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Digital Imaging and Communications in Medicine (DICOM)

Supplement 100: Color Softcopy Presentation State Storage SOP Classes

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DICOM Standards Committee, Working Group 11 Display

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Foreword

This Supplement defines Color, Pseudo-Color and Blending Softcopy Presentation State Storage SOP Classes and introduces device-independence and consistency of color through the use of ICC Profiles.

This Supplement has been prepared by the DICOM Working Group 11 (Display).

5 This document is a Supplement to the DICOM Standard. It is an extension to the following parts of the published DICOM Standard:

- Part 3 Information Object Definitions
- Part 4 Service Class Specifications
- Part 6 Data Dictionary

10 Scope and Field of Application

Color images are defined in DICOM but there is no existing mechanism to specify a presentation state that is applicable to such images. The Grayscale Softcopy Presentation State (GSPS) cannot be used for images that contain color information, since the transformation pipeline of the GSPS is defined only for grayscale values and output is defined only in terms of the Grayscale Standard Display Function (GSDF).

15 This supplement describes a color pipeline and a device-independent color space, and re-uses the remainder of the pixel transformation pipeline that describes displayed area selection, spatial transformations and annotation with vector graphics and plain text.

A Color Softcopy Presentation State (CSPS) Storage SOP Class is defined that implements this pipeline and device-independent color space. It may be applied to true color images (such as those with RGB and YBR Photometric Interpretations) and pseudo-color images (such as those with PALETTE COLOR Photometric Interpretation). No application to images with retired Photometric Interpretations (such as HSV, ARGB, SMYK) is defined.

25 DICOM also lacks a mechanism for specifying a pseudo-color palette to map many types of existing grayscale images (such as NM and PET images) into color using a lookup table. In some cases users prefer that a repeatable and consistent color map be applied to such images, rather than leaving the choice to the discretion of the display application.

A Pseudo-Color Softcopy Presentation State (PCSPS) Storage SOP Class is defined that inserts a lookup table into the grayscale transformation pipeline after the VOI LUT (window center and width) to map the entire range of selected grayscale pixel values through a lookup table into a device-independent color space and thence into the displayed area selection, spatial transformations and annotation steps. (Note that this mechanism differs from the Supplemental Color LUT that is used within some newer image storage SOP Classes, which maps a subset of the range of the stored (un-windowed) pixel values to color values).

35 An important application is the blending of two spatially co-registered sets of grayscale images, such as from different modalities like CT and PET, with the display of one as grayscale with the other superimposed as color of varying opacity. The description of the spatial registration, and the performance of any necessary re-sampling of one set of images or the other, are outside the scope of this Supplement,

but the specification of which two sets of images to display, and what color and degree of opacity to use, are described in a new Blending Softcopy Presentation State (BSPS) Storage SOP Class.

Similar to the GSPS, the images to which a CSPS or PCSPS applies must be part of the same study as the stored presentation state. Images may be selected individually or as a list of images. They may or
5 may not all be from one series. The two sets of images for the BSPS may be in separate studies, and indeed the BSPS may be in its own separate study.

In addition to the storage of presentation states and the definition of a color pixel transformation pipeline, an important objective of this supplement is color-rendering consistency. This is achieved by methods
10 similar to those used for grayscale consistency. A device-independent color space is specified, and the output of the color pixel transformation pipeline is defined in that space.

Since achieving device-independent representation of color is a non-trivial problem, and one that has already been addressed by the color printing and photographic industries, existing industry standard mechanisms are re-used. Specifically, rather than directly encoding color pixel values in a device-
15 independent space, they are instead defined by reference to an embedded color profile, as defined by the International Color Consortium (ICC). These ICC profiles define the transformation from the device-dependent space into the device-independent Profile Connection Space (PCS) defined by the ICC. As it happens, this PCS is the CIEXYZ or CIELAB space, though the ICC's choice of space is not exposed directly to the DICOM encoding. The use of the ICC profiles avoids the need to define a DICOM-specific
20 device-independent color space, and leverages the large installed base of support for ICC profiles in existing operating systems and non-medical image handling tools. The choice of ICC profiles over the simpler approach of requiring all images to be in the sRGB space was made because the gamut of the sRGB space is too constrained to cover many real world medical images.

The term Profile Connection Space Value (PCS-Value) is introduced to refer to the device-independent color values for the purpose of describing the color pixel transformation pipeline, analogous to the P-
25 Value for the grayscale pixel transformation pipeline.

Every DICOM color presentation state instance contains an ICC profile.

In addition, an optional ICC profile is added to all the existing color image IODs. This allows the embedding of color consistency information without the need for separate presentation states. It is
30 expected that all new color image IODs will make this information mandatory, just as all grayscale image IODs added since the GSDF was defined have had their output defined in P-Values.

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Digital Imaging and Communications in Medicine

PART 2 Addendum

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Conformance

Item: Add to table A.1-2 categorizing SOP Classes:

The SOP Classes are categorized as follows:

5

**Table A.1-2
UID VALUES**

UID Value	UID NAME	Category
...
1.2.840.10008.5.1.4.1.1.11.1	Grayscale Softcopy Presentation State Storage SOP Class	Transfer
<u>1.2.840.10008.5.1.4.1.1.11.2</u>	<u>Color Softcopy Presentation State Storage SOP Class</u>	<u>Transfer</u>
<u>1.2.840.10008.5.1.4.1.1.11.3</u>	<u>Pseudo-Color Softcopy Presentation State Storage SOP Class</u>	<u>Transfer</u>
<u>1.2.840.10008.5.1.4.1.1.11.4</u>	<u>Blending Softcopy Presentation State Storage SOP Class</u>	<u>Transfer</u>
...

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Digital Imaging and Communications in Medicine

PART 3 Addendum

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Information Object Definitions

Item: Add to Section 2 Normative References:

CIE Publication 15.2-1986 “Colorimetry, Second Edition”

IEC/CD 61966-2.1: Colour measurement and management in Multimedia systems and equipment – Part 2.1: Colour management in multimedia systems - Default RGB colour space - sRGB

Specification ICC.1:2003-09, File Format for Color Profiles (Version 4.1.0).

Item: Add to definition of device-independent values:

3.12 DICOM GRAYSCALE STANDARD DISPLAY FUNCTION DEVICE INDEPENDENT PIXEL VALUES

3.12.1 P-Value

This Part of the Standard makes use of the following term defined in PS 3.14:

a. P-Value

Note: The definition is “A device independent value defined in a perceptually linear grayscale space. The output of the DICOM Presentation LUT is P-Values, i.e. the pixel value after all DICOM defined grayscale transformations have been applied. P-Values are the input to a Standardized Display System.”

3.12.2 PCS-Value: Profile Connection Space Value. A device independent color value that is created by the application of the transformation specified in an ICC profile.

Item: Update Series IE definition:

A.1.2.3 SERIES IE

...

