Color Imaging Workflow Primitives: Details and Examples

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Color Fidelity

The term “color fidelity” refers to the successful interoperability of color data, from image creation to output across multiple targets, such that color reproduction quality consistent with the user’s intent can be achieved

Note: Interoperability among system color components, necessary for color fidelity, is both color-workflow and market-segment dependent

Let’s define our terms...

definitions for architecture, image state, and image processing

Color Control (ICC) Architecture Elements

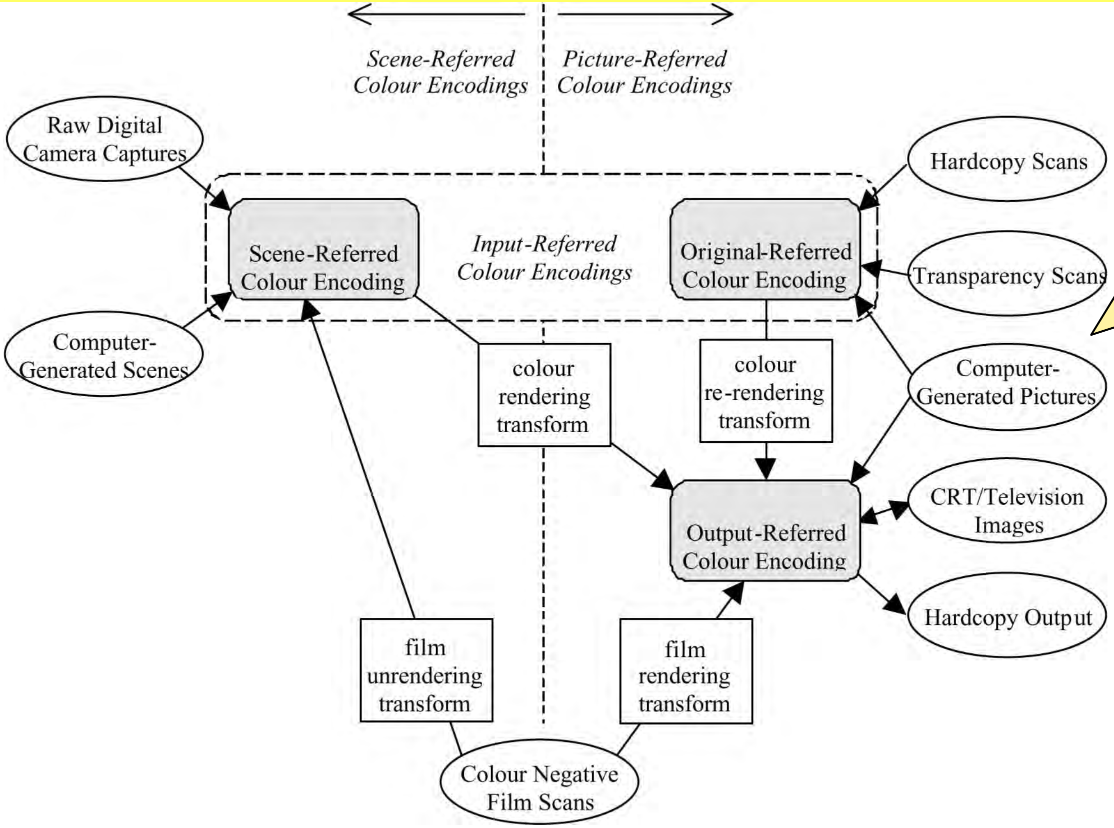
- Device calibration *Color Calibration*
  - Alters the color response of a device to return it to a known state
- Capture and visualization characterization *Color Characterization*
  - Describes the color response of an input or output condition
- Profile creation *Color Aim Implementation*
  - Encodes a characterization and a color aim for use in a transform
- Image color encoding *Color Source Specification*
  - Unrendered (e.g., capture a scene) vs. color-rendered (targeted)
- Profile selection and exchange *Color Communication*
  - Profiles can be embedded with an image or document, or can be transmitted as separate files
- Profile use *Color Transformation*
  - Profiles are applied in pairs to transform an image from a current encoding (the source) to another encoding (the destination)
- Visualization – the human element *Color Aim Expectation*
  - What does the human expect?

Color Control (ICC) Architecture

- ICC color management can be used to front-load color knowledge and color preference into a workflow ‘setup’
- Workflow elements are distributed over time and location
- Workflow elements are created by multiple vendors
- In such a distributed, multi-vendor system, interface definitions between the components are critical
    - Data definitions
    - Behavior definitions
- The ICC provides those definitions
    - Currently, the ICC specifies the data exchange format of the color transform metadata
    - In addition, the ICC specifies a limited set of profile “interpretation” rules recommending CMM behavior

Definitions

- Image state
  - The degree to which image data has been constrained or purposed to a particular visualization mechanism, as compared to the degree to which the image data has been retained unaltered with respect to its capture condition


Scene-Referred Colour Encodings
Picture-Referred Colour Encodings
Raw Digital Camera Captures
Computer-Generated Scenes
Scene-Referred Colour Encoding
Input-Referred Colour Encodings
Original-Referred Colour Encoding
Hardcopy Scans
Transparency Scans
Computer-Generated Pictures
colour rendering transform
colour re-rendering transform
Output-Referred Colour Encoding
CRT/Television Images
Hardcopy Output
film unrendering transform
film rendering transform
Colour Negative Film Scans

Concepts of scene-referred, original-referred, and output-referred image state as shown in ISO CD 22028-1-Part 1

ICC workflows include both Actual Output Referred (a particular visualization device) and Reference Output Referred (e.g., SWOP)

Definitions

- 'Scene-Referred image data' (SR)
  - Image data that unambiguously encod e spectral reflectances of e scene (including s -capture t us encodings)
  - A eferred ima d be using a very rge gamut, high nge
- 'Original-R
- 'Refe
  - Outpu rdized ou al specifica not be realizable)
- 'Actual-Outp Refer age (AOR)
  - Output-referred image that is rendered to a pecific, particular, realizable d e, e.g., enco ng the intended color appearance of an imag as it is to be printed to a particular printer

The idea of image state is intended to be useful in thinking about two concerns:

1. "What processing has been applied to this image?"
2. "How should I sequence my workflow to maximize color fidelity?"

(i.e., minimize the need to estimate colors)?

Definitions

- ‘Scene-Referred image data’ (SR)
  - Image data that unambiguously encodes the spectral reflectances of the scene (including scene-capture tristimulus encodings)
  - A scene-referred image would be encoded using a very large gamut, high dynamic range color encoding specification
- ‘Original-Referred image data’ (OR)
  - Image data that unambiguously encodes a captured computer-generated or hardcopy original
- 'Reference-Output-Referred image data' (ROR)
  - Output-referred image data that is color-rendered to a standardized output (i.e., an output that is defined through an ideal specification - a precise, arbitrary, output definition that may or may not be realizable)
- 'Actual-Output-Referred image data' (AOR)
  - Output-referred image data that is color-rendered to a specific, particular, realizable device, e.g., encoding the intended color appearance of an image as it is to be printed to a particular printer

Definitions

- The wide range of particular scene-referred instances, original-referred instances, reference-output-referred instances, and actual-output-referred instances are coalesced into these four meta-image-states, allowing the establishment of an overarching set of "workflow rules" governing the relationships between these image states:
  - Capture occurs into either the scene-referred state or the original-referred image state - i.e., a capture-referred state
  - Image data must be “color-rendered" to an actual-output-referred color encoding specification before it can be visualized through any output mechanism
  - A reference-output-referred image can be used as a standardized exchange of expected or preferred output color appearance, but may or may not be directly physically realizable
  - Device dependent color encodings that are not associated with any ICC profile or means of converting to CIE colorimetry (thereby achieving device independence) cannot be color managed

Definitions

- Workflow permutations
  - RGB workflow
    - RGB encoding is retained and exchanged
    - RGB can be ‘visualization constrained’ output-referred (e.g., sRGB) or capture-referred (calibrated digital camera RGB, calibrated scanner RGB)
  - CMYK workflow
    - CMYK ‘visualization constrained’ encoding is retained and exchanged
    - CMYK can be actual-output-referred
    - CMYK can be reference-output-referred
  - Re-targeting
    - Maintaining image colorimetry while changing device code values to customize to a particular device of the same or larger gamut
      - CMYK black channel preservation may or may not be included
    - Proofing a final visualization to an intermediate device can be successful to the degree that the proofing device gamut is larger or equal
  - Re-purposing
    - Re-color-rendering data that has been color-rendered for a particular output gamut to a different output gamut

Definitions

- Four fundamental image processing operations
  - Correction operations:
    - ‘Corrections’ are operations that are required based on device limitations or anomalies
    - 'Corrections' can be capture side image specific adjustments that prepare an image so that it can then be processed through gamut mapping operations, appearance operations, and/or preference operations in different ways for different output options
    - Capture correction operations can be image and capture method specific and should precede color-rendering operations
    - Correction operations can also occur at the final stage of output, within the output device (e.g., output device calibration)
    - Output correction operations are device specific, and are the responsibility of the output device

Definitions

- Four fundamental image processing operations
  - Appearance operations:
    - Appearance operations are input to output environment specific operations
    - Examples are
      - Lightening or dynamic range compression to compensate for illumination level and surround differences
      - Unsharp masking to maintain detail contrast
    - Depending on the particular situation, a preference or gamut mapping algorithm might operate prior to or following an appearance operation

Definitions

- Four fundamental image processing operations
  - Preference operations:
    - Preference operations are image specific and may be output gamut constrained
    - Preference issues deal with intentional alterations of appearance to increase the aesthetic value of an image
    - The preference may pertain to a particular visualization
      - Applied in an output-referred image state
    - The preference may pertain to all visualizations
      - Applied in a capture-referred image state
    - Examples
      - Sharpening and contrast boosting
      - Selecting a saturated green grass that you know is actually within a targeted output gamut ⇒ output constrained preference adjustment
      - Preference operations may be part of a color-rendering operation or may be distinct

Definitions

- Four fundamental image processing operations
  - Gamut mapping operations:
    - Gamut mapping operations are input to output specific
      - Mapping the co-ordinates of the elements of a source image to the co-ordinates of the corresponding elements of a reproduction
      - Compensating for differences in the source and output color gamut volume and shape
      - E.g., Perceptual PCS to visualization output gamut
    - Gamut mapping operations fit the results of appearance and preference operations into actual device/medium gamuts
      - Ideally providing best results when the operation is image specific
    - The term 'gamut mapping' includes the simple case of clipping at the gamut boundary as must occur when going from a larger gamut to a smaller gamut even in the media-relative colorimetric Rendering Intent case

The workflow primitives...

workflow building blocks and descriptions

Functional Workflow Primitives

- Capture
  - Device correction operations
  - Pro s control stabilit
  - Digitiz mat and e device d ar manufactu
- Co
  - App operati
  - Apply c cha
  - Apply 'referen encoding tran s
  - Apply visualization co n specific transforms
    - Scum dot elimination
    - Separation⇔gamut interactions

- Adjust image/object
  - Apply image preferences
  - Preference operations are arbitrar & use specific
- e object/entity
  - ication of objects
  - information
- ction operations
  - trolled
  - s control stability
  - s halftoning, trapping
  - Can ude black channel
    - UCR/GCR, black-only
    - Overprint/knockout
- Display the assembled entity

Identify the workflow primitives
that are the building blocks of every workflow.
Describe those workflow primitives and differentiate
them from each other.
Use these 'normalized' building blocks
to represent real world workflows.

