ICC Color Management

- What is the ICC?
- Why Color Management?
- ICC Profiles and the PCS
- Future Directions of the ICC

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The International Color Consortium (ICC)

- Established in 1993 by eight industry vendors.
- Goal: Create, promote and encourage the evolution of an open, vendor-neutral, cross-platform color management system architecture and components.

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ICC Membership

- Founders:
  - Adobe Systems Incorporated
  - Agfa-Gevaert N.V.
  - Apple Computer, Inc.
  - Eastman Kodak Company
  - FOGRA-Institute
  - Microsoft Corporation
  - Silicon Graphics Inc.
  - Sun Microsystems, Inc.

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ICC Membership

- Founding members comprise the ICC Steering Committee together with an additional seven members.
- Currently more than 70 members from all areas of the imaging and computer industry.

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The ICC Profile

- ICC promotes a standard color profile specification (ICC Profile).
- Initial profile specification based on Apple ColorSync™ 2.0
- Current version of the ICC Profile Specification is 3.4.
  - ICC.1:1998-09 with Addendum 2: ICC.1A: 1999-04
  - Available as PDF at www.color.org

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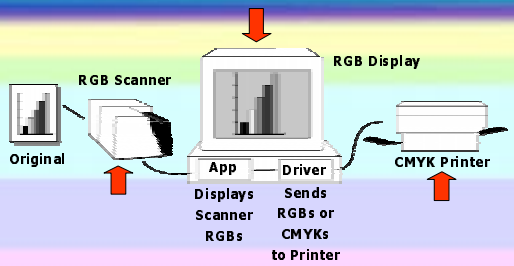
"Color" Workflow



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Everyday problems...

- *The same document looks different--*
  - -- printed on different printers.
  - -- viewed on different monitors.
  - -- viewed on a monitor and printed on a printer.
  - -- printed and viewed in a light booth and under office lighting.

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Why ?

- Devices, drivers, operating systems, and applications all interpret and reproduce colors differently.
- Input --
  Scanners, digital cameras
- Output --
  Printing: offset, gravure, inkjet, laser
  Display: CRT, LCD, PMP, DMD, video projectors...

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Device Color Gamuts

- Gamut = a device's range of realizable colors.
- A color gamut depends on viewing conditions: white point of the illuminant, surround, amount of light.
- A gamut can be visualized as a plane or volume in a standard color space:
  - CIE x,y chromaticity diagram
  - CIE L*a*b* (CIELAB)

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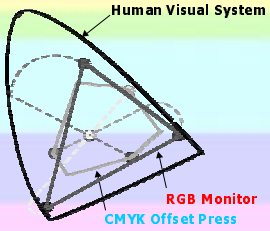
Offset Press vs. Monitor Gamuts

- CIE x,y chromaticity diagram of an offset press and monitor gamut.
- Note that
  Red ≠ 1 - Cyan
  Green ≠ 1 - Magenta
  Blue ≠ 1 - Yellow



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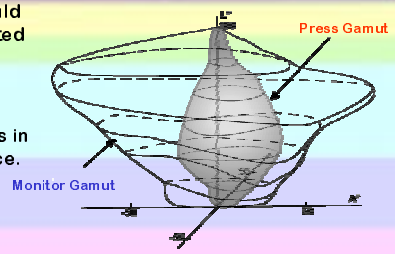
Offset Press vs. Monitor Gamuts

- Gamuts should be represented as volumes.
- Monitor and press gamuts in CIELAB space.



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What's the solution?

- A transform is needed to map the colors from one (source) device color space to another (destination) device color space.
  - The transform must account for the color characteristics of source and destination devices as well as viewing condition.

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Two transformation approaches

- Device-dependent color transformation
- Device-independent color transformation

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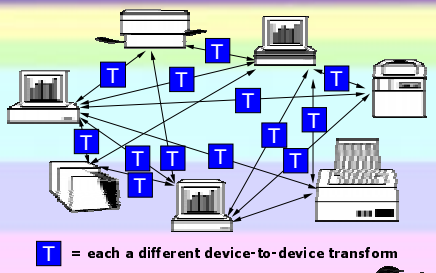
Device-dependent Color Transformations



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Device-dependent Color Transformations

- Primarily used in high-end proprietary systems.
- Dedicated, pair-wise transformation from source to destination.
- Transformations have both source and destination information (gamut, viewing conditions).
- Can be optimized for a device pair.

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Device-dependent Color Transformations

Disadvantages:

- For a system of *n* devices, n^2 transforms are needed.
- Adding a device requires *n* new color transforms.
- Re-calibrating a device requires *n* new color transforms.

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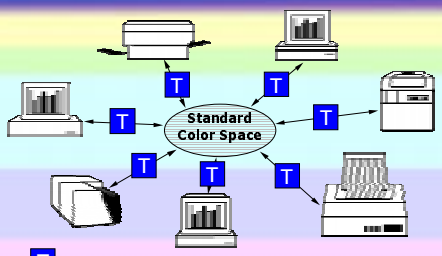
Device-independent Color Transformation



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Device-independent Color Transformation

- For each device, there is a transformation from device to standard color space.
- Transformations have source-to-standard color space or destination-to-standard color space information.

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Device-independent Color Transformation

Advantages:

- For a system of *n* devices, *n* transforms are needed.
- Adding a new device requires *only one* new color transform.
- Re-calibrating a device requires *only one* new color transform.

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ICC Workflow

- The transforms from device to common color space are embedded in the ICC profile.
- The common color space is called PCS (profile connection space).