Presentation States shall be grouped into Series without Images (i.e. in a different Series from the Series containing the Images to which they refer). The Frame of Reference IE is irrelevant to the Presentation State IE.

Note: The Series containing **Grayscale, Color and Pseudo-Color Softcopy** Presentation States and the Series containing the Images to which they refer are both contained within the same Study, **except for Blended Presentation States, which may refer to images from different Studies.**

...

Item: Update Presentation State IE definition:

A.1.2.11 PRESENTATION STATE IE

The Presentation State IE defines how a referenced image (or images) will be presented (e.g. displayed) in a device independent grayscale space (i.e. in P-Values) **or color space (i.e. in PCS-values)**, and what graphical annotations and spatial and grayscale contrast transformations will be applied to the referenced image pixel data.

5

Item: Add to PS 3.3 Table A.1-1

**Table A.1-2
COMPOSITE INFORMATION OBJECT MODULES OVERVIEW – NON-IMAGES**

IODs Modules	Grayscale Pres State	Color Pres State	Pseudo- Color Pres State	Blending Pres State
Patient	M	<u>M</u>	<u>M</u>	<u>M</u>
Patient Summary				
Specimen Identification				
Clinical Trial Subject	U	<u>U</u>	<u>U</u>	<u>U</u>
General Study	M	<u>M</u>	<u>M</u>	<u>M</u>
Patient Study	U	<u>U</u>	<u>U</u>	<u>U</u>
Clinical Trial Study	U	<u>U</u>	<u>U</u>	<u>U</u>
Study Content				
General Series	M	<u>M</u>	<u>M</u>	<u>M</u>
Clinical Trial Series	U	<u>U</u>	<u>U</u>	<u>U</u>
Spatial Registration Series				
Spatial Fiducials Series				
PET Series				
PET Isotope				
PET Multi-gated Acquisition				
RT Series				
Presentation Series	M	<u>M</u>	<u>M</u>	<u>M</u>
SR Document Series				
Key Object Document Series				
Frame Of Reference				

Synchronization				
Cardiac Synchronization				
Respiratory Synchronization				
Bulk Motion Synchronization				
General Equipment	M	<u>M</u>	<u>M</u>	<u>M</u>
General Image				
Image Plane				
Image Pixel				
Multi-frame				
Multi-frame Functional Groups				
Multi-frame Dimension				
Mask	C		<u>C</u>	
Display Shutter	C	<u>C</u>	<u>C</u>	
Bitmap Display Shutter	C	<u>C</u>	<u>C</u>	
<u>Palette Color LUT</u>			<u>M</u>	<u>M</u>
Raw Data				
MR Spectroscopy				
MR Spectroscopy Pulse Sequence				
MR Spectroscopy Data				
RT Dose				
RT DVH				
Structure Set				
ROI Contour				
RT Dose ROI				
RT ROI Observations				
RT General Treatment Record				
RT Treatment Machine Record				

Measured Dose Reference Record				
Calculated Dose Reference Record				
RT Beams Session Record				
RT Brachy Session Record				
RT Treatment Summary Record				
RT General Plan				
RT Prescription				
RT Tolerance Tables				
RT Patient Setup				
RT Fraction Scheme				
RT Beams				
RT Brachy Application Setups				
Approval				
SR Document General				
SR Document Content				
Key Object Document				
Overlay Identification				
Overlay Plane	C	<u>C</u>	<u>C</u>	
Multi-frame Overlay				
Curve Identification				
Curve				
PET Curve				
Audio				
Waveform Identification				
Waveform				
Waveform				

Annotation				
Displayed Area	M	<u>M</u>	<u>M</u>	<u>M</u>
Overlay/Curve Activation	C	<u>C</u>	<u>C</u>	
Graphic Annotation	C	<u>C</u>	<u>C</u>	<u>C</u>
Spatial Transformation	C	<u>C</u>	<u>C</u>	<u>C</u>
Graphic Layer	C	<u>C</u>	<u>C</u>	<u>C</u>
Modality LUT	C		<u>C</u>	
VOI LUT				
Softcopy VOI LUT	C		<u>C</u>	
Softcopy Presentation LUT	M			
Image Histogram				
Presentation State <u>Identification</u>	M	<u>M</u>	<u>M</u>	<u>M</u>
<u>Presentation State Relationship</u>	<u>M</u>	<u>M</u>	<u>M</u>	
<u>Presentation State Shutter</u>	<u>M</u>	<u>M</u>	<u>M</u>	
<u>Presentation State Mask</u>	<u>M</u>		<u>M</u>	
<u>Presentation State Blending</u>				<u>M</u>
<u>ICC Profile</u>		<u>M</u>	<u>M</u>	<u>M</u>
LUT Identification				
Spatial Registration				
Spatial Fiducials				
Common Instance Reference				
Acquisition Context				
SOP Common	M	<u>M</u>	<u>M</u>	<u>M</u>

Item: Amend A.33 to refactor Presentation State Module

A.33 SOFTCOPY PRESENTATION STATE INFORMATION OBJECT DEFINITIONS

A.33.1 Grayscale Softcopy Presentation State Information Object Definition

A.33.1.1 Grayscale Softcopy Presentation State IOD Description

5 The Grayscale Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to present (display) images that are referenced from within the IOD.

It includes capabilities for specifying:

- a. the output grayscale space in P-Values
- b. grayscale contrast transformations including modality and VOI LUT
- 10 c. mask subtraction for multi-frame images
- d. selection of the area of the image to display and whether to rotate or flip it
- e. image and display relative annotations, including graphics, text and overlays

A.33.1.2 Grayscale Softcopy Presentation State IOD Module Table

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**Table A.33.1-1
Grayscale Softcopy Presentation State IOD MODULES**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Equipment	General Equipment	C.7.5.1	M
Presentation State	Presentation State <u>Identification</u>	C.11.10	M
	<u>Presentation State Relationship</u>	<u>C.11.11</u>	<u>M</u>
	<u>Presentation State Shutter</u>	<u>C.11.12</u>	<u>M</u>
	<u>Presentation State Mask</u>	<u>C.11.13</u>	<u>M</u>
	Mask	C.7.6.10	C - Required if the referenced image(s) are multi-frame and are to be subtracted
	Display Shutter	C.7.6.11	C - Required if a Display Shutter is to be applied to referenced image(s) and the Bitmap Display Shutter Module is not present
	Bitmap Display Shutter	C.7.6.15	C - Required if a Display Shutter is to be applied to

		referenced image(s) and the Display Shutter Module is not present
Overlay Plane	C.9.2	C - Required if Overlay is to be applied to referenced image(s) or the Bitmap Display Shutter Module is present
Overlay/Curve Activation	C.11.7	C- Required if referenced image contains curve or overlay data that is to be displayed
Displayed Area	C.10.4	M
Graphic Annotation	C.10.5	C - Required if Graphic Annotations are to be applied to referenced image(s)
Spatial Transformation	C.10.6	C - Required if rotation or flipping are to be applied to referenced image(s)
Graphic Layer	C.10.7	C - Required if Graphic Annotations or Overlays or Curves are to be applied to referenced image(s)
Modality LUT	C.11.1	C - Required if a Modality LUT is to be applied to referenced image(s)
Softcopy VOI LUT	C.11.8	C - Required if a VOI LUT is to be applied to referenced image(s)
Softcopy Presentation LUT	C.11.6	M
SOP Common	C.12.1	M

In the Grayscale Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module, **and** the Presentation State **Mask Module specializes some Attributes of the Mask Module, and the Presentation State Shutter** Module specializes some Attributes of the **Bitmap Display Shutter** and Display Shutter Modules.