Functional Workflow Primitives

- Capture
  - Device correction operations
  - Process control stability
  - Digitized format and data are device dependent and manufacturer controlled
- Color-Render (CMM)
  - Appearance and gamut mapping operations - input to output
  - Apply capture specific characterization transform
  - Apply ‘reference’ color space encoding transforms
  - Apply visualization condition specific transforms
    - Scum dot elimination
    - Separation⇔gamut interactions
- A
  - operations are arbitrary & use specific
- Assemble object/entity
  - ts
  - mation
- Visualize
  - Device correction operations
  - Manufacturer controlled
  - Process control stability
  - Includes halftoning, trapping
  - Can include black channel
    - UCR/GCR, black-only
    - Overprint/knockout
  - Display the assembled entity

What is that proprietary function that handles digitization?

What is the “primitive” functionality of a CMM?

Functional Workflow Primitives

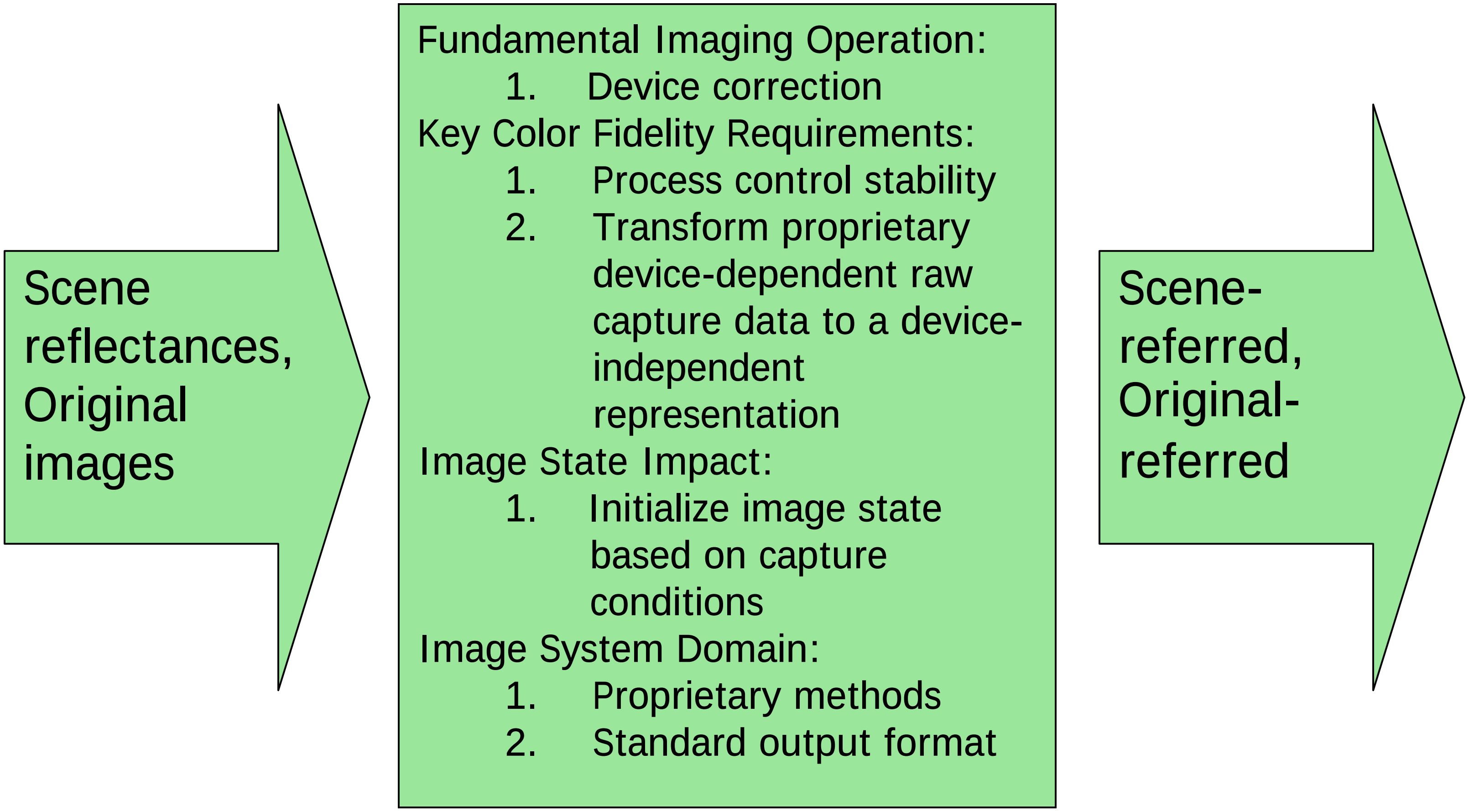
- Capture
  - Devic
  - Pr
  - Dig device dep m
- Co
  - App encoding trans
  - Apply visualiz specific transf
    - Scum dot el
    - Separation⇔gam ctions
- Adjust image/object
  - Apply image preferences
  - Preference operations are arbitrary & use specific
- Assemble object/entity
  - Combination of objects
  - Control of job information
- Visualize
  - Device correction operations
  - Manufacturer controlled
  - Process control stability
  - Includes halftoning, trapping
  - Can include black channel
    - UCR/GCR, black-only
    - Overprint/knockout
  - Display the assembled entity

How do we factor in to the workflow the image edits that people want to do to improve their images?

In many workflows, probably all workflows in the commercial world, we need to combine images, text, and vector… …and we need to keep track of all of the data and metadata in a “job”

What is the proprietary function that handles display?

The Capture Workflow Primitive



Scene reflectances, Original images

Fundamental Imaging Operation:

1. Device correction

Key Color Fidelity Requirements:

1. Process control stability
2. Transform proprietary device-dependent raw capture data to a device-independent representation

Image State Impact:

1. Initialize image state based on capture conditions

Image System Domain:

1. Proprietary methods
2. Standard output format

Scene-referred, Original-referred

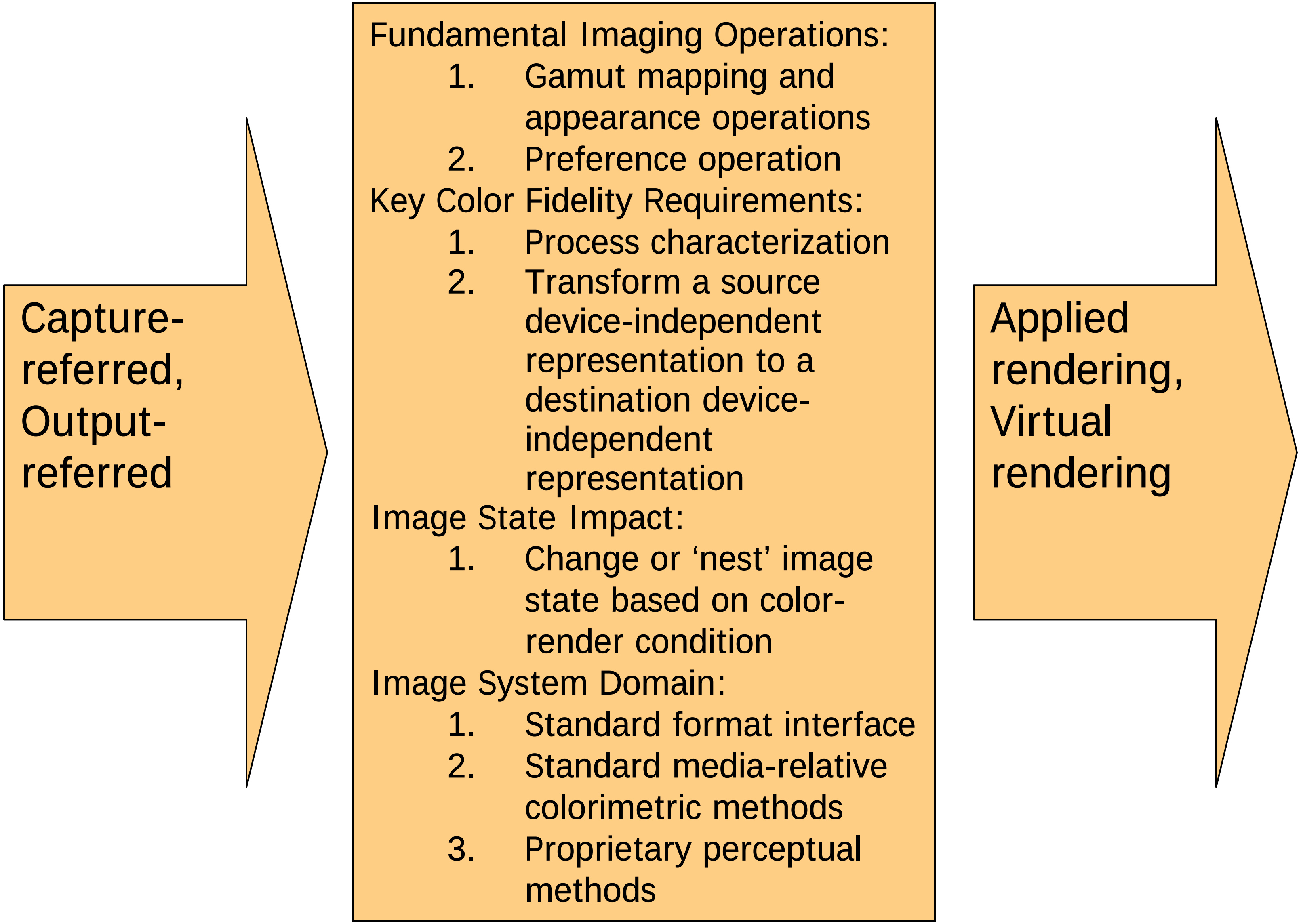
The Capture Workflow Primitive

- Capture Scene
  - Image state is initialized to scene-referred
  - Capture scene-referred images from a digital camera or from a scan of a negative
  - Process to correct for capture device, e.g., gray balance and intensity adjustment
  - Data is not color-rendered to any visualization, i.e., an ICC profile is associated but not applied
  - Scene capture refers to capture of the spectral radiances of a view of the natural world and may also include capture of a computer simulation of such spectral radiances
  - The Capture Scene primitive produces scene-referred images - each with an associated input profile - characterizing the capture condition (negative scanner, digital camera)

