A Systematic Approach to Color Management

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Agenda

• What is Color Management?
• Basic Color Theory
• Design Side Color Management
• Less Ink - More Color
• Maintaining Consistent Repeatable Color
The “Real” World
What is Color Management?

Controlled conversion between the color representations of:

• Digital cameras
• Monitors
• Offset presses
• Wide format inkjet printers

The goal being to obtain a common visual appearance across the different devices and medias output by the devices where appropriate.
Color Management Visually

Camera’s RGB

Scanner’s RGB

CIELAB

Monitor’s RGB

Printer’s CMYK

Color Casters
Color Perception

Color results from an interaction between, light, object and the observer. It is light that has been modified by an object in such a manner that the observer (human visual system) perceives the modified light as a distinct color.
Human Visual Spectrum

The typical human eye perceives colors in the 380 to 720 nanometer range of the electromagnetic spectrum.

Humans have 3 peak color sensitivities, in the Red, Green, & Blue ranges.
How Many Colors Are There?

The average human eye can see millions of colors!

An RGB monitor can typically reproduce around 16.8 million colors.

A typical CMYK printing device can reproduce thousands of different colors depending on calibration and dot structure or halftone used.
Defining Color-Additive Color Model

RGB-When two additive primaries overlap, a subtractive primary is produced.

Where all three are combined, white light is produced.
RGB Color Space

- Additive color - used by the following:

Humans
Cameras
Monitors
Scanners
CMYK Color Space - Subtractive

Subtractive color system:
Equal portions of cyan, magenta and yellow subtract color from the viewer’s eye to produce black. Additional black ink or toner is used to create a more true black tone.

CMYK colors are used by:
Wide format printers, copiers and full-color printing presses
Additive vs. Subtractive Models

Primary Colors of Light

- Additive Mixing: green, red, blue
- Subtractive Mixing: yellow, magenta, cyan
3 Dimensions of Color

- **Hue**: Basic color, such as red, pink, or orange, etc.
- **Saturation or Chroma**: Vividness or dullness
- **Lightness**: Brightness or darkness
What’s the Difference?

• Humans are very discerning about neutral color variations, gray shades.
• Trained eyes can discern a delta of 2-3, untrained 5-6.
• In fact, the average observer will see hue differences first, chroma or saturation differences second, and lightness or darkness differences last.
• There are a number of tolerancing methods – Delta-E 76, Delta-E 94, Delta-E 2000
Gamut refers to the range of color that a device can capture (camera or scanner), or reproduce (monitor, proofing system, or printing process). Every device will have its own unique gamut.

2D and 3D Gamut Map: Outside shape is Adobe RGB (1998) - shape in middle is GRACol2013 CRPC6
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Color Management Visually

Color Casters
What is an ICC profile?

• A look-up table that represents the color input or output of a given device.

• The design is specified by the International Color Consortium (ICC).

• We connect the devices in a Profile Connection Space (PCS).
  • Occurs in L*a*b*
Gamut Conversion

- Color workflows work from larger gamut input devices, to a smaller gamut output device
- RGB? - CMYK?
- Rendering intents translate the differences
Perceptual rendering intent
Compresses all colors (detail) into the destination space while trying to preserve color appearance and color relationships. It does this by adjusting all of the colors - even those that were in gamut. This causes more colors to shift than any other rendering intent.
Relative Colorimetric

- **Relative Colorimetric Rendering Intent**
  1 to 1 matching of in-gamut colors. Out of gamut colors are clipped to nearest reproducible hue. Relative colorimetric causes the white in the source space to be re-mapped to the white point of the destination space.

All colors maintain relative position to the white point.
Perception of Color Varies
Design Side Color Settings

• Adobe Apps
  • Photoshop
    • Edit->Color Settings

• Default settings
  • Why?
Design Side Color Settings

Adobe Apps
Edit->Color Settings
Suggested Settings
Why?
Less Ink = More Color

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Kinds of ICC Profiles

Canned

Custom
Kinds of Profiles

Canned Profiles

- Consider the source.
- Match your printer, media and ink?
- Ink restrictions for your environment?
- For color critical work, leaves a lot to be desired.
- But cost-effective and quick.
Kinds of Profiles

Custom Profiles
- You are the source (or you hired a color management expert).
- Perfect match for your printer, media and ink.
- Ink restrictions tweaked for your environment - maximized gamut.
- Perfect for color critical work.
- But it’s not free and takes time.
Why?

Why would you want to go to all the effort of building custom ICC profiles for your device?