5

Notes: 1. Subtraction between different images is not supported.

2. The Mask Module condition implies that it need not be supported by an SCP that supports presentation states only for single frame image storage SOP Classes, or instances of multi-frame image Storage SOP Classes that contain only one frame.

10

3. The Display Shutter may be used to darken image areas that surround important information and exclude extraneous bright areas that increase glare and ambient lighting impairing image interpretation. For example, unexposed areas in a CR image might be obscured using the Display Shutter, rather than permanently replacing image pixels in those areas.

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4. This IOD does not support the storage of a multi-frame overlay in the IOD itself, but does support selective activation of multi-frame overlays within the referenced images via the Overlay/Curve Activation Module.

Item: Add to PS 3.3 new Section A.33.2

A.33.2 Color Softcopy Presentation State Information Object Definition

A.33.2.1 Color Softcopy Presentation State IOD Description

- 5 The Color Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to present (display) color images that are referenced from within the IOD.

It includes capabilities for specifying:

- a. the output color space in PCS-Values
- b. color transformations from device-dependent color to PCS-Values using an ICC profile
- 10 c. selection of the area of the image to display and whether to rotate or flip it
- d. image and display relative annotations, including graphics, text and overlays

A.33.2.2 Color Softcopy Presentation State IOD Module Table

**Table A.33.2-1
Color Softcopy Presentation State IOD MODULES**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.12.2	M
Equipment	General Equipment	C.7.5.1	M
Presentation State	Presentation State Identification	C.11.10	M
	Presentation State Relationship	C.11.11	M
	Presentation State Shutter	C.11.12	M
	Display Shutter	C.7.6.11	C – Required if a Display Shutter is to be applied to referenced image(s) and the Bitmap Display Shutter Module is not present
	Bitmap Display Shutter	C.7.6.15	C – Required if a Display Shutter is to be applied to referenced image(s) and the Display Shutter Module is not present
	Overlay Plane	C.9.2	C – Required if Overlay is to be applied to referenced image(s) or the Bitmap Display Shutter Module is present
	Overlay/Curve Activation	C.11.7	C- Required if referenced image contains curve or overlay data which is to be displayed
	Displayed Area	C.10.4	M
	Graphic Annotation	C.10.5	C – Required if Graphic Annotations are to be applied to referenced image(s)
	Spatial Transformation	C.10.6	C – Required if rotation, flipping or magnification are to be applied to referenced image(s)
Graphic Layer	C.10.7	C – Required if Graphic Annotations or Overlays or	

		Curves are to be applied to referenced image(s)
ICC Profile	C.11.15	M
SOP Common	C.12.1	M

In the Color Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module, and the Presentation State Module specializes some Attributes of the Bitmap Display Shutter and Display Shutter Modules.

Item: Add to PS 3.3 new Section A.33.3

A.33.3 Pseudo-Color Softcopy Presentation State Information Object Definition

A.33.3.1 Pseudo-Color Softcopy Presentation State IOD Description

5 The Pseudo-Color Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to present (display) images that are referenced from within the IOD.

It includes capabilities for specifying:

- a. the output color space in PCS-Values
- b. grayscale contrast transformations including modality and VOI LUT
- c. a color palette to map the transformed grayscale values into pseudo-color
- 10 d. mask subtraction for multi-frame images
- e. selection of the area of the image to display and whether to rotate or flip it
- f. image and display relative annotations, including graphics, text and overlays

A.33.3.2 Pseudo-Color Softcopy Presentation State IOD Module Table

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**Table A.33.3-1
Pseudo-Color Softcopy Presentation State IOD MODULES**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Equipment	General Equipment	C.7.5.1	M
Presentation State	Presentation State Identification	C.11.10	M
	Presentation State Relationship	C.11.11	M
	Presentation State Shutter	C.11.12	M
	Presentation State Mask	C.11.13	M
	Mask	C.7.6.10	C - Required if the referenced image(s) are multi-frame and are to be subtracted
	Display Shutter	C.7.6.11	C - Required if a Display Shutter is to be applied to referenced image(s) and the Bitmap Display Shutter Module is not present
	Bitmap Display Shutter	C.7.6.15	C - Required if a Display Shutter is to be applied to referenced image(s) and the

		Display Shutter Module is not present
Overlay Plane	C.9.2	C - Required if Overlay is to be applied to referenced image(s) or the Bitmap Display Shutter Module is present
Overlay/Curve Activation	C.11.7	C- Required if referenced image contains curve or overlay data that is to be displayed
Displayed Area	C.10.4	M
Graphic Annotation	C.10.5	C - Required if Graphic Annotations are to be applied to referenced image(s)
Spatial Transformation	C.10.6	C - Required if rotation or flipping are to be applied to referenced image(s)
Graphic Layer	C.10.7	C - Required if Graphic Annotations or Overlays or Curves are to be applied to referenced image(s)
Modality LUT	C.11.1	C - Required if a Modality LUT is to be applied to referenced image(s)
Softcopy VOI LUT	C.11.8	C - Required if a VOI LUT is to be applied to referenced image(s)
Palette Color LUT	C.7.9	M
ICC Profile	C.11.15	M
SOP Common	C.12.1	M

5 In the Pseudo-Color Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module, the Presentation State Mask Module specializes some Attributes of the Mask Module, and the Presentation State Shutter Module specializes some Attributes of the Bitmap Display Shutter and Display Shutter Modules.

The Presentation LUT Module shall not be present in this IOD.

Item: Add to PS 3.3 new Section A.33.4

A.33.4 Blending Softcopy Presentation State Information Object Definition

A.33.4.1 Blending Softcopy Presentation State IOD Description

5 The Blending Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to blend two sets of images that are referenced from within the IOD for the purpose of presentation (display).