The Capture Workflow Primitive

- Capture Original
  - Image state is initialized to original-referred
  - Capture reflection or transparency color-rendered images, scan from reflection hardcopy (e.g., artwork), or scan from positive transparency; or capture color-rendered computer generated image
  - Process to correct for capture device, e.g., gray balance and intensity
  - The original-referred image data contains color-rendering to the output gamut of the process that created the original hardcopy
  - This case includes color-rendered computer graphics images: image data created through computer graphics application that is rendered to an image look and is original-referred to the creation station
  - Computer generated color-rendered images may be rendered to the gamut of the creation display, or rendered to a print softcopy
  - The Capture Original primitive produces original-referred images - each with an associated input profile - characterizing the capture condition (e.g., reflection scanner, positive transparency scanner, computer graphics workstation monitor) - the profiles are not applied

The Color-Render (CMM) Workflow Primitive



Capture-referred, Output-referred

Fundamental Imaging Operations:

1. Gamut mapping and appearance operations
2. Preference operation

Key Color Fidelity Requirements:

1. Process characterization
2. Transform a source device-independent representation to a destination device-independent representation

Image State Impact:

1. Change or ‘nest’ image state based on color-render condition

Image System Domain:

1. Standard format interface
2. Standard media-relative colorimetric methods
3. Proprietary perceptual methods

Applied rendering, Virtual rendering

The Color-Render (CMM) Workflow Primitive

- Color-Render CHANGES IMAGE STATE
- Color-Render includes profile based gamut mapping and manual adjustments to correct gamut mapping
- Color-Render includes gamut to gamut transform, e.g., CMYK to CMYK, sRGB to monitor RGB transform, within the same meta-image-state
- Color-Render includes appearance (viewing environment) adaptation and preferential aspects of the perceptual intent
- Color-Render may occur ONE or N TIMES
  - Following Capture
  - Before Adjust Image/Object
  - Following Adjust Image/Object
  - As a substep of Assemble Object/Entity
  - After Assemble Object/Entity
  - As a substep of Visualization
  - Using Visualization (manual color-rendering)

The Color-Render (CMM) Workflow Primitive

- Gamut mapping and appearance mapping are carried out in combination between a source profile, a destination profile, and a color management module (CMM)
- Both gamut mapping and appearance adaptation are built into the perceptual transforms of source and destination profiles
- Chromatic adaptation is built into media-relative colorimetric intent transforms
- A CMM handles clipping to the destination gamut boundary as required for the media-relative colorimetric intent
- A CMM should handle certain gamut mapping cases
  - E.g., for perceptual, media-relative colorimetric, and saturation intents, white should NEVER be interpolated
    - 255r,255g,255b should always convert to non-image/non-ink values (255,255,255 for RGB and 0,0,0,0 for CMYK)

The Color-Render (CMM) Workflow Primitive

- ‘Virtual color-rendering’ can be used to assign a visualization for later use

⇒ Producing images with an associated (but not applied) Visualization Condition (ICC Profile), e.g., “Virtual CMYK”

Examples

- SR Data + Input Profile ⇒ SR Data + Input Profile + Output Profile(s)**
- OR Data + Input Profile ⇒ OR Data + Input Profile + Output Profile(s)**
- ROR Data + Source Profile ⇒ ROR Data + Source Profile + Output Profile(s)**
- AOR Data + Source Profile ⇒ AOR Data + Source Profile + Output Profile(s)**

**optional additional Output Profile to handle proofing, image setter, etc. The 2nd or additional output profile would be chained following the input and primary output profiles when the image data is processed for the proofer, imagesetter, etc.

- ‘Applied color-rendering’ can be used to process image data through a source profile and one or more destination profiles

⇒ Producing images realized in a Visualization Condition (output-referred state)

Examples

- SR Data + Input Profile ⇒ AOR or ROR Data + Source Profile
- OR Data + Input Profile ⇒ ROR or AOR Data + Source Profile
- ROR or AOR Data + Source Profile ⇒ a different ROR or AOR Data + Source Profile

The Color-Render (CMM) Workflow Primitive

- ‘Virtual color-rendering’ can be used to sign a visualization for la r use
  - ⇒ Produ ges with an d (bu ed) Visuali Condition (ICC Pro Virtu

  Examples
  - SR Data + Inp
  -
  - AOR s)**

  **op

  The the

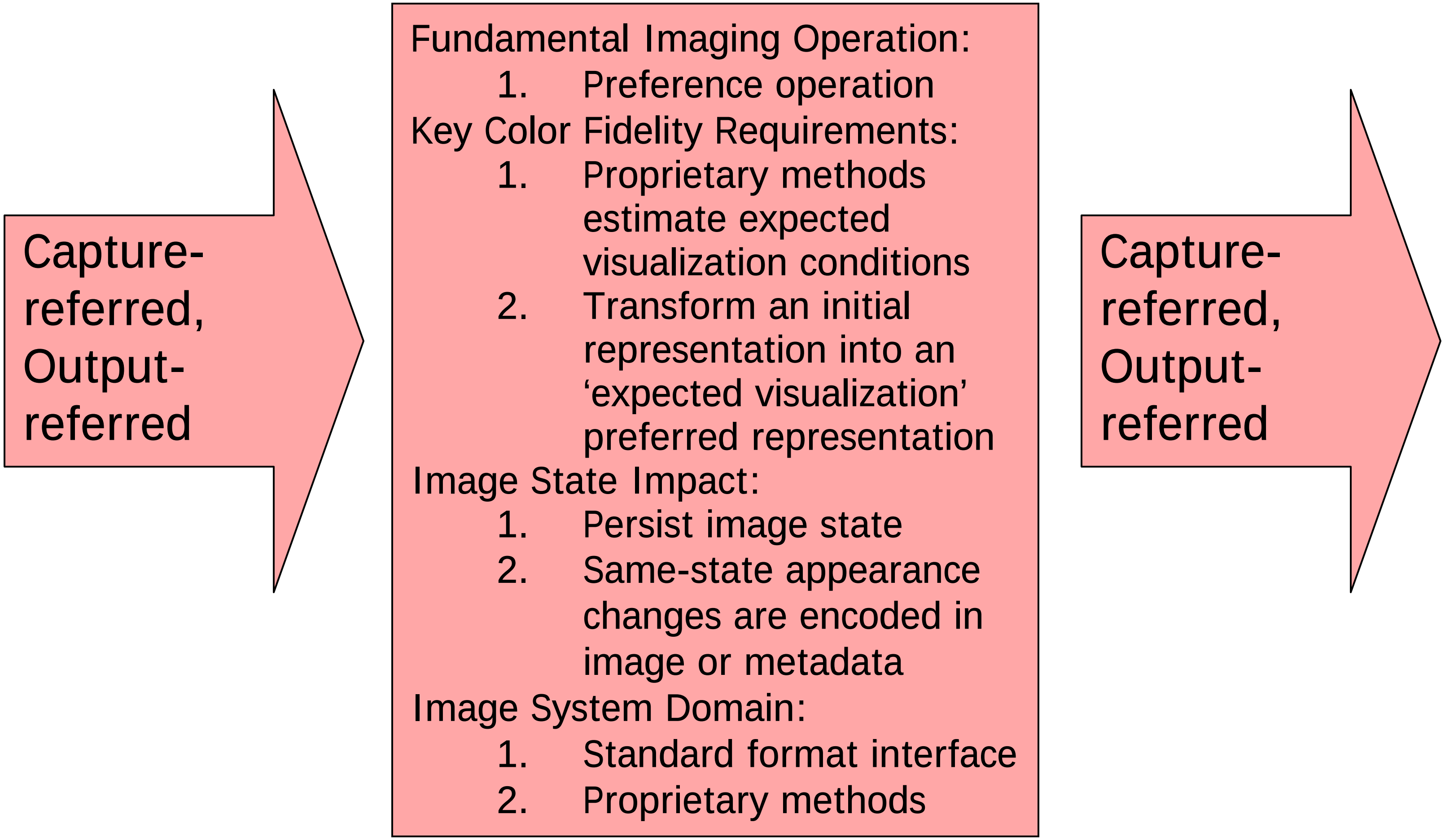
  , image.

Note that in a Version 4 Input profile –
the media-relative colorimetric rendering intent
portrays a capture-referred image into the
Colorimetric PCS – in this case a Color-Render
transform is applied (chromatic adaptation, white
point mapping)- but the image does not become
"output-referred"
...so in this case managing the display image state is
up to the destination profile.