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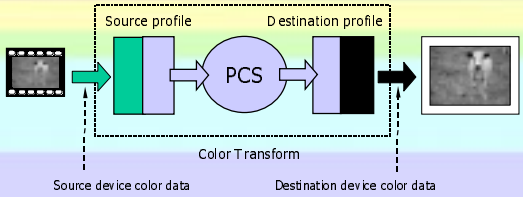
ICC Workflow



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The ICC Profile

- The ICC profile contains the transforms from "device" to PCS.
- There are several kinds of profiles:
  - *Input device* (scanner, digital camera, etc.)
  - *Output device* (printers, film recorders, etc.)
  - *Display* (CRTs, LCDs, projectors, etc.)
  - *Device Link* (dedicated device-to-device)
  - *Color space* (sRGB, CIE XYZ, L*a*b*, etc.)
  - *Abstract* (effects, PCS-to-PCS, etc.)
  - *Named Color* (Pantone®, Truematch®, etc.)

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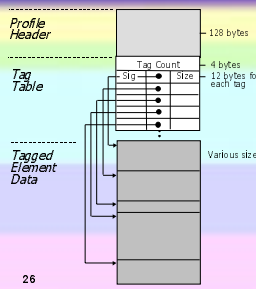
ICC Profile Format



- 128 byte header
- Tag-based (like TIFF)
- Public required tags
- Public optional tags
- Private tags

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ICC Profile Models

- Shaper/matrix profiles are used for RGB and single channel (grayscale) input and display profiles.
- Shaper/multi-functional-table (MFT) profiles are used for complex RGB and CMYK input, for RGB, CMYK and n-colorant output, color space conversion, and abstract profiles.
- The construction and content of the matrices and LUTs in a profile are vendor specific, and not defined in the ICC specifications.

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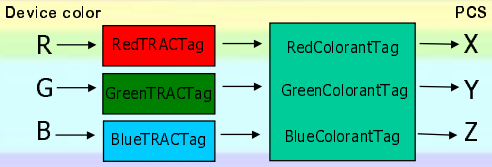
Shaper/matrix Processing: RGB input profile



1D "shaper" LUTs (gamma tables) for linearization.

3x3 matrix, includes source to PCS white point scaling.

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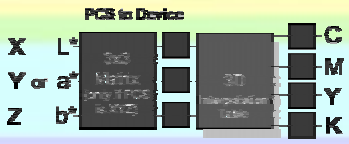
Shaper/MFT Processing: CMYK output profile



BToAnTag

n=0, 1, 2

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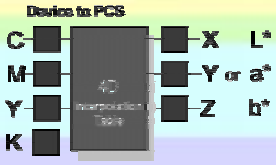
Shaper/MFT Processing: CMYK output profile



AToBnTag

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Four Rendering Intents

- Relative colorimetric
  - the white point of the actual medium is mapped to the white point of the reference medium. The colors map accordingly.
- Absolute colorimetric
  - the white-point of the illuminant maps to white point of the reference illuminant. The colors map accordingly.

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Four Rendering Intents

- Perceptual
  - the full gamut of the image is compressed or expanded to fill the gamut of the destination device. Gray balance is preserved but colorimetric accuracy might not be.
- Saturation
  - the saturation of the pixels in the image is preserved, perhaps at the expense of accuracy in hue and lightness.

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The PCS

- In the ICC workflow, the common color space is called the profile connection space (PCS).
- Each profile describes the transformation from source (device) space to PCS, and vice versa in case of output profiles.
- The current PCS describes an ideal reflection print viewed in a graphic arts viewing environment (D50 white point).

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PCS Encoding

- The encoding to PCS can assume either:
  - CIEXYZ, relative colorimetry, D50 white point
  - CIELAB, relative colorimetry, D50 white point
- 8 and 16-bit/channel encoding is allowed.
  - Defines the output data format for input LUTs (AToBnTags) and the input data format for output LUTs (BToAnTags)
- Matrix based profiles can only be used when the PCS encoding is in XYZ.

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ICC Today

- Profile Specifications 3.4
- Operating System Support on Apple, Microsoft, Sun, SGI, Java.
- Support for most high-end (and some consumer) graphic arts and photography input and output devices.
- Support in most professional graphic arts and photography applications.

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ICC Today

- The ICC allows vendors to register a unique signature of a device.
- The ICC has a characterization data registry that can be accessed when building profiles for specific press or proofing conditions.

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ICC Today

- The ICC today is working on the next major revision of the specification:
  - To be published soon.
  - Clarify the profile specifications to improve operability.
  - Clarify the PCS to improve operability (Annex E).

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ICC Today

- Different working groups investigate and work on recommendations/solutions for:
  - Conformance testing
  - Specification editing
  - Graphic arts special interest
  - Research implementation
  - ICC user groups support

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ICC Tomorrow

- The research implementation WG studies color management architectures and ICC specifications two years or more in the future.
  - Measurement based profiles?
  - Smart CMMs?
  - PCS based on CIECAM97s?

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Summary

- The ICC has achieved its goal: a color management architecture that allows for communication of color across devices, applications, and operating systems.
- In the future, the architecture will be broadened to fit additional color workflows, and specifications tightened to improve interoperability.

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Summary

- Joining the ICC enables you to participate and influence future color management architectures for any color image and document work flow!

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How to contact the ICC

- www.color.org
- Chairman: Lars Borg
  - Voice: +1.408.536.2723/536.6000
  - E-mail: borg@adobe.com
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