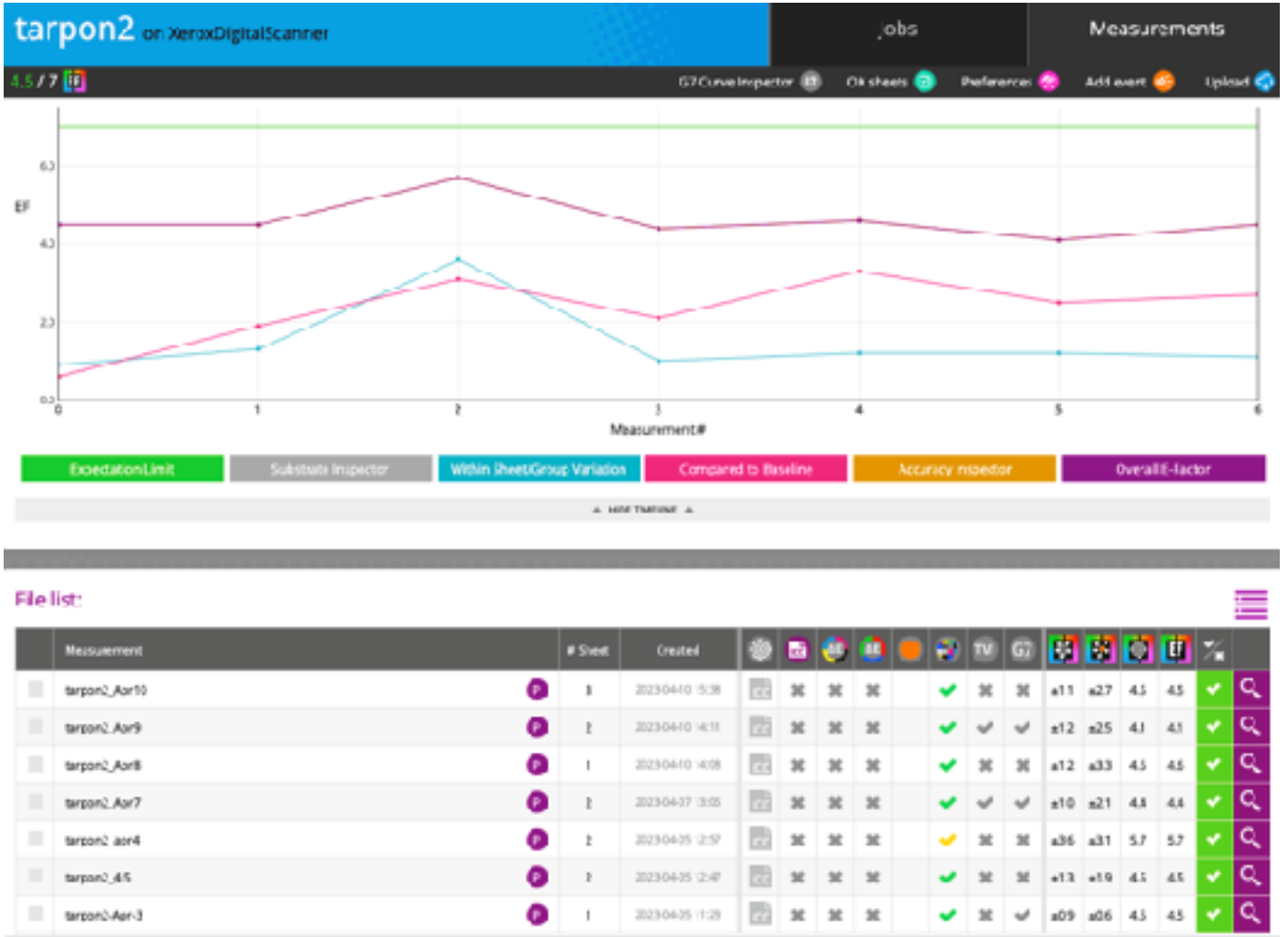
Actual Scenario- Assessing Print

Print same target, every day for a week…



When to use What Methodology?