- ‘Applied color-r e proc age data through a sou profil one e destina n profiles
  - ⇒ Producing images realized sualization ition (output-referred state)

  Examples
  - SR Data + Input Profile ⇒ AOR ROR Data + Source Profile
  - OR Data + Input Profile ⇒ ROR r AOR Data + Source Profile
  - ROR or AOR Data + Source Profile ⇒ a different ROR or AOR Data + Source Profile

The Adjust Image/Object Workflow Primitive



Capture-referred, Output-referred

Fundamental Imaging Operation:

1. Preference operation

Key Color Fidelity Requirements:

1. Proprietary methods estimate expected visualization conditions
2. Transform an initial representation into an ‘expected visualization’ preferred representation

Image State Impact:

1. Persist image state
2. Same-state appearance changes are encoded in image or metadata

Image System Domain:

1. Standard format interface
2. Proprietary methods

Capture-referred, Output-referred

The Adjust Image/Object Workflow Primitive

- Adjust deals with preference and aesthetic changes, not changes required due to constraints imposed by any particular visualization mechanism
  - Adjust does NOT change image state
  - Adjust DOES change encoded values
  - Adjust does not change image or assembled object file formats
- Adjust includes local and/or global preference operations
- Adjust may occur ONE or N TIMES
  - Following Capture
  - Before Color-Render
  - Following Color-Render
  - As a substep of Assemble Object/Entity
  - As a substep of Visualization
  - Using Visualization
- Global preference changes may be accomplished by adjusting a profile

The Adjust Image/Object Workflow Primitive

- Directly Preference adjust image data
  - Any associated profile(s) are carried along but not changed
  - This method will support local changes as well as global changes in the image data
  - Optionally, adjust image data while viewing through the associated input/source profile, or the concatenated input/source and destination profiles
  - Adjust image data while viewing through the available profile(s) to get the desired real or virtual output appearance and to ensure that the preference adjustments are compatible with profile-based color-renderings

The Adjust Image/Object Workflow Primitive

- Preference adjust the perceptual intent of the input/source profile associated with an image
  - While viewing the (capture-referred or reference-output-referred) image through the input/source profile and, if a destination profile is associated, while also viewing it through the destination profile
  - The edits are applied to the perceptual intent transform of the input/source profile and the viewing is through the perceptual intent transform(s) of the associated profile(s)
  - This method allows only global changes using the current ICC paradigm
- This path requires an image container or file format that can support embedding or associating at least one profile with an image, so that the input/source profile containing the edits can be linked with the image
- If an output profile is also associated, then the image container must allow two linked profiles

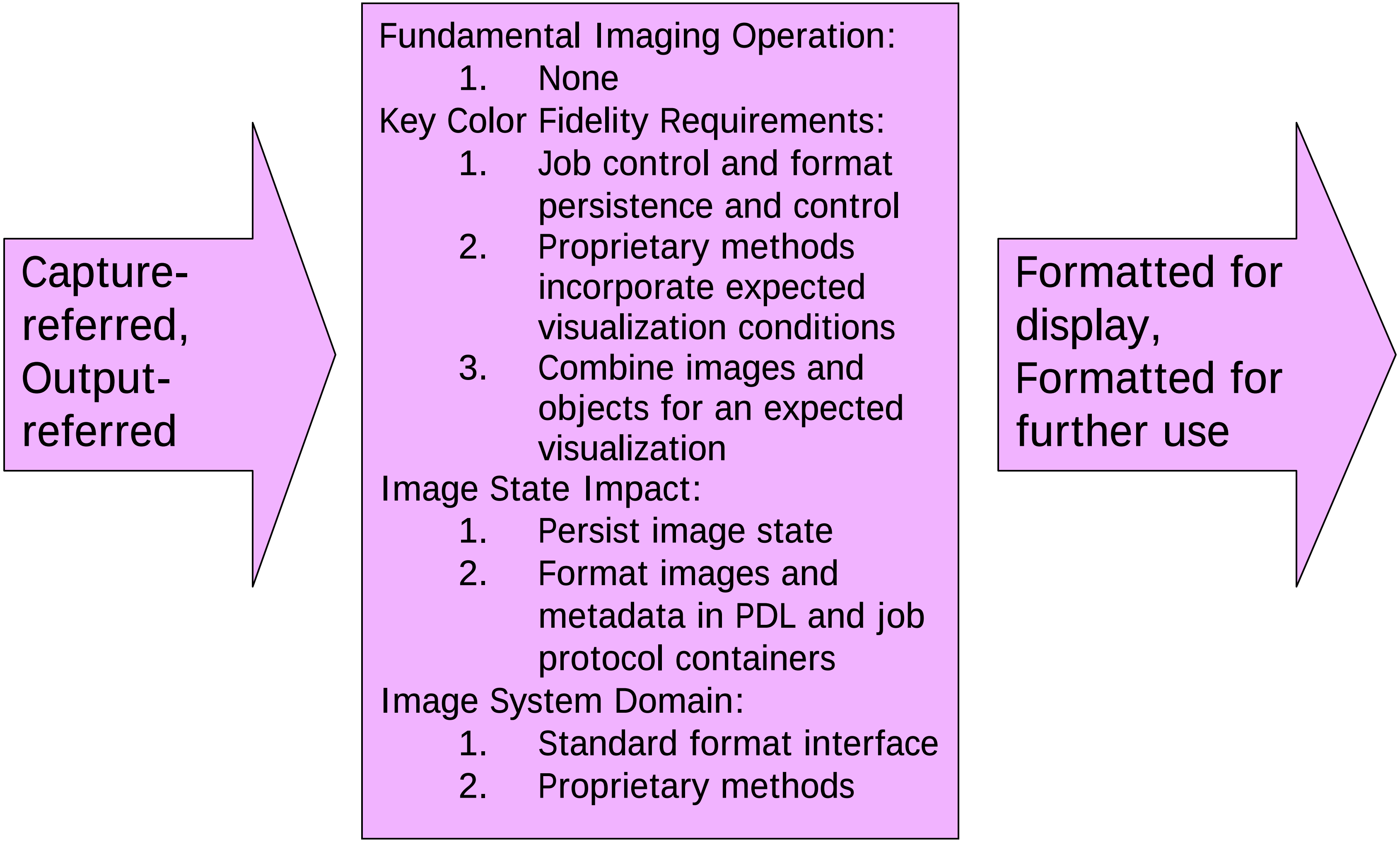
The Adjust Image/Object Workflow Primitive

- Preference adjust an abstract profile associated with an image
  - While viewing the (capture-referred or reference-output-referred) image through the input (or) source profile and, if a destination profile is associated, while also viewing it through the destination profile
  - One advantage in using an abstract profile to capture edits, compared to using either a source/input or destination profile, is that then image dependence can be constrained to the abstract profile, rather than being merged with the device-centric source/input or destination profiles
  - This method allows only global changes using the current ICC paradigm
  - **This path requires an image container or file format that can support embedding or associating more than one profile with an image, so that at least 2 profiles (the input/source profile and the abstract profile) can be linked with the image**
  - **If an output profile is also associated, then the image container must allow three linked profiles**

The Adjust Image/Object Workflow Primitive

- Preference adjust the perceptual intent transform of the output profile associated with an image (before it is applied)
  - While viewing the (capture-referred or reference-output-referred) image through the input/source profile and output profile
  - The edits are applied to the output profile perceptual intent transform and the viewing is through the perceptual intent transform(s) of the associated profiles
  - This method allows only global changes using the current ICC paradigm
- This path requires an image container or file format that can support embedding or associating at least two profiles with an image, so that the input/source profile, and the output profile with the edits, can be linked with the image
- This method can be used to accomplish visualization-specific preference adjustments

The Assemble Object/Entity Workflow Primitive



Capture-referred, Output-referred

Fundamental Imaging Operation:

1. None

Key Color Fidelity Requirements:

1. Job control and format persistence and control
2. Proprietary methods incorporate expected visualization conditions
3. Combine images and objects for an expected visualization

Image State Impact:

1. Persist image state
2. Format images and metadata in PDL and job protocol containers

Image System Domain:

1. Standard format interface
2. Proprietary methods

Formatted for display, Formatted for further use

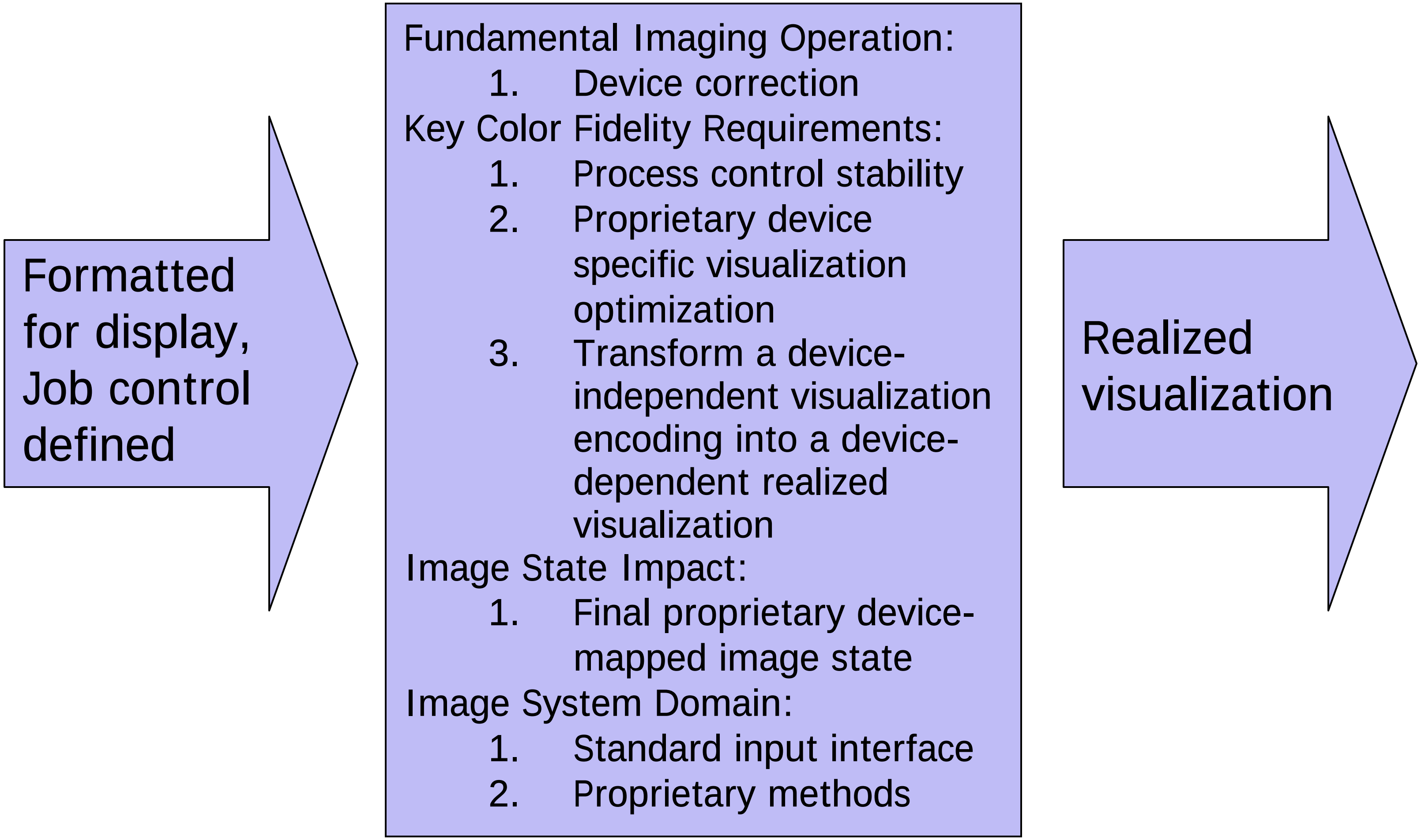
The Assemble Object/Entity Workflow Primitive