After all, there are perfectly good canned profiles available for free from equipment and media companies.
Do You Want To Improve:

Color Consistency?

Color Matching Between Printers and Substrates?

Matching Spot Colors More Accurately and Precisely?
Color Management Pyramid

- Profile
- T.A.C.
- Linearization
- Primary Ink Restrictions
- RIP Settings
- Calibrating Media to Printer
- Ambient / Environmental Conditions
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Stabilize the System
Stabilize The System

Ambient / Environmental Conditions.
- Temperature
- Humidity
- Static Electricity
- Electrical Power Issues
- Dust/Dirt, Etc.
Stabilize The System

Calibrating Media to Printer
• Head Height
• Nozzles
• Uni/Bi Directional Alignment
• Media Feed Adjustment
• Heat/Cure Settings
Stabilize The System

RIP Settings
• Dot Pattern
• Resolution
• Pass Count
• Print Speed
• Overprint/2\textsuperscript{nd} Strike
• Variable Dot Settings
• Light Ink Transitions
Profile Creation

Profile
T.A.C.
Linearization
Primary Ink Restrictions
RIP Settings
Calibrating Media to Printer
Ambient / Environmental Conditions

Stabilize the System

Color Management Pyramid
Inkjet is different.

At some point on the uncalibrated tone ramps, each primary color stops being the color we expect it to be (ISO 12647-2) in conventional printing and becomes some other color.
Properly setting primary (or single channel) ink restrictions is the single most important aspect of creating inkjet profiles. This is particularly challenging with solvent, dye sublimation and UV.
What an ISO compliant ink looks like

Reaches the target delta-E ellipses via a fairly linear and predictable path.

This graph is the end result of a properly ink restricted and profiled aqueous printer that passed G7 Color Space certification.
Where we run into problems...

- Notice cyan coming up short.
- And a hooked magenta.
- Then, see what happens to red as a result of a hooked magenta.
- AND this is after proper ink restrictions and profiling.

Color Casters
One more look: side-by-side
RIP Linearization
RIP Linearization
Total Area Coverage (T.A.C.)
Set The T.A.C.

A: Do gradient patches maintain different color?
B: Are small characters clear?
C: Are patch boundaries clear?
Color Management Pyramid

- Profile Creation
  - Profile
  - T.A.C.
  - Linearization
  - Primary Ink Restrictions
  - RIP Settings
  - Calibrating Media to Printer
  - Ambient / Environmental Conditions

Stabilize the System
Print and Measure ICC Target
ICC Profile Creation Options

1. Maximum total area coverage.
2. Maximum Black only coverage.
3. Black ink starting point.
4. Black ink curve (GCR)
• 1 Facility
• UV, Aqueous, & Solvent
• Paper, PVC, Banner, and Vinyl
• Certified G7 Master Printer for Color Space and Gray Scale
Maintaining Consistent and Repeatable Color
Process Control

ICC Profile

Calibration

Verification

Why Statistical Process Control?
Print, Measure and Verify
Understand The Color Targets

• What is the target?
  - CRPC?

• Have a plan to get to the select color target(s)
  - The right software and instruments

• Verify the process
  - If it’s not repeatable, color management will be difficult or even impossible
Accuracy vs Precision

Precise, but not Accurate

Accurate, and Precise

Accurate, but not Precise
Gray Balance

Date/Time: 7/23/19 11:14 AM
Plant:
Meas. Name: Dye Sub Demo
Job Number:
Job Name:
Client:
Form/Page:
Side:

CMY G7 Gray Balance
- Avg wΔCh ≤ 1.5: 0.81
- Max wΔCh ≤ 3.0: 1.43
- Avg wΔL*: 0.45
- Max wΔL*: 1.40

K G7 NPD
- Avg wΔL*: 0.77
- Max wΔL*: 1.61

Pass

Print Sticker
91.8%: No Visual Difference
Date/Time: 12/1/16 10:19 AM
Plant: 
Meas. Name: Vivid Ink, Inc. After G7 Cal
Job Number: Submission ID: 10937
Job Name: SIHL 3620, CMYK, GRACOL2013
Client: 
Form/Page: 
Side: 
Reference Set: GRACoL 2013 Coated – CRPC6
Control Strip: IT8.7-4
Tolerance Set: Visual Match Scorecard (ΔE 2000)
Visual match (CRF)

![Frequency Histogram](image)
A Picture is Worth 1000 Words

Color Casters
Process Control: The Long View
Thank You!
Any Questions?

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