It includes capabilities for specifying:

- a. the output color space in PCS-Values
- b. grayscale contrast transformations including modality and VOI LUT for both the
10 underlying and superimposed image sets
- c. a color palette to map the transformed grayscale values of the superimposed image set into pseudo-color
- d. selection of the area of the blended images to display and whether to rotate or flip it
- e. image and display relative annotations, including graphics, text and overlays

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A.33.4.2 Blending Softcopy Presentation State IOD Module Table

**Table A.33.4-1
Blending Softcopy Presentation State IOD MODULES**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Equipment	General Equipment	C.7.5.1	M
Presentation State	Presentation State Identification	C.11.10	M
	Presentation State Blending	C.11.14	M
	Displayed Area	C.10.4	M
	Graphic Annotation	C.10.5	C - Required if Graphic Annotations are to be applied
	Spatial Transformation	C.10.6	C - Required if rotation or flipping are to be applied
	Graphic Layer	C.10.7	C - Required if Graphic Annotation Module is present
	Palette Color LUT	C.7.9	M
	ICC Profile	C.11.15	M
	SOP Common	C.12.1	M

In the Blending Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module.

The Presentation LUT Module shall not be present in this IOD.

- 5 The Modality LUT and Softcopy VOI LUT Module shall not be present in this IOD, since the Presentation State Blending Module subsumes their function.

The Palette Color LUT Module describes the color mapping to be used for the superimposed image set.

- 10 The Displayed Area and Graphic Annotation Modules specifically identify those images or frames to which they apply, and may include images or frames from the underlying or superimposed set.

The Spatial Transformation Module describes any necessary spatial transformation of the image to be rendered after the blending operation.

The Overlay Plane and Overlay/Curve Activation Modules shall not be present, and any overlays present in the referenced images shall not be displayed.

- 15 The Display Shutter and Bitmap Display Shutter Modules shall not be present, since the underlying image geometry may differ between the two sets of images.

The ICC Profile Module shall always be present. If the color space to be used is not calibrated (i.e., a device-specific ICC Input Profile is not available), then an ICC Input Profile specifying a well-known space (such as sRGB) may be specified.

- 20

<i>Item: Add optional ICC Profile Attribute to Section C.7.6.3 Image Pixel Module</i>

C.7.6.3 Image Pixel Module

...

Table C.7-11b
IMAGE PIXEL MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
...
ICC Profile	(0028,2000)	3	<p>An ICC Profile encoding the transformation of device-dependent color stored pixel values into PCS-Values.</p> <p>See Section C.11.15.1.1.1.</p> <p>When present, defines the color space of color Pixel Data (7FE0,0010) values, and the output of Palette Color Lookup Table Data (0028,1201-1203).</p> <p>Note: The profile applies only to the Pixel Data (7FE0,0010) attribute at the same level of the dataset and not to any icons nested within sequences, which may or may not have their own ICC profile specified.</p>

Item: Amend Section C.7.6.11 Display Shutter Module

5 **C.7.6.11 Display Shutter Module**

...

Table C.7-17
DISPLAY SHUTTER MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
...			
Shutter Presentation Value	(0018,1622)	3	<p>The A single gray unsigned value used to replace those parts of the image occluded by the shutter, when rendered on a monochrome display. The units are specified in P-Values, from a minimum of 0000H (black), up to a maximum of FFFFH (white).</p> <p>Note: The maximum P-Value for this Attribute may be different from the maximum P-Value from the output of the Presentation LUT, which may be less than 16 bits in depth.</p>
Shutter Presentation Color CIELab Value	(0018,1624)	3	<p>A color triplet value used to replace those parts of the image occluded by the shutter, when rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See C.10.7.1.1.</p>

Item: Amend Section C.7.6.15 Bitmap Display Shutter Module

C.7.6.15 Bitmap Display Shutter Module

**Table C.7.6.15-1
BITMAP DISPLAY SHUTTER MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...			
Shutter Presentation Value	(0018,1622)	1	<p>The A single gray unsigned value used to replace those parts of the image occluded by the shutter, when rendered on a monochrome display. The units are specified in P-Values, from a minimum of 0000H (black)_up to a maximum of FFFFH (white).</p> <p>Note: The maximum P-Value for this Attribute may be different from the maximum P-Value from the output of the Presentation LUT, which may be less than 16 bits in depth.</p>
<u>Shutter Presentation Color CIE Lab Value</u>	<u>(0018,1624)</u>	<u>3</u>	<u>A color triplet value used to replace those parts of the image occluded by the shutter, when rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIE Lab. See C.10.7.1.1.</u>

5

Item: Amend PS 3.3 Section C.10.7

C.10.7 Graphic Layer Module

...

**Table C.10-7
GRAPHIC LAYER MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...
>Graphic Layer Recommended Display Grayscale Value	(0070,0066)	3	A default single gray unsigned value in which it is recommended that the layer be rendered on a monochrome display. The units are specified in P-Values from a minimum of 0000H (black) up to a maximum of FFFFH (white). Note: The maximum P-Value for this Attribute may be different from the maximum P-Value from the output of the Presentation LUT, which may be less than 16 bits in depth.
>Graphic Layer Recommended Display RGB Value	(0070,0067)	3	A triplet of unsigned RGB values in which it is recommended that the layer be rendered on a color display. The minimum intensity displayable is specified as 0000H\0000H\0000H (black) and the maximum intensity displayable as FFFFH\FFFFH\FFFFH (white).
>Graphic Layer Recommended Display CIELab Value	(0070,0401)	3	<u>A default color triplet value in which it is recommended that the layer be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See C.10.7.1.1.</u>
...

5 **Note:** Graphic Layer Recommended Display RGB Value (0070,0067) was previously used in this Module, but has been retired and its function replaced by Graphic Layer Recommended Display CIELab Value (0070,0401). See PS 3.3 2004.

C.10.7.1 Graphic Layer Module Attributes

C.10.7.1.1 Encoding of CIELab Values

10 **Attributes such as Graphic Layer Recommended Display CIELab Value (0070,0401) consist of three unsigned short values:**

- An L value linearly scaled to 16 bits, such that 0x0000 corresponds to an L of 0.0, and 0xFFFF corresponds to an L of 100.0.
- An a* then a b* value, each linearly scaled to 16 bits and offset to an unsigned range, such that 0x0000 corresponds to an a* or b* of -128.0, 0x8080 corresponds to an a* or b* of 0.0 and 0xFFFF corresponds to an a* or b* of 127.0

15 **Note:** This is the same form of encoding as used for the PCS in ICC Profiles.

Item: Correct title of C.11 section to recognize that it includes more than just LUTs

C.11 LOOK UP TABLE AND PRESENTATION RELATED MODULES

Item: Factor out macros from Modality and VOI LUT Modules for re-use in Blended Grayscale Transformations Module

C.11.1 Modality LUT module

5 ...