- Assemble Object/Entity deals with image and/or object formats; selection, format, and linkage of metadata and job information
  - Assemble Object/Entity does not change image state, or image encoding values
  - Assemble Object/Entity creates and changes object combinations using page description language (PDL) containers
  - Assemble Object/Entity embeds or links images into PDL containers
- Assemble may occur ONE or N TIMES
  - Following Capture
  - Before Adjust Image/Object
  - Following Adjust Image/Object
  - Before Color-Render
  - Following Color-Render
  - Using Visualization

The Assemble Object/Entity Workflow Primitive

- Assemble Object/Entity includes consideration of the color-rendering condition of an assembled entity
  - I.e., do the image states (color-render conditions) of an assembled entity and its linked components meet the submission requirements of the targeted visualization path?
  - Image or object components can be pre-color-rendered to match the submission requirements of a targeted visualization path
- Assemble Object/Entity can produce combinations of
  - Job submission protocols, job tickets, PDL files, application files
    - Containing encapsulated, embedded, or referenced image and line art elements
      - Color-Rendered Images (AOR) + Source Profile(s)
      - Reference Color-Rendered Images (ROR) + Source Profile(s)
      - Capture-referred Images + Input Profiles
      - Color-Render Deferred Images + Input/Source Profile(s) + Output Profile(s)
    - ICC profiles can be linked to specific images or can be associated with an entire object or an entire entity

The Visualization Workflow Primitive



Formatted for display, Job control defined

Fundamental Imaging Operation:

1. Device correction

Key Color Fidelity Requirements:

1. Process control stability
2. Proprietary device specific visualization optimization
3. Transform a device-independent visualization encoding into a device-dependent realized visualization

Image State Impact:

1. Final proprietary device-mapped image state

Image System Domain:

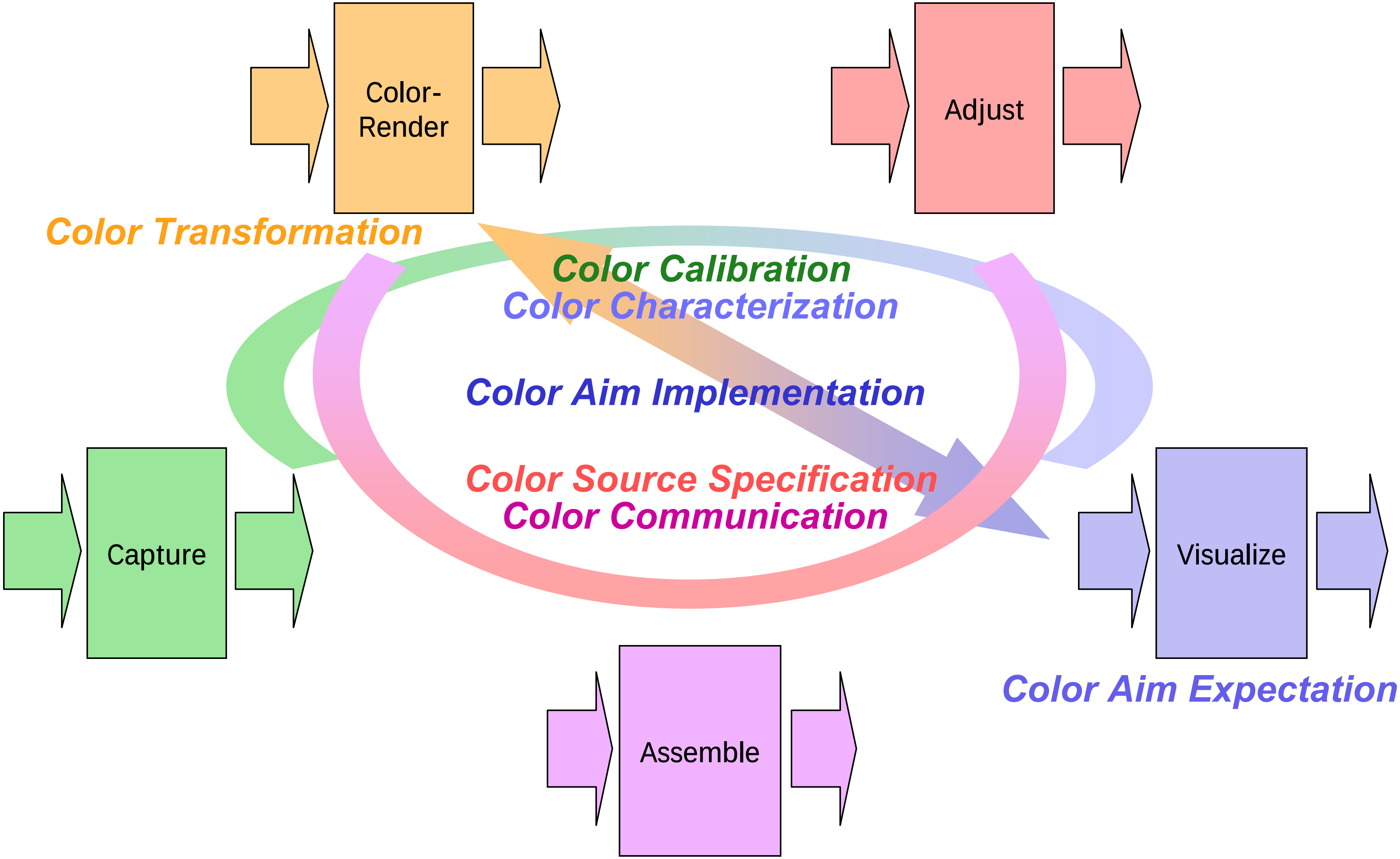
1. Standard input interface
2. Proprietary methods

Realized visualization

The Visualization Workflow Primitive

- Visualization performs a final visualization-condition-specific image state transition to create a realized visualization
  - Each visualization system imposes a set of ‘submission condition requirements’ on received data
  - When submission conditions are not met a job may fail or may produce unexpected results
- As an image, object, or entity is used
  - Visualizations can occur sequentially leading to a final visualization
  - Visualizations can occur in parallel, leading to multiple final visualizations
  - Intermediate visualizations can occur as required for
    - Adjust
    - Color-Render
    - Assemble
  - When the submission condition requirements of an intermediate visualization and a targeted final visualization are aligned - the job can be ‘proofed’

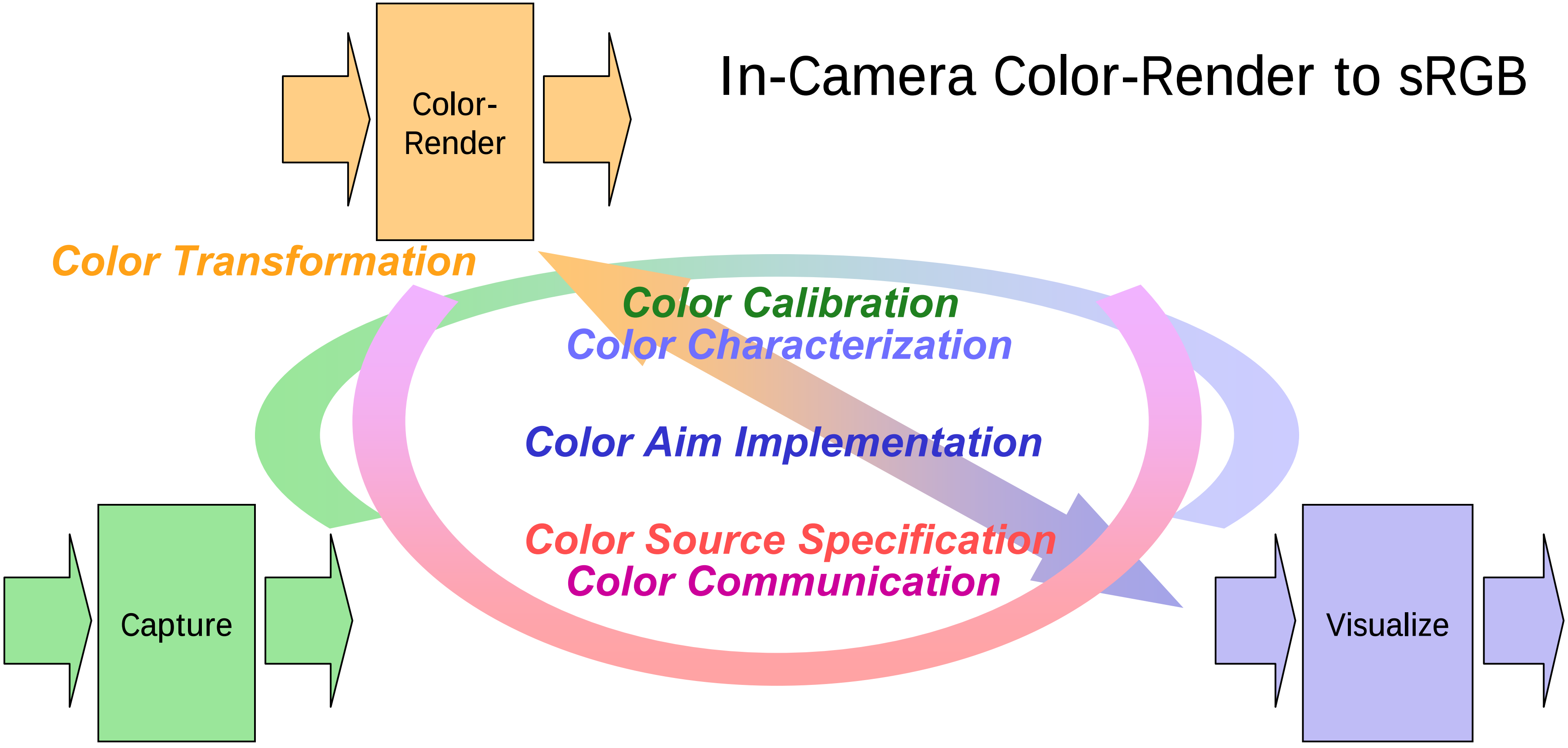
Workflow Functional Primitives Depend on a Color Control Architecture