Digital Printing Processes: Digital Press/Large Format

- Ensure printer is calibrated: RIP supported
- Optional G7 Calibration methodology
  - *If Expectations are "pleasing color," 5+ E-Factor- only G7*
  - *If Expectations are demanding, skip G7- create Characterization*
- Create Characterization ICC Profile
  - *Make immediately after calibration*
  - *Configure ICC Profiles for proper conversion in workflow*

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Calibration Summary

Color Control Starts with Calibrating all devices

- Process Control requires defined expectations of Result
- Expectations determine how much, what type process control
- Every type of device should be Calibrated
- Methods quantify variation and to build calibration schedules
- Is calibration control enough, or Characterization required…

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Call to action: Download- Print- Measure

Baseline Your Printing devices

- Production Printing Devices
- Assess against GRACoL
- Assess G7 Compliance
- Assess printer to printer match

For step by step instruction scan QR code or visit:

https://chromachecker.com/trial

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Color Control
Characterization

Presented by: David Hunter

Characterization (ICC Profile Creation)

Characterization process is demanding- Requires:

- Ensuring printing devices are precise and repeatable
- Measuring devices are precise, accurate to reference
- Measuring a lot of color patches
- Using ICC Profile creation software ($$) to create profile
- Compatible workflow/RIP to accept ICC Profiles
- Understanding how to configure profiles in workflow
- **Benefits**- More accurate result over any type of calibration

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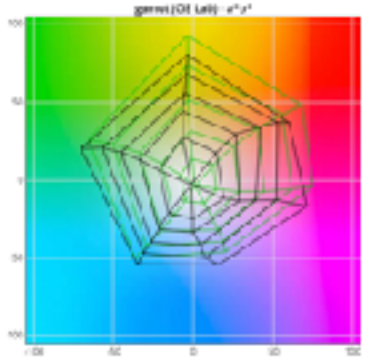
#3 C- Characterization (ICC Profile Creation)

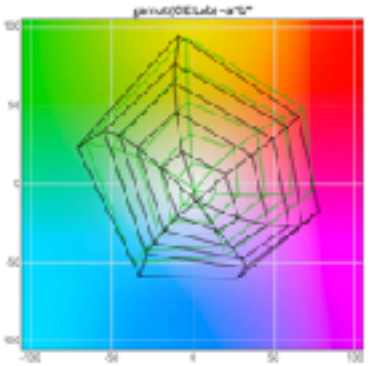
Defines Color Space of Printing Condition

- Defines gamut (range of color) of ink, substrate, calibration



C M Y K

3. 62. 19. 0



C M Y K

3. 62. 19. 0

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#3 C- Characterization (ICC Profile Creation)

Defines Color Space of Printing Condition

- Each device speaks a different language- define language
- Defines gamut (range of color) of ink, substrate, calibration
- Qualify Substrates first (determine most used, similarity)
- Allows printer to simulate standard (GRACoL)

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#3 Characterization (ICC Profile Creation)

Steps:

1. Verify Printer is stable and consistent
2. Qualify substrates- Print target on all important substrates
   - *Use ChromaChecker substrate qualifier to group substrates per EF*
3. Choose Characterization software to use (ChromaChecker)
4. Choose profile target (IT8 7/5) compatible w/capture device
5. Print multiple times immediately after calibration done
6. Measure multiple targets, compare differences, average
7. Create ICC Profile using correct settings
   - *Defining Black replacement of CMY, Black start, TAC limit*

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Color Control
Conversion

Presented by: David Hunter

#5 C- Conversion of Files and Documents

Converting from current space to desired print space

- Convert pages and images, RGB and CMYK
- Convert brand colors- Named colors to look up table (LUT)
- Workflow/RIP function, some support, some don’t

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#5 C- Conversion of Documents

Input or Source Space

- Defines the existing gamut that file is defined in
- Represents how the file was created/separated
- Acts as the “original” what you want the file to look like
- Usually Legacy Print condition or an Industry Standard
- Direction analogy, have to know where file is starting from to know how to convert it to the destination