**Table C.11-1a
MODALITY LUT MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
<i>Include Modality LUT Macro Table C.11-1b</i>			

**Table C.11-1b
MODALITY LUT MACRO ATTRIBUTES**

10

Attribute Name	Tag	Type	Attribute Description
Modality LUT Sequence	(0028,3000)	1C	Defines a sequence of Modality LUTs. Only one Item may be present. Shall not be present if Rescale Intercept (0028,1052) is present.
>LUT Descriptor	(0028,3002)	1C	Specifies the format of the LUT Data in this Sequence. See C.11.1.1 for further explanation. Required if the Modality LUT Sequence (0028,3000) is sent.
>LUT Explanation	(0028,3003)	3	Free form text explanation of the meaning of the LUT.
>Modality LUT Type	(0028,3004)	1C	Specifies the output values of this Modality LUT. See C.11.1.1.2 for further explanation. Required if the Modality LUT Sequence (0028,3000) is sent.
>LUT Data	(0028,3006)	1C	LUT Data in this Sequence. Required if the Modality LUT Sequence (0028,3000) is sent.
Rescale Intercept	(0028,1052)	1C	The value b in relationship between stored values (SV) and the output units specified in Rescale Type (0028,1054). Output units = m*SV + b. Required if Modality LUT Sequence (0028,3000) is not present. Shall not be present otherwise.
Rescale Slope	(0028,1053)	1C	m in the equation specified by Rescale Intercept (0028,1052). Required if Rescale Intercept is present.
Rescale Type	(0028,1054)	1C	Specifies the output units of Rescale

			<p>Slope (0028,1053) and Rescale Intercept (0028,1052). See C.11.1.1.2 for further explanation. Required if Rescale Intercept is present.</p>
--	--	--	---

C.11.2 VOI LUT module

...

**Table C.11-2
VOI LUT MODULE ATTRIBUTES**

5

Attribute Name	Tag	Type	Attribute Description
<i>Include VOI LUT Macro Table C.11-2b</i>			

**Table C.11-2b
VOI LUT MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
VOI LUT Sequence	(0028,3010)	31C	Defines a sequence of VOI LUTs. <u>One or more items shall be present.</u> <u>Required if Window Center (0028,1050) is not present. May be present otherwise.</u>
>LUT Descriptor	(0028,3002)	1C	Specifies the format of the LUT Data in this Sequence. See C.11.2.1.1 for further explanation. <u>Required if the VOI LUT Sequence (0028,3010) is sent.</u>
>LUT Explanation	(0028,3003)	3	Free form text explanation of the meaning of the LUT.
>LUT Data	(0028,3006)	1C	LUT Data in this Sequence. <u>Required if the VOI LUT Sequence (0028,3010) is sent.</u>
Window Center	(0028,1050)	31C	Window Center for display. See C.11.2.1.2 for further explanation. <u>Required if VOI LUT Sequence (0028,3010) is not present. May be present otherwise.</u>
Window Width	(0028,1051)	1C	Window Width for display. See C.11.2.1.2 for further explanation. Required if Window Center (0028,1050) is sent.
Window Center & Width Explanation	(0028,1055)	3	Free form explanation of the meaning of the Window Center and Width. Multiple values correspond to multiple Window Center and Width values.

C.11.8 Softcopy VOI LUT module

...

Table C.11.8-1
SOFTCOPY VOI LUT MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Softcopy VOI LUT Sequence	(0028,3110)	1	Defines a sequence of VOI LUTs or Window Centers and Widths and to which images and frames they apply. No more than one VOI LUT Sequence containing a single Item or one pair of Window Center/Width values shall be specified for each image or frame. One or more Items shall be present.
>Referenced Image Sequence	(0008,1140)	1C	Sequence of Repeating Items where each Item provides reference to a selected set of Image SOP Class/SOP Instance pairs that are defined in the Presentation State Module, to which this VOI LUT or Window Center and Width applies. Required if a sequence item is present, and if the VOI LUT transformation in this Item does not apply to all the images listed in the Presentation State Module.
<i>>Include Image SOP Instance Reference Macro Table 10.3</i>			
>>Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if sequence item is present.
>>Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if sequence item is present.
>>Referenced Frame Number	(0008,1160)	1C	Identifies the frame numbers within the referenced SOP Instance to which this VOI LUT or Window Center and Width applies. Required if sequence item is present and the referenced image is a multi-frame image and the VOI LUT or Window Center and Width does not apply to all frames.
<i>>Include VOI LUT Macro Table C.11-2b</i>			
>VOI LUT Sequence	(0028,3010)	1C	Defines a sequence of VOI LUTs. Only one Item may be present. Required if Window Center (0028,1050) is not present.
>>LUT Descriptor	(0028,3002)	1C	Specifies the format of the LUT Data in this Sequence.

			See C.11.2.1.1 for further explanation. Required if the VOI LUT Sequence (0028,3010) is sent.
>>LUT Explanation	(0028,3003)	3	Free form text explanation of the meaning of the LUT.
>>LUT Data	(0028,3006)	1C	LUT Data in this Sequence. Required if the VOI LUT Sequence (0028,3010) is sent.
>Window Center	(0028,1050)	1C	Window Center for display. See C.11.2.1.2 for further explanation. Required if VOI LUT Sequence (0028,3010) is not present.
>Window Width	(0028,1051)	1C	Window Width for display. See C.11.2.1.2 for further explanation. Required if Window Center (0028,1050) is sent.
>Window Center & Width Explanation	(0028,1055)	3	Free form explanation of the meaning of the Window Center and Width.

Item: Refactor Presentation State Module Section C.11.10

C.11.10 Presentation State Identification Module

Table C.11.10-1 contains Attributes that identify ~~and describe~~ a Presentation State.

**Table C.11.10-1
PRESENTATION STATE IDENTIFICATION MODULE ATTRIBUTES**

5

Attribute Name	Tag	Type	Attribute Description
Instance Number	(0020,0013)	1	A number that identifies this presentation (SOP Instance). Note: In previous versions of the Standard this Attribute was referred to as Image Number.
Content Label	(0070,0080)	1	A label that is used to identify this presentation. Note: This value may be used by an application as a Defined Term in order to imply some grouping of different presentation states, i.e. it may have the same value for different presentation state instances that share some common concept.
Content Description	(0070,0081)	2	A description of this presentation.
Presentation Creation Date	(0070,0082)	1	Date on which this presentation was created. Note: This date may be different from the date that the DICOM SOP Instance was created, since the presentation state information contained may have been recorded earlier.
Presentation Creation Time	(0070,0083)	1	Time at which this presentation was created. Note: This time may be different from the time that the DICOM SOP Instance was created, since the presentation state information contained may have been recorded earlier.
Content Creator's Name	(0070,0084)	2	Name of operator saving the presentation state (such as a technologist or physician).
Referenced Series Sequence	(0008,1115)	4	Sequence of Items where each Item includes the Attributes of one Series to which the Presentation applies. One or more Items shall be present.
>Series Instance UID	(0020,000E)	1C	Unique identifier of a Series that is part of this Study. Required if sequence item is present.
>Retrieve AE Title	(0008,0054)	3	Title of the DICOM Application Entity where the Image(s) may be retrieved on