The workflow primitives...

workflow examples and color management scenarios

A Minimal Workflow



Color-Render

In-Camera Color-Render to sRGB

Color Transformation

Color Calibration
Color Characterization

Color Aim Implementation

Color Source Specification
Color Communication

Capture

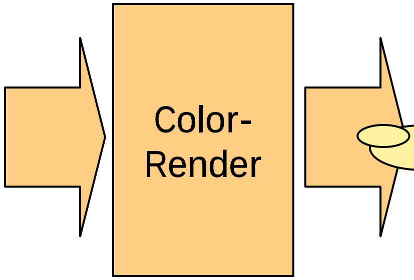
Visualize

Color Aim Expectation

Digital Camera Capture

Softcopy Image Display

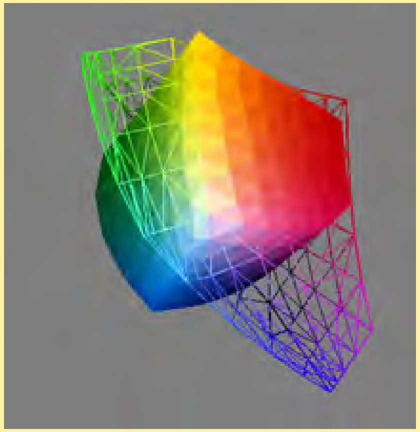
A Minimal Workflow



In-Camera Color-Render to sRGB

Color Transformation

Immediate color-render to a CRT-output-referred state sub-optimizes the image for print display



Keep in mind the gamut volume relationships among different potential visualizations when transforming an image

Wireframe shows sRGB, solid shows desktop color laser

When an image is color-rendered to an output-referred state in a capture device - reference to the scene or original is lost (e.g., sRGB becomes the source profile)

A Minimal Workflow

Color-
Rend

Color Tr

Ca

Dig

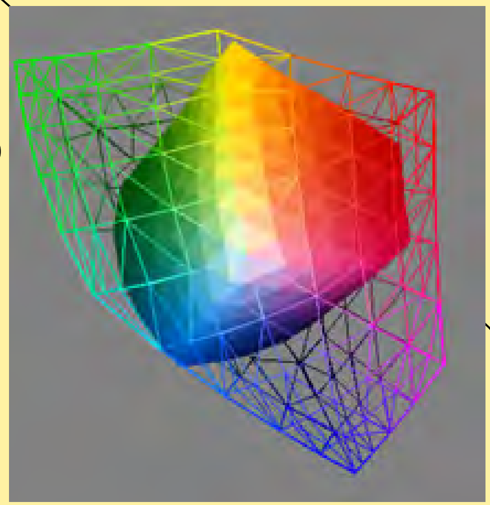
pture

In-Camera Color-Render to sRGB

Alternatives:
1. Color-Render to a large volume RGB working space (e.g., Adobe 98 RGB, ROMM RGB, ...)
2. Maintain the capture RGB (e.g., scanner RGB, camera RGB) and color-render as needed for actual visualizations

Both of these alternatives require the use of ICC compliant applications and formats

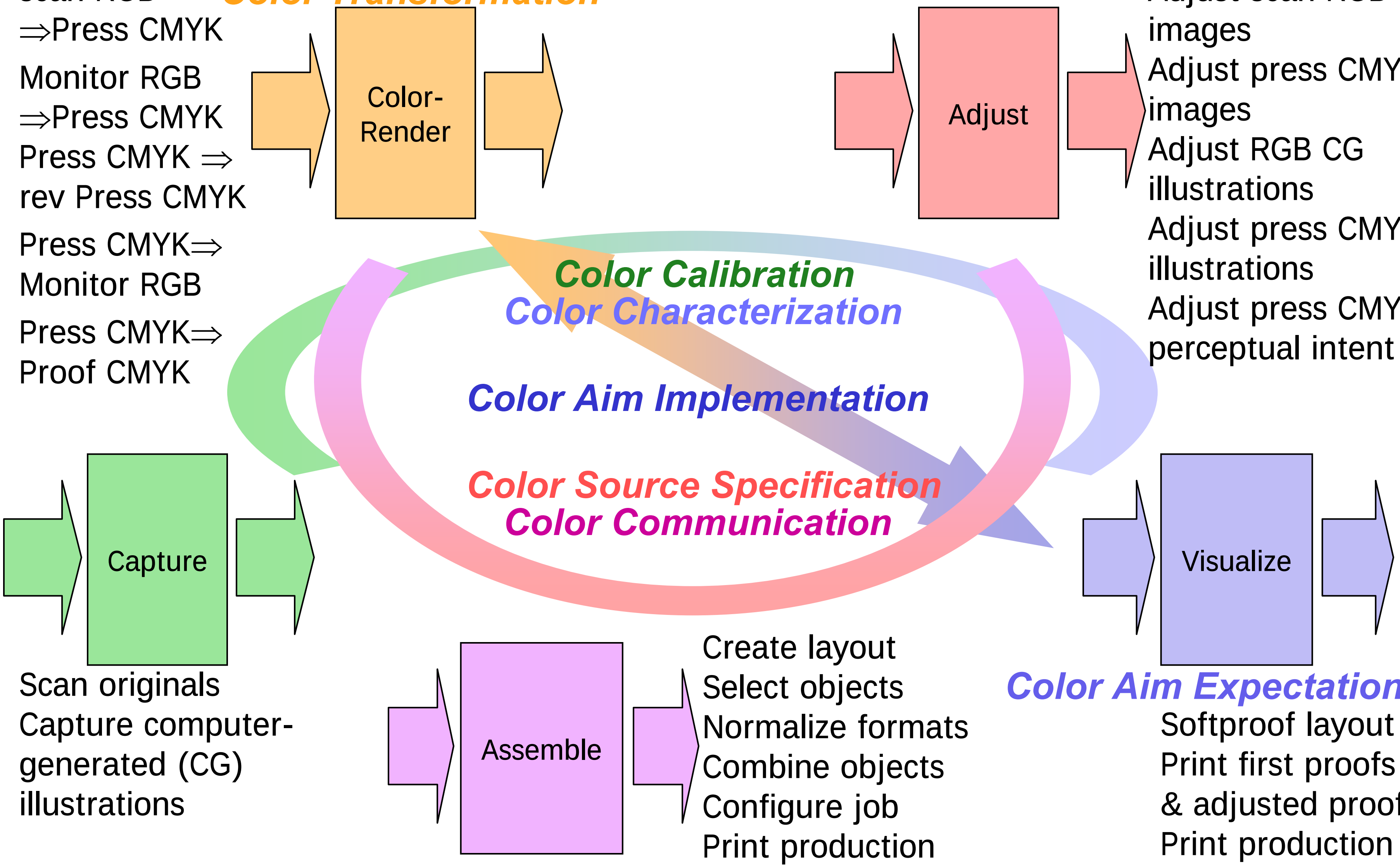
Adobe 98 RGB in relation to the same desktop laser



ation

isplay

A Commercial Print Workflow



Color Transformation

scan RGB
⇒Press CMYK

Monitor RGB
⇒Press CMYK

Press CMYK ⇒
rev Press CMYK

Press CMYK⇒
Monitor RGB

Press CMYK⇒
Proof CMYK

Color-Render

Adjust

Adjust scan RGB images
Adjust press CMYK images
Adjust RGB CG illustrations
Adjust press CMYK illustrations
Adjust press CMYK perceptual intent

Color Calibration
Color Characterization

Color Aim Implementation

Color Source Specification
Color Communication

Capture

Scan originals
Capture computer-generated (CG) illustrations

Assemble

Create layout
Select objects
Normalize formats
Combine objects
Configure job
Print production