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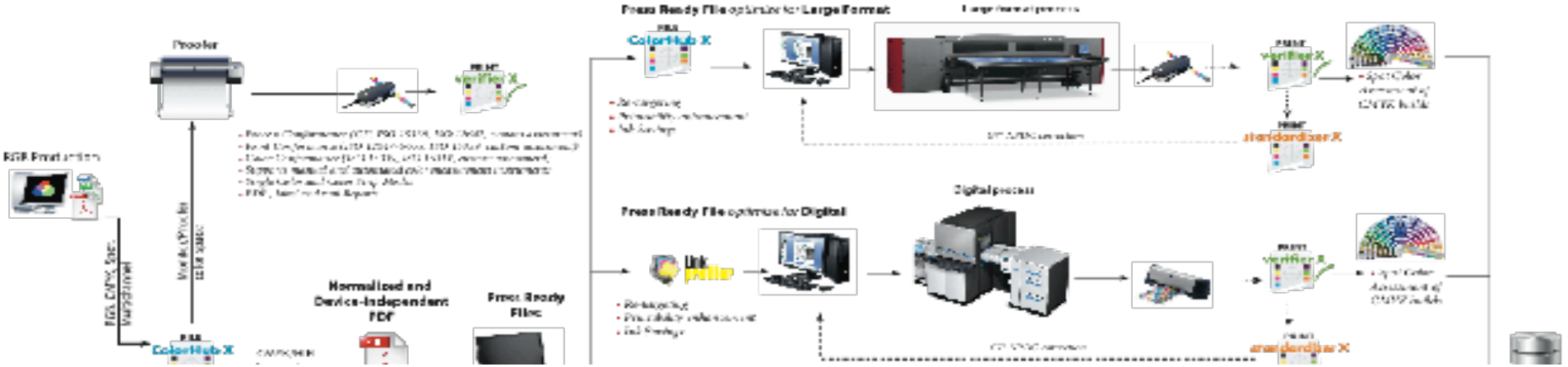
#5 C- Conversion of Documents

Flow Chart of Conversion

- Flowchart the gamut of actual output device space
- PDF X4 and X5



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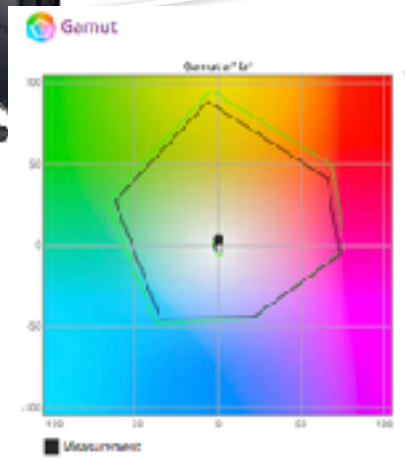
#5 C- Conversion of Documents

Output or Destination Space

- Defines the gamut of actual output device space
- Defines how the color has to be converted to match original
- Supplemental variables affect result:
  - *Rendering intent, Black Point Comp, and more will affect result*

C M Y K

3, 62, 19, 0



C M Y K

3, 62, 19, 0

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- Supplemental variables affect result:
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C M Y K

3, 62, 19, 0

C M Y K

10, 53, 9, 0

C M Y K

6, 74, 11, 0

#5 C- Conversion of Brand Colors

Same CMYK values render differently on different printers

- Need to Convert specific to different ICC Profiles

C M Y K
3. 62. 19. 0

C M Y K
3. 62. 19. 0

DON'T MATCH

C M Y K
3. 62. 19. 0

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#5 C- Conversion of Brand Colors

Spot Color Look Up Table (LUT)

- Renders Brand color to device CMYK values

C M Y K
6, 74, 0, 0

C M Y K
3, 62, 19, 0

C M Y K
1, 75, 1, 0

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#4 C- Conversion of Files and Documents

Converting from current space to desired print space

- Convert pages and images, *Universal Translator*
- Convert brand colors- Named colors to look up table (LUT)
- Workflow/RIP function, some support, some don't

GRACoL

C M Y K

6, 74, 0, 0

C M Y K

3, 62, 19, 0

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#4 C- Conversion of Brand Colors

Spot Color Look Up Table (LUT)