			the network.
>Storage Media File-Set ID	(0088,0130)	3	The user or implementation specific human readable identifier that identifies the Storage Media on which the Image(s) reside.
>Storage Media File-Set UID	(0088,0140)	3	Uniquely identifies the Storage Media on which the Image(s) reside.
>Referenced Image Sequence	(0008,1140)	1C	Sequence of Items where each Item provides reference to a selected set of Image SOP Class/SOP Instance pairs that are part of this Study and the Series defined by Series Instance UID (0020,000E). Required if a sequence item is present.
>>Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if sequence item is present. Shall be the same for all Images referenced by this presentation state.
>>Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if sequence item is present.
>>Referenced Frame Number	(0008,1160)	1C	Identifies the frame numbers within the referenced SOP Instance to which the presentation applies. Note: This Attribute may be multi-valued. Required if sequence item is present and the referenced SOP Instance is a multi-frame image and the presentation does not apply to all frames.
Shutter Presentation Value	(0018,1622)	1C	The value used to replace those parts of the image occluded by the shutter, in P-Values, from a minimum of 0000H (black) up to a maximum of FFFFH (white). Required if the Display Shutter Module or Bitmap Display Shutter Module is present. Note: The requirement in this module is type 1C, which overrides the type 3 in the Display Shutter Module.
Mask Subtraction Sequence	(0028,6100)	1C	Required if Mask Module is present. Only one Item shall be present. Applicable Frame Range (0028,6102) shall not be included in the Sequence Item. See C.7.6.10 for a complete definition of

			<p>the Attributes in the Items of this Sequence other than Mask Operation (0028,6101) and Applicable Frame Range (0028,6102).</p> <p>Notes: 1. This Sequence is replicated here in order to specify one item, additional conditions on Mask Operation (0028,6101) and to forbid Applicable Frame Range (0028,6102).</p> <p>2. The role of Applicable Frame Range (0028,6102) is replaced by Referenced Frame Number (0008,1160).</p>
>Mask Operation	(0028,6101)	1	<p>Type of mask operation to be performed</p> <p>Enumerated Values:</p> <p>_____AVG_SUB</p> <p>_____TID</p> <p>See C.7.6.10.1 for further explanation.</p> <p>Note: The requirement in this module is for Enumerated Values_i which override the requirements of the Mask Module.</p>
>Contrast Frame Averaging	(0028,6112)	1C	<p>Specified the number of contrast frames to average together before performing the mask operation.</p> <p>Required if Mask Frame Numbers (0028,6110) specifies more than one frame (i.e. is multi-valued).</p> <p>Note: The requirement in this module is conditional and overrides the optional requirements of the Mask Module.</p>
Recommended Viewing Mode	(0028,1090)	1C	<p>Specifies the recommended viewing protocol(s).</p> <p>Enumerated Value:</p> <p>SUB = for subtraction with mask images</p> <p>Required if Mask Subtraction Sequence (0028,6100) is present.</p> <p>Note: The requirement in this module is type 1C and an Enumerated Value is specified which override the requirements of the Mask Module.</p>

Item: Add a new Presentation State Relationship Module; note that the contents are not changed from what was previously in the Presentation State Module, other than to factor out a macro for re-use in the Presentation State Blending Module.

C.11.11 Presentation State Relationship Module

- 5 Table C.11.11-1 contains Attributes that describe the images to which a Presentation State applies.

**Table C.11.11-1
PRESENTATION STATE RELATIONSHIP MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
<i>Include Presentation State Relationship Macro Table C.11.11-1b</i>			

10

**Table C.11.11-1b
PRESENTATION STATE RELATIONSHIP MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Referenced Series Sequence	(0008,1115)	1	Sequence of Items where each Item includes the Attributes of one Series to which the Presentation applies. One or more Items shall be present.
>Series Instance UID	(0020,000E)	1	Unique identifier of a Series that is part of the Study to which the Presentation applies , defined by the Study Instance UID (0020,000D) in the enclosing data set. Note: The Study Instance UID (0020,000D) will be that of the presentation state itself, unless the macro is invoked from the Blending Sequence (0070,0402) in the Presentation State Blending Module, in which case it will be explicitly specified.
>Referenced Image Sequence	(0008,1140)	1	Sequence of Items where each Item provides reference to a selected set of Image SOP Class/SOP Instance pairs to which the Presentation applies that are part of the Study defined by Study Instance UID (0020,000D) and the Series defined by Series Instance UID (0020,000E). One or more Items shall be present. The referenced SOP Class shall be the same for all Images in any Item of this Referenced Series Sequence (0008,1115).
>>Include Image SOP Instance Reference Macro, Table 10-3			
>>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class. Shall be the same for all Images referenced by this presentation state.

>>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.
>>Referenced Frame Number	(0008,1160)	1C	Identifies the frame numbers within the referenced SOP Instance to which the presentation applies. Note: This Attribute may be multi-valued. Required if the referenced SOP Instance is a multi-frame image and the presentation does not apply to all frames.

Item: Add a new Presentation State Shutter Module; where the contents are changed from what was previously in the Presentation State Module, bold underline and strike-through are used.

C.11.12 Presentation State Shutter Module

- 5 Table C.11.12-1 contains Attributes that specialize Attributes in other Modules included in a Presentation State.

**Table C.11.12-1
PRESENTATION STATE SHUTTER MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Shutter Presentation Value	(0018,1622)	1C	The <u>A single gray unsigned</u> value used to replace those parts of the image occluded by the shutter, <u>when rendered on a monochrome display. The units are specified</u> in P-Values, from a minimum of 0000H (black)_up to a maximum of FFFFH (white). Required if the Display Shutter Module or Bitmap Display Shutter Module is present. Note: The requirement in this module is type 1C, which overrides the type 3 in the Display Shutter Module.
<u>Shutter Presentation Color CIELab Value</u>	<u>(0018,1624)</u>	<u>1C</u>	<u>A color triplet value used to replace those parts of the image occluded by the shutter, when rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See C.10.7.1.1.</u> <u>Required if the Display Shutter Module or Bitmap Display Shutter Module is present and the SOP Class is other than Grayscale Softcopy Presentation State Storage.</u> <u>Note: The requirement in this module is type 1C, which overrides the type 3 in the Display Shutter and Bitmap Display Shutter Modules.</u>

Item: Add a new Presentation State Mask Module; note that the contents are not changed from what was previously in the Presentation State Module.