Visualize

Color Aim Expectation

Softproof layout
Print first proofs
& adjusted proofs
Print production

A Commercial Print Workflow - Scenario One

scan RGB ⇒Press CMYK

Monitor RGB ⇒Press CMYK

Press CMYK ⇒ rev Press CMYK

Press CMYK⇒ Monitor RGB

Press CMYK⇒ Proof CMYK

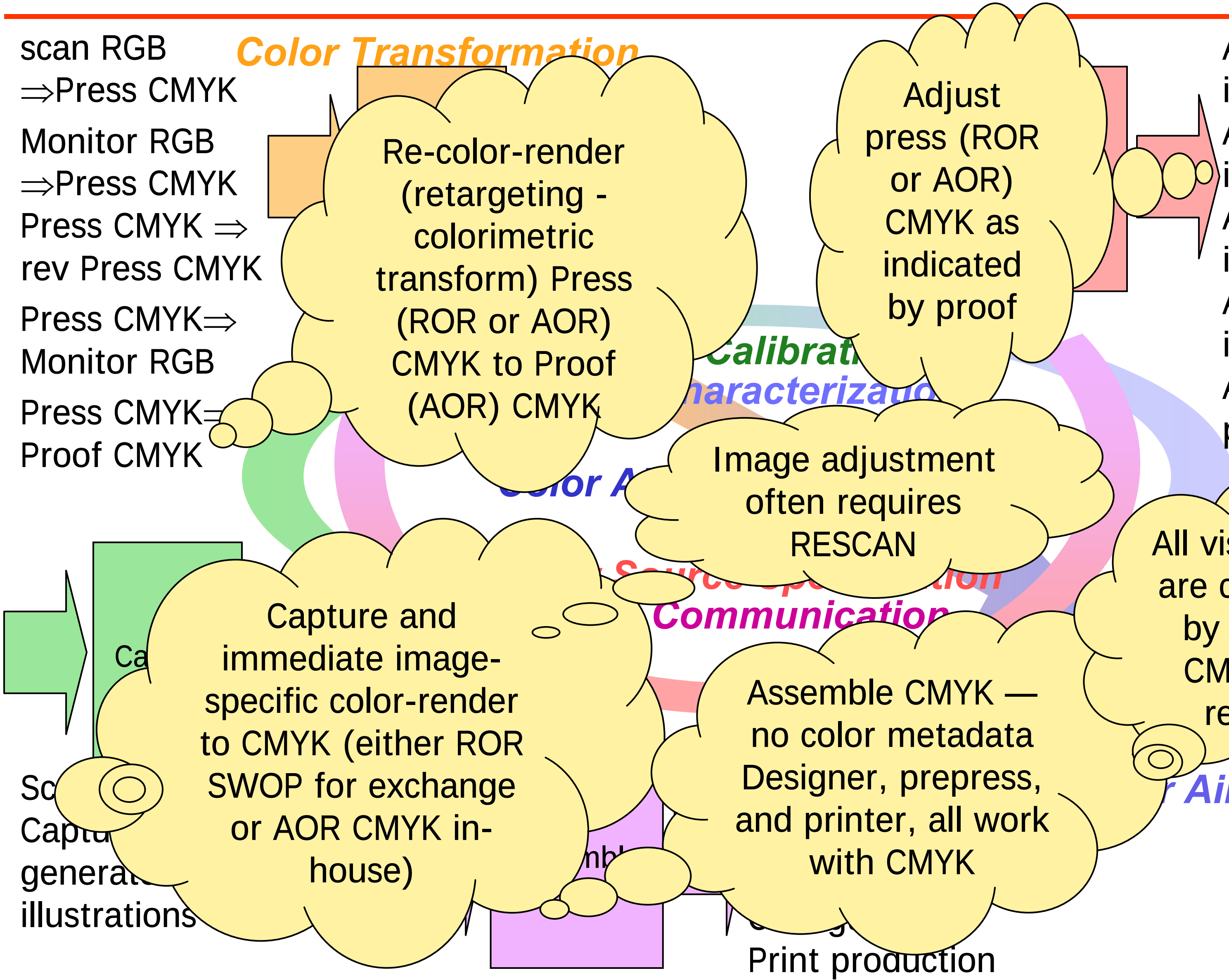
Adjust scan RGB images

Adjust press CMYK images

Adjust RGB CG illustrations

Adjust press CMYK illustrations

Adjust press CMYK perceptual intent



Re-color-render (retargeting - colorimetric transform) Press (ROR or AOR) CMYK to Proof (AOR) CMYK

Adjust press (ROR or AOR) CMYK as indicated by proof

Image adjustment often requires RESCAN

All visualizations are constrained by the initial CMYK color-rendering

Capture and immediate image-specific color-render to CMYK (either ROR SWOP for exchange or AOR CMYK in-house)

Assemble CMYK — no color metadata Designer, prepress, and printer, all work with CMYK

Sc Captu generat illustrations

Softproof layout

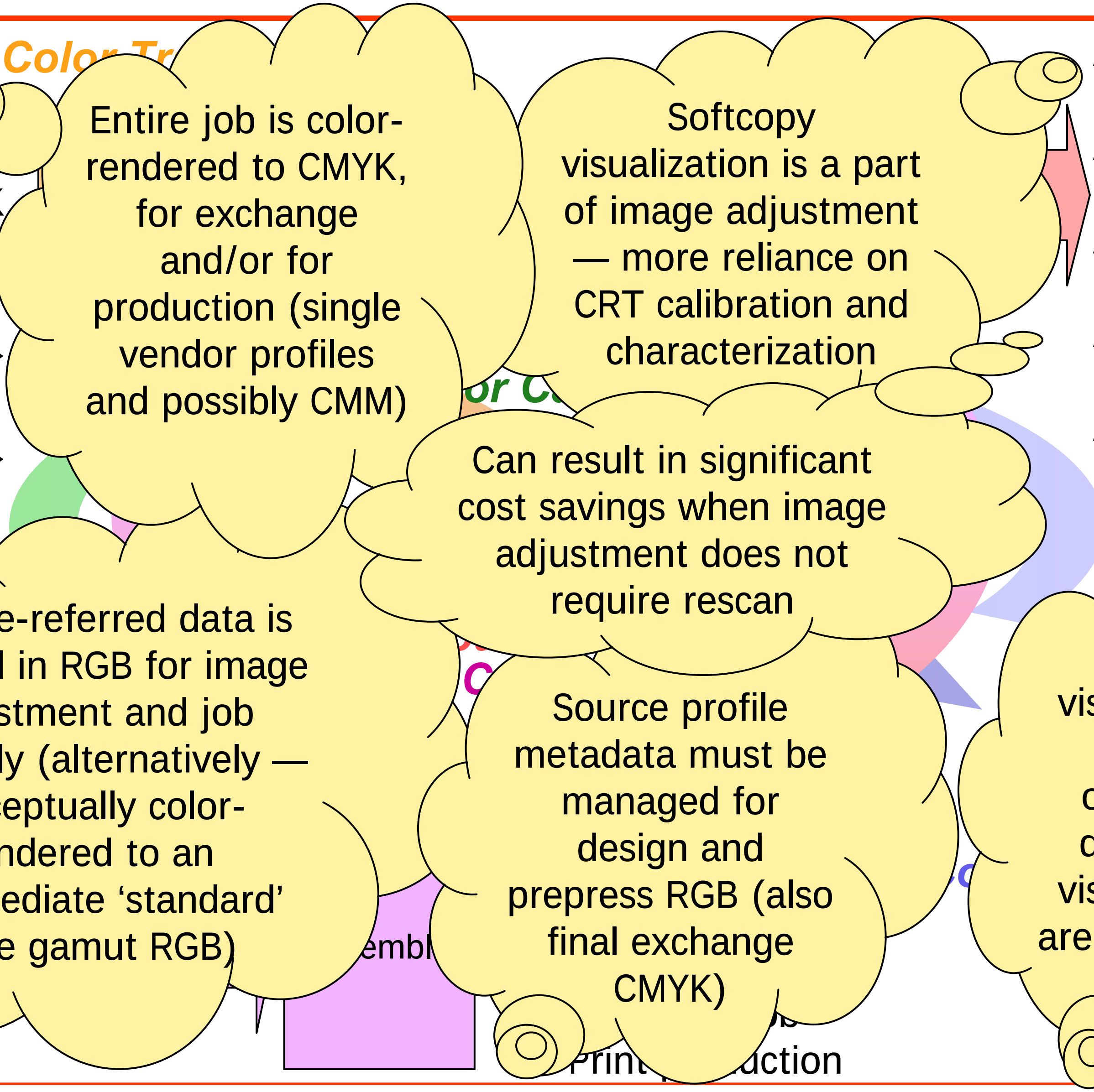
Print first proofs & adjusted proofs

Print production

A Commercial Print Workflow - Scenario Two

scan RGB
⇒Press CN
Monitor RGB
⇒Press CMYK
Press CMYK ⇒
rev Press CMY
Press CMYK⇒
Monitor RGB
Press CMYK⇒
Proof CMYK

gene
illust



Entire job is color-rendered to CMYK, for exchange and/or for production (single vendor profiles and possibly CMM)

Softcopy visualization is a part of image adjustment — more reliance on CRT calibration and characterization

Can result in significant cost savings when image adjustment does not require rescan

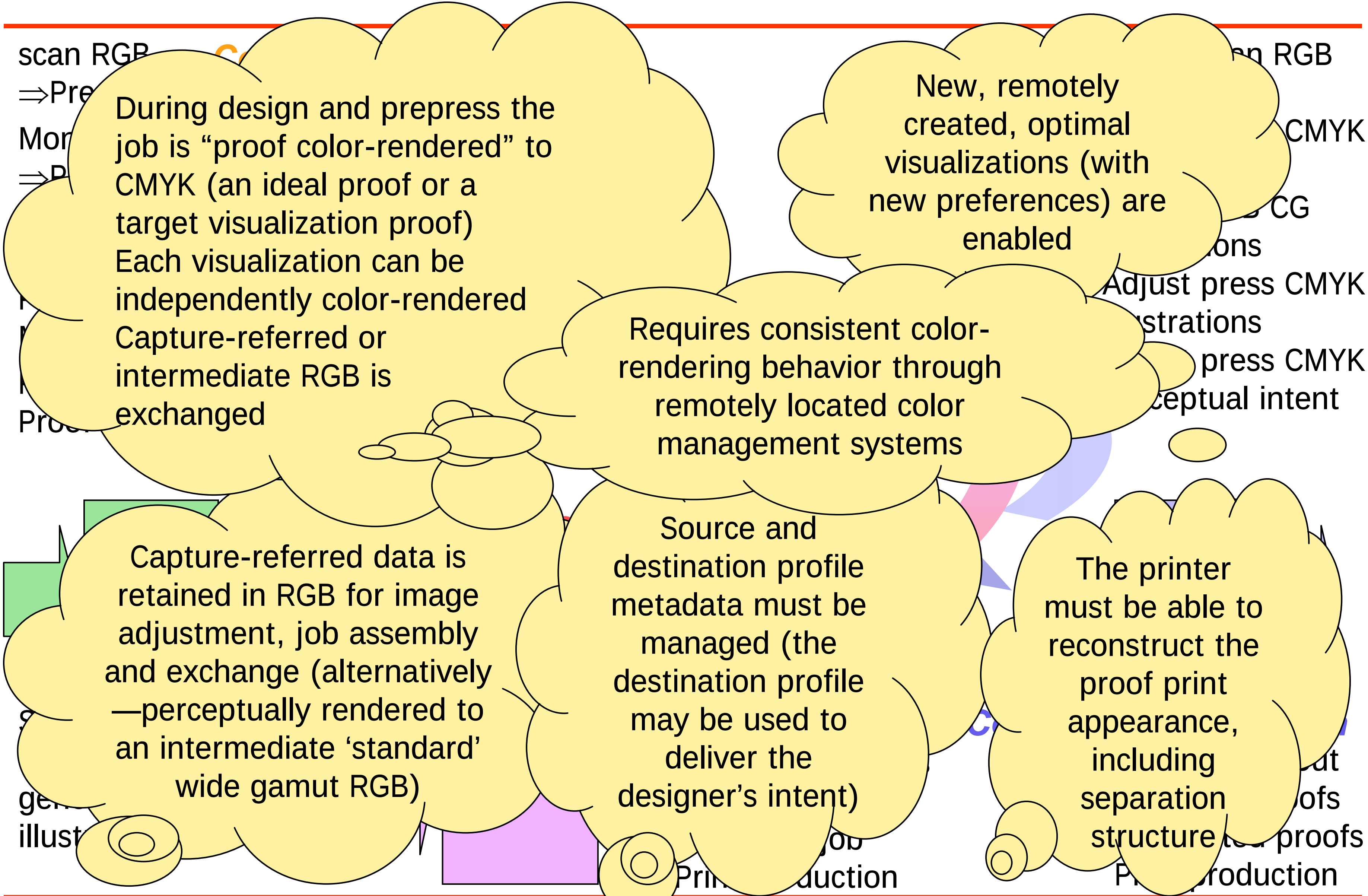
Capture-referred data is retained in RGB for image adjustment and job assembly (alternatively — perceptually color-rendered to an intermediate ‘standard’ wide gamut RGB)