- Renders Brand color to device CMYK values

C M Y K
6, 74, 0, 0

C M Y K
3, 62, 19, 0

C M Y K
1, 75, 1, 0

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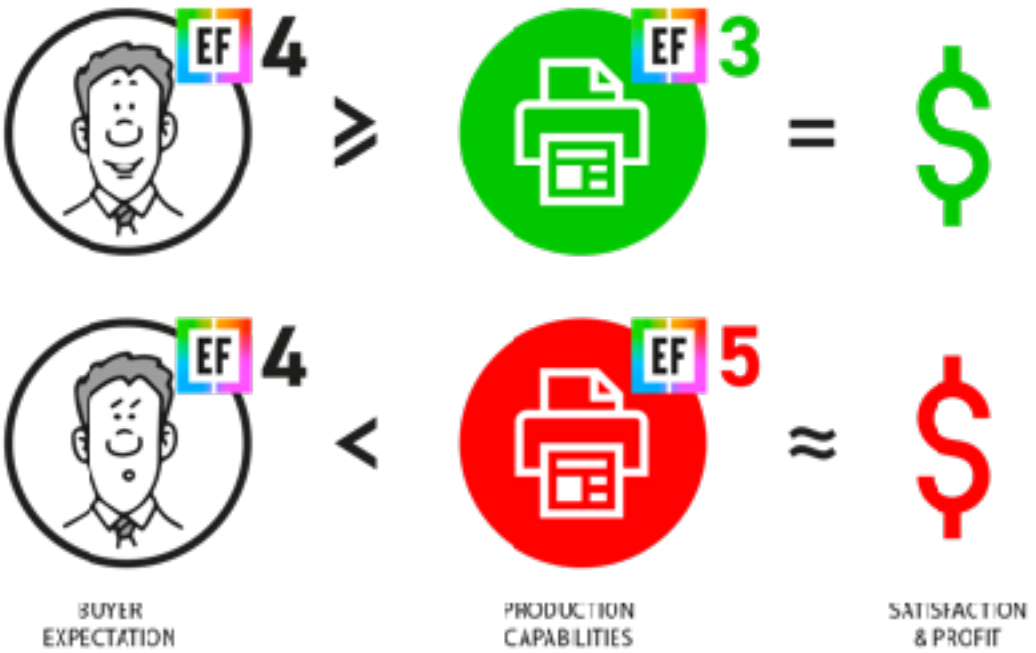
Color Control
Conformance

Presented by: David Hunter

#5 C- Conformance- is it Salable?

Summary/Result of all 5 C's - is the print salable?

- Does Print meet customer expectations (E-Factor)?
- Provide Job reports proving to customer job success



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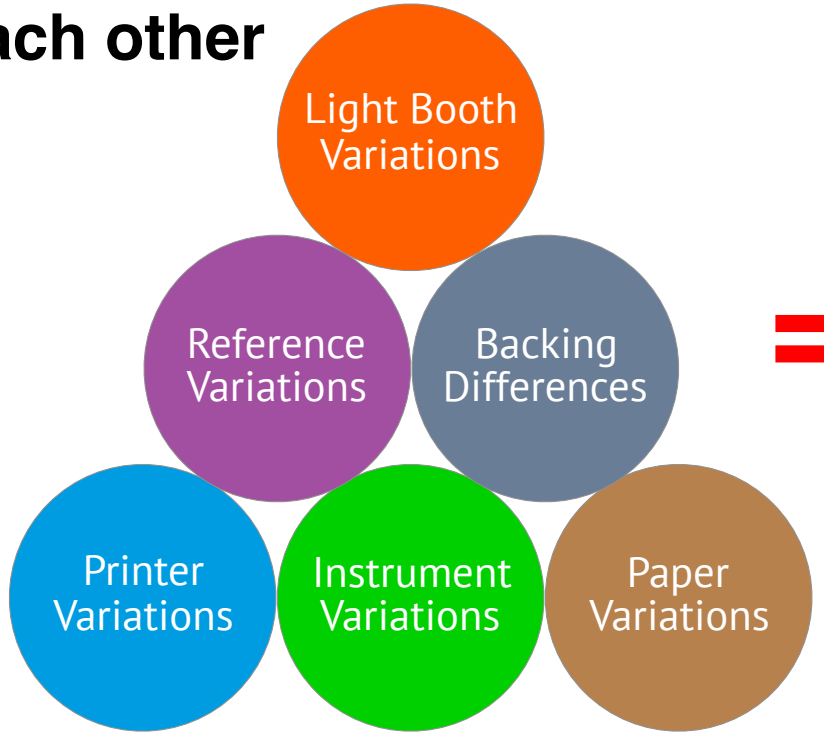
Each Variable Stacks on Top of Each Other

Cumulative Process:

- Each Workflow Component is tracked using **ΔE** or **E-Factor**
- **They all stack on each other**