C.11.13 Presentation State Mask Module

5 Table C.11.13-1 contains Attributes that specialize the use of masks in a Presentation State.

**Table C.11.13-1
PRESENTATION STATE MASK MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Mask Subtraction Sequence	(0028,6100)	1C	<p>Required if Mask Module is present. Only one Item shall be present. Applicable Frame Range (0028,6102) shall not be included in the Sequence Item. See C.7.6.10 for a complete definition of the Attributes in the Items of this Sequence other than Mask Operation_(0028,6101) and Applicable Frame Range (0028,6102).</p> <p>Notes: 1. This Sequence is replicated here in order to specify one Item, additional conditions on Mask Operation (0028,6101) and to forbid Applicable Frame Range (0028,6102). 2. The role of Applicable Frame Range (0028,6102) is replaced by Referenced Frame Number (0008,1160).</p>
>Mask Operation	(0028,6101)	1	<p>Type of mask operation to be performed Enumerated Values: AVG_SUB TID</p> <p>See C.7.6.10.1 for further explanation. Note: The requirement in this module is for Enumerated Values, which override the requirements of the Mask Module.</p>
>Contrast Frame Averaging	(0028,6112)	1C	<p>Specified the number of contrast frames to average together before performing the mask operation. Required if Mask Frame Numbers (0028,6110) specifies more than one frame (i.e. is multi-valued). Note: The requirement in this module is conditional and overrides the optional requirements of the Mask Module.</p>
Recommended Viewing Mode	(0028,1090)	1C	Specifies the recommended viewing protocol(s).

		<p>Enumerated Value: SUB = for subtraction with mask images Required if Mask Subtraction Sequence (0028,6100) is present.</p> <p>Note: The requirement in this module is type 1C and an Enumerated Value is specified which override the requirements of the Mask Module.</p>
--	--	---

Item: Add a new Presentation State Blending Module.

C.11.14 Presentation State Blending Module

5 Table C.11.14-1 contains Attributes that describe the identification of two sets of grayscale images and the grayscale transformations to be applied to them, for the purpose of blending.

**Table C.11.14-1
PRESENTATION STATE BLENDING MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Blending Sequence	(0070,0402)	1	A Sequence of exactly two Items, one identifying and describing transformations upon a set of underlying grayscale images, and the other identifying and describing transformations upon a set of superimposed grayscale images. See C.11.14.1.1.
>Blending Position	(0070,0405)	1	Whether or not the contents of the Item represent the superimposed or underlying image set. Enumerated Values: SUPERIMPOSED UNDERLYING
>Study Instance UID	(0020,000D)	1	Unique identifier for the Study that contains the images, which may differ from the Study in which the presentation state is contained.
<i>>Include Presentation State Relationship Macro Table C.11.11-1b</i>			
<i>>Include Modality LUT Macro Table C.11-1b</i>			
>Softcopy VOI LUT Sequence	(0028,3110)	1	Defines a sequence of VOI LUTs or Window Centers and Widths and to which images and frames they apply. No more than one VOI LUT Sequence containing a single Item or one pair of Window Center/Width values shall be specified for each image or frame. One or more Items shall be present.
>>Referenced Image Sequence	(0008,1140)	1C	Sequence of Items identifying images that are defined in the enclosing Item of the

			<p>Blending Sequence (0070,0402), to which this VOI LUT or Window Center and Width applies.</p> <p>Required if the VOI LUT transformation in this Item does not apply to all the images in the enclosing Item of the Blending Sequence (0070,0402).</p>
<i>>>>Include Image SOP Instance Reference Macro Table 10.3</i>			
<i>>>Include VOI LUT Macro Table C.11-2b</i>			
Relative Opacity	(0070,0403)	1	<p>A value from 0.0 to 1.0 indicating the relative opacity of the pixels of the superimposed image, where 1.0 means that pixels of the superimposed image completely replace the pixels of the underlying image, and 0.0 means that the pixels of the underlying image completely replace the pixels of the superimposed image.</p> <p>See PS 3.4 for a detailed description of the blending operation.</p>
Referenced Spatial Registration Sequence	(0070,0404)	3	<p>A reference to Spatial Registration Instances that may be used to register the underlying and superimposed images.</p> <p>Zero or more Items may be present.</p> <p>Note: A Spatial Registration Instance may identify registration between frames of reference, or between explicitly identified images. In the latter case, the list of images referenced by the Presentation State, not the list of images referenced by the Spatial Registration Instance, are to be blended.</p>
<i>>Include SOP Instance Reference Macro Table C.17-3</i>			

C.11.14.1 Presentation State Blending Module Attributes

C.11.14.1.1 Blending Sequence

5 The Blending Sequence (0070,0402) Attribute is used to identify two sets of images, one to be superimposed upon the other.

The sets of images and any subset of the frames therein in the case of multi-frame images are identified by Study, Series, SOP Instance and Frame Number.

10 This module specifies no explicit relationship (such as pairing or ordering) between the sets of images and frames defined in the first item for the underlying images, and the second item for the superimposed images. This module does not define how the images are spatially related, and what re-sampling, if any, needs to be performed before the images are blended for rendering.

Note: The images in the two sets may share the same Frame of Reference, in which case the rendering application can spatially relate the two sets of images based on their Image Position (Patient) (0020,0032) and Image Orientation (Patient) (0020,0037) Attributes.

Alternatively, a Spatial Registration SOP Instance may exist that relates either two different Frames of Reference, or two sets of images identified by UID and frame.

Whilst the two sets of images may already be spatially co-registered and oriented in the same plane, or even be sampled at the same in-plane and between-plane resolution, this will frequently not be the case.

See PS 3.4 for behavioral requirements that apply to Storage SOP Classes using this Module.

Item: Add new ICC Profile Module to PS 3.3.

C.11.15 ICC Profile Module

Table C.11.15-1 contains Attributes that identify and describe an ICC Profile.

**Table C.11.15-1
ICC PROFILE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
ICC Profile	(0028,2000)	1	An ICC Profile encoding the transformation of device-dependent color stored pixel values into PCS-Values.

C.11.15.1 Attribute descriptions

C.11.15.1.1 ICC Profile

The ICC Profile (0028,2000) Attribute encodes an ICC Input Device Profile that encodes the transformation of device-dependent color stored pixel values into PCS-Values.

Notes: 1. Only Input Device profiles are encoded, since display and output device profiles are not interchanged in DICOM, though they may be used internally within display and output devices, for example when they are calibrated.

2. Since the version of the ICC Profile is encoded within the profile itself, no additional version information is encoded in the ICC Profile Module.

The following constraints on the encoding of the ICC Profile shall be observed:

- The profile shall be of the Input Device class, i.e., header bytes 12 through 15, Profile Device/Class Signature, shall be “scnr”
- The color space of the input shall be RGB, i.e., header bytes 16 through 19, Color Space Signature, shall be “RGB”, regardless of the Photometric Interpretation of the image pixel data prior to decompression
- PCS shall be CIELab or CIEXYZ, i.e., header bytes 20 through 23, Profile Connection Space, shall be either “Lab” or “XYZ”.