Source profile metadata must be managed for design and prepress RGB (also final exchange CMYK)

Local visualizations can be optimized, distributed visualizations are constrained

Adjust scan RGB images
Adjust press CMYK images
Adjust RGB CG illustrations
Adjust press CMYK illustrations
Adjust press CMYK perceptual intent

A Commercial Print Workflow - Scenario Three



During design and prepress the job is “proof color-rendered” to CMYK (an ideal proof or a target visualization proof) Each visualization can be independently color-rendered Capture-referred or intermediate RGB is exchanged

New, remotely created, optimal visualizations (with new preferences) are enabled

Requires consistent color-rendering behavior through remotely located color management systems

Capture-referred data is retained in RGB for image adjustment, job assembly and exchange (alternatively—perceptually rendered to an intermediate ‘standard’ wide gamut RGB)

Source and destination profile metadata must be managed (the destination profile may be used to deliver the designer’s intent)

The printer must be able to reconstruct the proof print appearance, including separation structure

A Commercial Print Workflow - Re-targeting

scan RGB
⇒Press CMYK

Monitor RG
⇒Press C
Press C
rev Pre
Press C
M

Color Transform

st scan RGB
s
ss CMYK
MYK
YK

Re-targeting: After data is color-rendered to an ROR or AOR visualization condition, the DEV to PCS media-relative colorimetric transform of the source profile is sequenced with the PCS to DEV media-relative colorimetric transform of a “proofing” destination profile
⇒ The “proof” quality will be proportional to the ability of the proofing visualization condition to portray the full appearance of the production visualization condition

When an ROR or AOR visualized image is to be re-targeted to a further constrained visualization condition (and in-gamut color accuracy is not required) — then the DEV to PCS media-relative colorimetric transform of the source profile can be sequenced with the PCS to DEV perceptual transform of the destination profile ⇒ the color fidelity of the results will depend on the specific visualization conditions involved

Scan
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production

Expectation

Softproof layout
Print first proofs
& adjusted proofs
Print production

A Commercial Print Workflow - Re-purposing

scan RGB
⇒Press CMYK

Monitor RGB
⇒Press C
Press C
rev Pres

Press C
M

Color Transformati

st scan RGB

ress CMYK

YK

K

Two methods of re-purposing are available:

Capture-referred (or intermediate wide gamut RGB) data can be retained
⇒this enables maximum flexibility and fidelity to the capture for each visualization color-rendering

ROR or AOR data can be retained - with a fully populated Version 4 source profile
⇒re-purposing is accomplished by sequencing the DEV to PCS perceptual transform of the source profile (inverting the initial perceptual color-rendering), with the PCS to DEV perceptual transform of the new destination profile

In this scenario, the dependent visualizations will be constrained by gamut boundary losses experienced through the gamut mapping implemented in the PCS to DEV perceptual transform of the initial visualization

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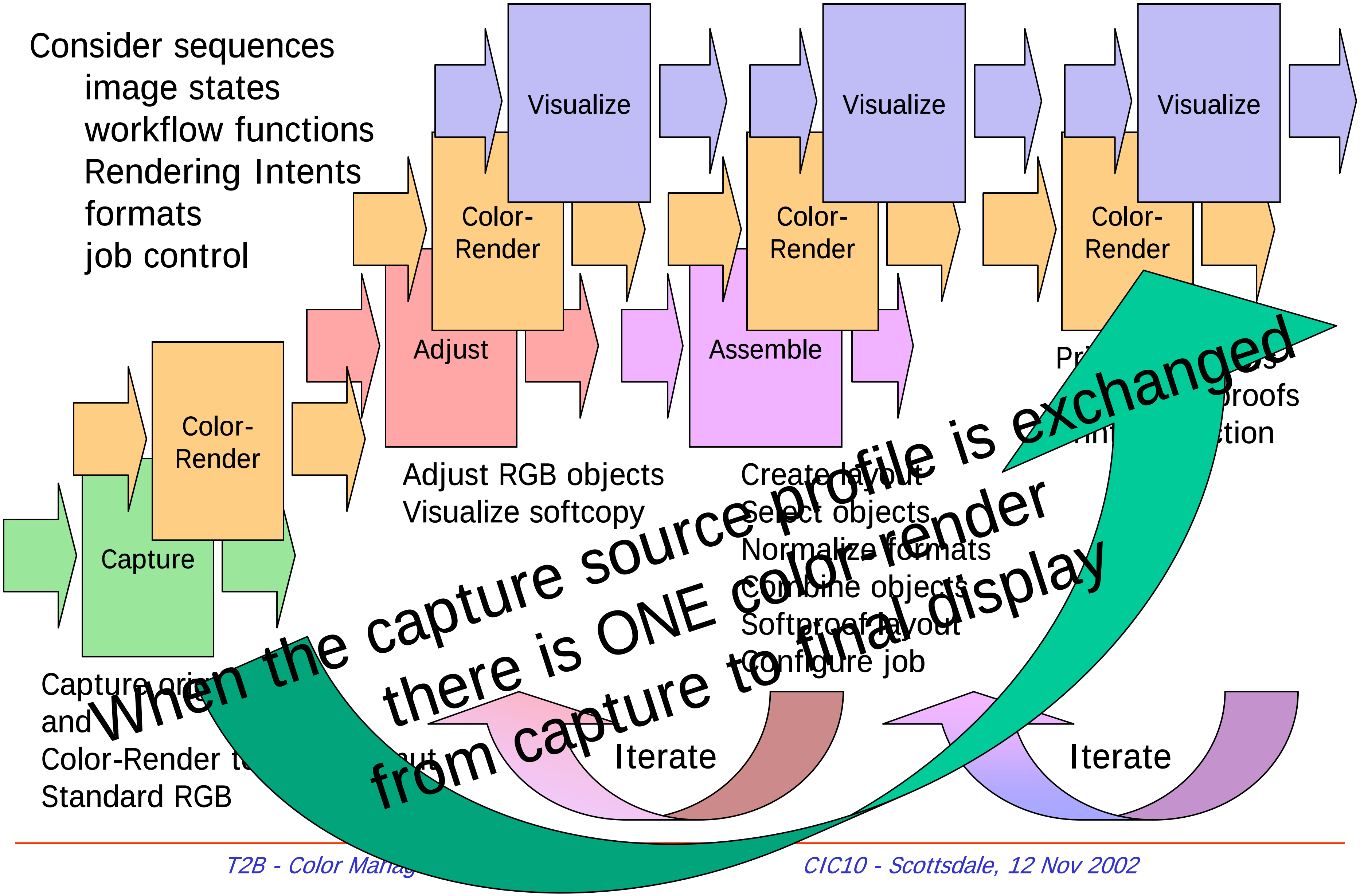
job
production

Expectation
Softproof layout
Print first proofs
& adjusted proofs
Print production

Scenario Three - Sequential View

Consider sequences
- image states
- workflow functions
- Rendering Intents
- formats
- job control



Capture ori
and
Color-Render t
Standard RGB

Adjust RGB objects
Visualize softcopy

Create layout
Select objects
Normalize formats
Combine objects
Softproof layout
Configure job

Pr
proofs
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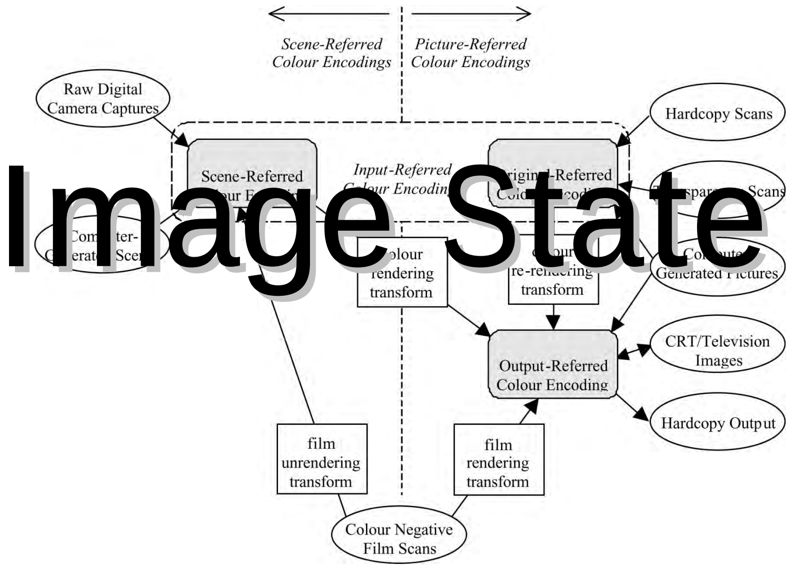
When the capture source profile is exchanged
there is ONE color-render
from capture to final display

Four Meta-Systems Deliver Color Fidelity

Image State


Scene-Referred Colour Encodings
Picture-Referred Colour Encodings
Raw Digital Camera Captures
Computer-Generated Scenes
Scene-Referred Colour Encoding
Input-Referred Colour Encoding
Original-Referred Colour Encoding
Hardcopy Scans
Transparency Scans
Computer-Generated Pictures
colour rendering transform
colour re-rendering transform
Output-Referred Colour Encoding
CRT/Television Images
Hardcopy Output
film unrendering transform
film rendering transform
Colour Negative Film Scans

Workflow Primitives

Color Control Architecture

Color Transformation

Color Calibration

Color Characterization

Color Aim Implementation

Color Source Specification

Color Communication

Color Aim Expectation

Formats & Protocols

NEWS IN BRIEF

Former president takes Continental to show safety

Surplus may fund retreat center

UPD enforces

Honoring Sully

PUBLIC EYE

SPORTS

OPINION

Workflow Considerations

scan RGB
⇒Press CMYK
Monitor RGB
⇒Press C
Press C
rev Pres
Press C
M

Color Transformat

ust scan RGB
s
press CMYK
G
YK
YK

- Determine the limiting factors in your color print workflow
- Determine the capabilities of the data exchange methods available to you (TIFF, EPS, PostScript, PDF, PDF/X, job folder, JDF, etc...)
- Align workflow primitives and color controls with visualization expectations
  - Establish your color control architecture
  - Control image state and Rendering Intent through each transformation
  - Design the workflow to place control where it needs to be so that color fidelity expectations are met
- Understand device limitations (ask for what you can get)
- Understand the long term use potential for each image or assembled object when selecting the exchange / archive image state and format

Scan
Cap
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production

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