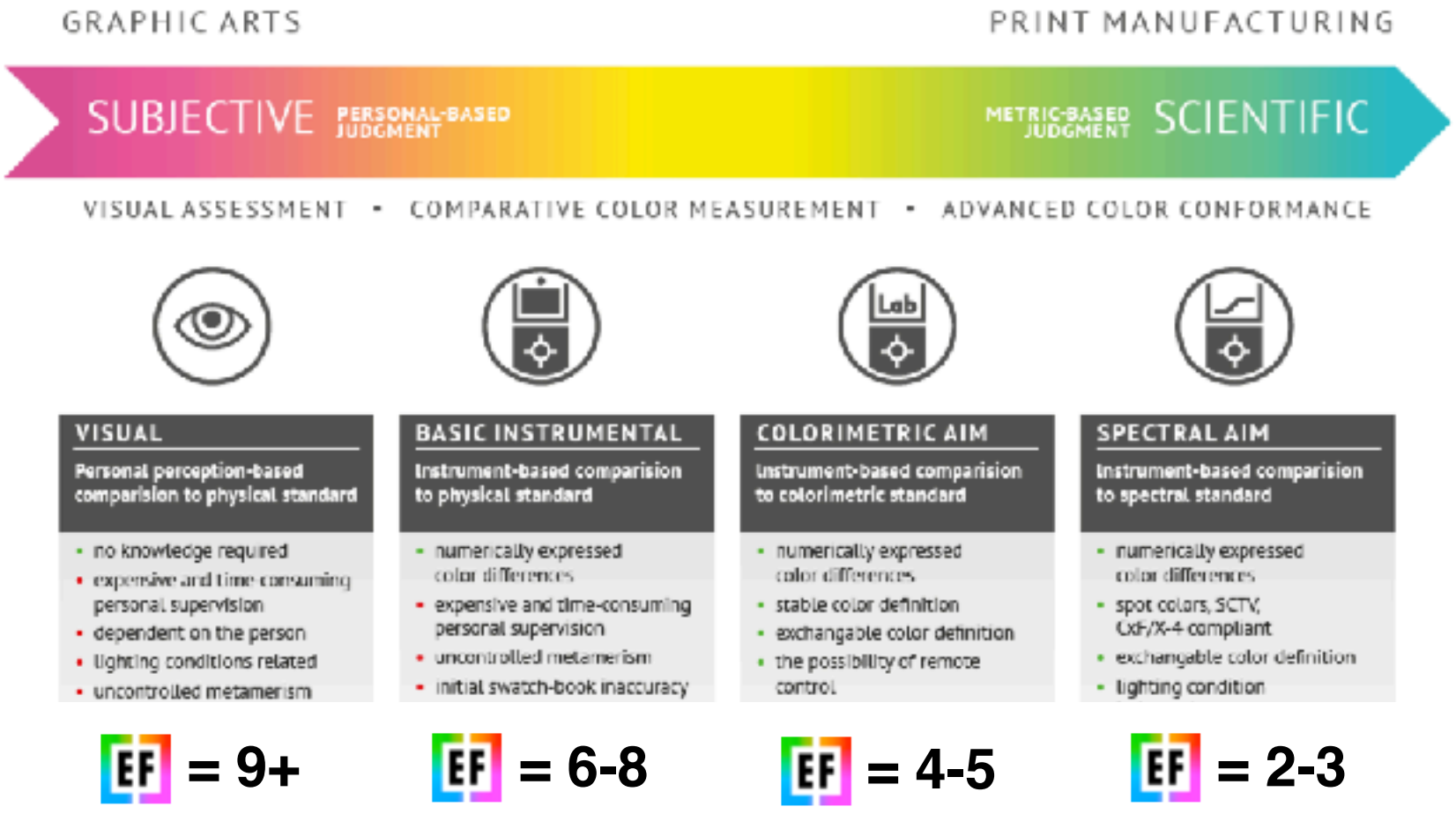
or 12 EF

= 8 EF

or 5 EF

Salable Print Manufacturing

Road Map to Analytics Based Print Manufacturing



Summary

Color Control requires understanding many variables

- Measure, Compare, Track, Assess
- Multiple Tools to ensure Color meets expectations
- Hands on Training showing how tools can be applied

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5 C's Use Cases for each C

#1- Capture Device

- How to apply for your use

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Measurement Factors to Consider

- Use Case- Calibrate, Characterize and or Conformance
  - *Calibrate/Conformance- 84 patches or less, Characterize- >1000*
- Substrate thickness, texture, opacity/translucence
  - *Thin substrates- ISIS, Thick- i1IO*
- Ease of Use and Level of Automation
  - *Feed target into device- bar code scans and routes to correct track*
  - *Measure prints without color bars*
- Precision of Instrument- to itself and others- Key for E-Factor
- Application- Spot and or Process Measurements
  - *Spot color (brand colors) single measurement at time*

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Use Cases:

- Operator measuring Calibration/Conformance target
  - *Generally less than 100 patches, usually once a shift*
- Operator assessing Process and or Spot compliance
  - *Process- less than 100 patches, usually once per shift*
  - *Spot- Less than 5 patches*
- Substrate thickness, texture, opacity/translucence
  - *Thin substrates- ISIS, Thick- i1IO, Translucence- Barbieri, i1Pro3+*
- Creating Characterizations (ICC Profiles for Accuracy)
  - *Characterizing print conditions*

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Use Cases: Measure Calibration target

- Operator measuring Calibration/Linearization target
- Least Expensive – Manual strip reader (i1) Good Choice
- More Expensive- Automated strip reader (i1iO or ISIS)
  - *Can share amongst a group, Central workstation*
- Most Expensive- Inline measurement (Dependent on Printer)

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Ease of Use for low skilled user

- Physical steps to measure target
  - *Feed target into device- bar code scans and routes to correct track*
  - *Position print on table same way every time*
  - *See demo*
- Precision of Instrument- to itself and others- Key for E-Factor
- Substrate thickness, texture, opacity/translucence
  - *Thin substrates- ISIS, Thick- i1IO*
- Application- Spot and or Process Measurements
  - *Spot color (brand colors) single measurement at time*

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5 C's Use Cases for each C

#2- Calibration Use Cases

- How to determine how often you calibrate

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5 C's Use Cases for each C

#3- Characterization Use Cases

- How to determine how to choose target
- How to print target
- How to measure target
- How to create profile
- How to assess profile

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5 C's Use Cases for each C

#4- Conversion Use Cases

- Setting up Input and Output profiles
- Some workflows/RIPs do not support color conversions
  - *Canon 6000 Printer, driver supports RGB input files, can't*
- Configuring Spot (named) color look up tables
  - *PrintFactory and Freeflow RIPs don't support spot tables*

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5 C's Use Cases for each C

#5- Conformance Use Cases

- Affect of Light booth in visualizing color
- Determine what is salable
- Differentiate Waste —- critical for improving profitability

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What is “Normal Variation”

- Device Consistency
  - *Compared to what? First OK Sheet*
  - *Use a target, Which one, how many patches?*
  - *Two on a page, Rotated from one another*
  - *Measure and compare what*
- Maintenance, End of Life Consumable
  - *Measure after break in period, on New side of life*

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Difference Between:

- Precision versus Accuracy

Low Accuracy
Low Precision

Low Accuracy
High Precision

High Accuracy
Low Precision

High Accuracy
High Precision

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Difference : Precision vs. Accuracy

- *Precision (Repeatability) Depends on:*
  - Correct Color Measurement Devices
  - Proper Calibration for Devices and Instruments
- *Accuracy (Match Defined Condition) Depends on:*
  - Valid Characterization (ICC Profiles)
  - Proper Color Conversions
- *Conformance Verifies that Everything is Working*
  - Verifies Precision & Accuracy w/Specifications

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Difference : Precision vs. Accuracy

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Difference : Precision vs. Accuracy

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- *Accuracy (Match Defined Condition) depends on:*
  - Valid Characterization (ICC Profiles)
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- *Conformance Verifies that Everything is Working*
  - Verifies precision & accuracy w/in expectations

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Variation - Understanding “Normal”

Remote Benchmark

- You download test files
- Print on your devices at different intervals
- Measure the Targets, Name appropriately
- Upload the data
- We Supply Reports which shows you that Variation is in your process

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Why Not Use G7 to define Color Match?

Both are G7 Compliant- but NOT ACCEPTABLE

- E-Factor = 7, not acceptable for many people

Color Control
Define Conformance

Presented by: David Hunter

5 C'S OF COLOR CONTROL AGENDA

Process Discipline for each color printer

Conformance — assess where your printers are at...

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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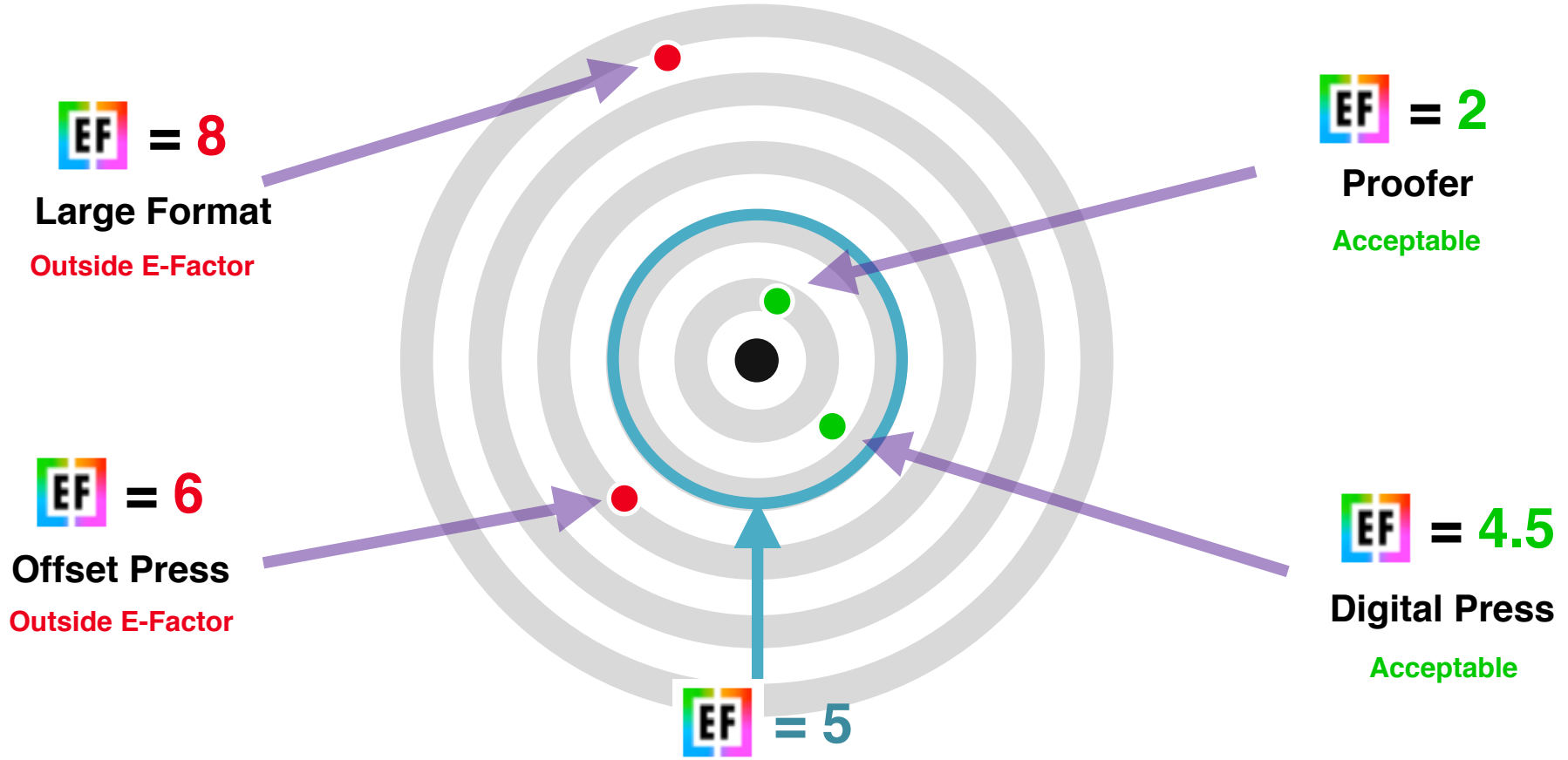
HOW CLOSE IS “CLOSE ENOUGH”?

What’s your color “match” Expectation Factor



Expectation Factor EF is the distance from the bullseye which is salable

Conformance Expectations

Quantify Color Expectations

- Benchmark how printing devices are performing
- Visually understand where printers are at today
- Determine if you need to improve any of them
- Look at 5C's to improve printers if required
- Prioritize resources based on expectations

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Conformance Expectations

Benchmark Kit Purpose

- Visual images to assess color expectations
  - Compare to GRACoL* and to one another
- Easily measure using CC Capture
  - Will assess E-Factor and G7 compliance
  - Works with most measurement instruments
  - Works on Mac or Windows
- Includes PDF (to print) and software to measure

* Requires E-Factor Exercise ($99) to compare to GRACoL

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Conformance Expectations

Benchmark Printing Devices

- Register and Download Benchmark App and files
- Print ChromaChecker PDF out on all printers
  - Use Normal Production settings
- Measure using CC Capture
- Record E-Factor value at top
- Lower E-Factor- closer to GRACoL
- Compare to one another

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Video Showing How to Use CC Capture S/W

Measure the 3 row target

- Result:

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Determine Conformance Expectations

Visually compare prints to one another

- EF number shows how different from GRACoL*

Proofer

EF = 2

Large Format

EF = 8

Digital Press

EF = 4.5

GRACoL Sample

Included with E-Factor Exercise

$99

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Determine Expectations

Compare prints to reference and one another

- E-Factor Difference to GRACoL

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Determine Expectations

Full E-Factor Exercise- $99

- Shows E-Factor differences of: 2, 3, 4.5 and 6

What is Personal E-Factor™ Exercise?

This is a set of six pages.

Each page is marked with one of the icons:

Printing Color, Quantify Differences

What Type of Color Match?

- Match for specific individual brand colors: Spot Color

- Match between pages and or images: Process Color

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Printing Color, Quantify Differences

What Type of Color Match?

- Match for specific individual brand colors: Spot Color
  - **ΔE (delta E**) quantifies spot difference
  - Bigger the number, bigger the difference

- Match between pages and or images: Process Color
  - **E-Factor** (EF)- quantifies process color difference
  - Bigger the number, bigger the difference
  - Think ΔE for process colors, same relative difference

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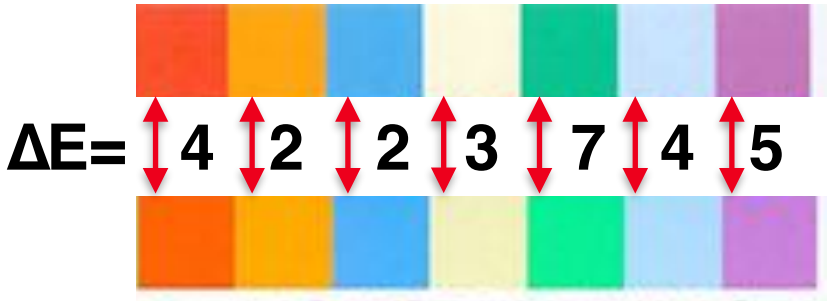
Printing Color, Quantify Differences

What Type of Color Match?

- Match for specific individual brand colors: Spot Color



- Match between pages and or images: Process Color

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Technical Definition: E-Factor

95% of colors are within that delta E

- Used to quantify page, and image differences (not spot)
- Requires at least 60 different patch color definitions
- Compares the patch definitions and sort highest delta E
  - *95% worst delta E is the E-Factor*
  - *CRF at 95th percentile ΔE 2000*
  - *Defined in G7 Color Space tolerances and TR016*
- Co-relates great with spot color delta E differences
- Lower the number= Closer color match, better match

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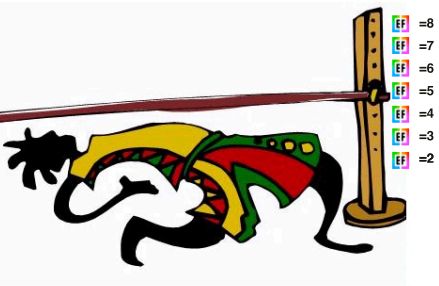
Determine E-Factor: Expectations

Factors to Consider

- Different customers have different expectations
- Evaluate how satisfied current customers are
- Nothing wrong with having high E-Factor if salable
- Start with higher E-Factor, reduce if necessary
  - Don’t set the bar to hard to begin with
  - Will lose support of operators and staff
  - Need to provide more time, tools, training to lower



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Conformance: Salability Platform!

Define Expectations for printing devices

- Defines Production Capability of all printing devices
- Defines if devices are within Customer Expectations
  - Operator- Real time judgement reduces waste
  - Sales/Customer Service/Management/Customer

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5 C'S OF COLOR CONTROL SUMMARY

E-Factor affects all aspects of Printer's workflow

Conformance — assess where your printers are at...

Capture — assess instrumentation precision and accuracy

Calibration — how often and what type of calibration required

Characterization — requirement and quality of ICC profile

Conversion — how the conversion is applied to files

Conformance — verify new results and meet expectations

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