Notes: 1. In the case of a PCS of CIELab, the profile will contain an N-component LUT-based AtoB0Tag, since three-component matrix based transformations are only possible with a PCS of CIEXYZ. A three-component matrix based transformation might be used to define a well-known rather than device-specific profile for such spaces as sRGB.

2. Selection of a PCS of CIELab or CIEXYZ within the ICC profile does not impact the DICOM encoding, since all color management systems support both.

The following constraints on the encoding of the ICC Profile are recommended:

- The Rendering Intent should be Perceptual.

5 Notes: 1. The rendering intent specifies how rendering will take place when the ICC Input Profile is linked with another Profile for the purpose of display.
 2. A perceptual rendering intent implies that AtoB0Tag and BtoA0Tag tags will be present in the profile. The AtoB0Tag allows mapping from the input values to the PCS. The BtoA0Tag allows mapping from the PCS to the input values, though this is not required for the color rendering pipeline defined in PS 3.4.

10

- All LUTs should be represented as 16 bit values, using tag type lut16Type, for greater precision.
- The chromaticAdaptationTag should be set if the actual illumination source is not D50.

15

Note: See the discussion of white point in PS 3.4.

Item: Update Presentation State Directory Record to remove restriction to greyscale:

F.5.23 Presentation State Directory Record Definition

5 The Directory Record is based on the specification of Section F.3. It is identified by a Directory
Record Type of Value "PRESENTATION". Table F.5-23 lists the set of keys with their associated
Types for such a Directory Record Type. The description of these keys may be found in the
Modules related to **Grayscale** Softcopy Presentation State Storage IODs. This Directory Record
shall be used to reference a **Grayscale** Softcopy Presentation State Storage SOP Instance. This
10 Type of Directory Record may reference a Lower-Level Directory Entity ~~which that~~ includes one or
more Directory Records as defined in Table F.4-2.

5

Digital Imaging and Communications in Medicine

PART 4 Addendum

Service Class Specifications

10

Item: Add to definitions

3.10 DEVICE INDEPENDENT PIXEL VALUES

This Part of the Standard makes use of the following terms defined in PS 3.3:

- a. **P-Value**
- b. **PCS-Value**

Item: Add to PS 3.4 B.5

B.5 STANDARD SOP CLASSES

The SOP Classes in the Storage Service Class identify the Composite IODs to be stored. Table B.5-1 identifies Standard SOP Classes.

**Table B.5-1
STANDARD SOP CLASSES**

SOP Class Name	SOP Class UID	IOD Specification
...		
<u>Color Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.2</u>	<u>Color Softcopy Presentation State</u>
<u>Pseudo-Color Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.3</u>	<u>Pseudo-Color Softcopy Presentation State</u>
<u>Blending Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.4</u>	<u>Blending Softcopy Presentation State</u>

B.5.1.4 Grayscale Softcopy Presentation State Storage SOP Classes

See Annex N.

Item: Add to PS 3.4 I.4

I.4 MEDIA STORAGE STANDARD SOP CLASSES

The SOP Classes in the Media Storage Service Class identify the Composite and Normalized IODs to be stored. The following Standard SOP Classes are identified in Table I.4-1.

**Table I.4-1
Media Storage Standard SOP Classes**

SOP Class Name	SOP Class UID	IOD Specification
...		
<u>Color Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.2</u>	<u>Color Softcopy Presentation State</u>
<u>Pseudo-Color Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.3</u>	<u>Pseudo-Color Softcopy Presentation State</u>
<u>Blending Softcopy Presentation State Storage</u>	<u>1.2.840.10008.5.1.4.1.1.11.4</u>	<u>Blending Softcopy Presentation State</u>

I.4.1.1 Grayscale Softcopy Presentation State Storage SOP Classes

See Annex N.

Item: Amend Annex N in PS 3.4:

Annex N GRAYSCALE SOFTCOPY PRESENTATION STATE STORAGE SOP CLASSES (Normative)

5 N.1. OVERVIEW

N.1.1 SCOPE

The ~~Grayscale~~ Softcopy Presentation State Storage SOP Classes extends the functionality of the Storage Service class (defined in Annex B) to add the ability to convey an intended presentation state or record an existing presentation state. The SOP Classes specifies the information and behavior that may be used to present (display) images that are referenced from within the SOP Classes.

It ~~They~~ includes capabilities for specifying:

a. the output grayscale space in P-Values

b. the color output space as PCS-Values

15 ~~bc.~~ grayscale contrast transformations including modality, ~~and~~ VOI **and presentation** LUT

~~ed.~~ mask subtraction for multi-frame **grayscale** images

~~de.~~ selection of the area of the image to display and whether to rotate or flip it

~~ef.~~ image and display relative annotations, including graphics, text and overlays

g. the blending of two image sets into a single presentation

20 The **grayscale** softcopy presentation state refers to the grayscale image transformations that are to be applied in an explicitly defined manner to convert the stored image pixel data values in a Composite Image ~~Storage~~ Instance to presentation values (P-Values) when an image is displayed on a softcopy device. The P-Values are in a device independent perceptually linear space that is formally defined in PS 3.14 Grayscale Standard Display Function.

25 **The color and pseudo-color softcopy presentation states refer to the color image transformations that are to be applied in an explicitly defined manner to convert the stored image pixel data values in a Composite Image Instance to Profile Connection Space values (PCS-Values) when an image is displayed on a softcopy device. The PCS-Values are in a device independent space that is formally defined in the ICC Profiles as CIEXYZ or CIELab values.**

30 **The blending presentation states specify two sets of images, an underlying set, and a superimposed set, and the manner in which their pixel values are blended. The underlying set is rendered as grayscale and the superimposed set is rendered as color. The blending is not defined in a pair wise image-by-image or frame-by-frame manner, but rather the manner in which the two sets are combined is left to the discretion of the implementation. Specifically, matters of spatial registration, and any re-sampling and the mechanism of interpolation are not specified.**

35

The ~~Grayscale~~ Softcopy Presentation State Storage SOP Classes may be used to store a single state per image, or a common state to be shared by multiple selected images. All images to which the **Grayscale**,

Color and Pseudo-Color Presentation States state applies must be a part of the same study that the stored state is a part of, and be of **the same a single** Composite Image Storage SOP Class.

The two sets of images to which the Blended Presentation State applies may be in separate Studies. Each set shall be within a single study. Each set shall be of a single Composite Image Storage SOP Class.

How an SCU of this SOP Class records or generates this state is beyond the scope of the standard.

Note: For example, an acquisition device may acquire, reconstruct and store to a workstation or archive images that are later examined by an operator for the purpose of quality assurance or printing. At that time a selected grayscale transformation (such as a window level/width operation) may be applied by the operator, and that activity captured and saved as a Grayscale Softcopy Presentation State Storage SOP Instance to the same workstation or archive, from which it is subsequently available for use by another user. Another workstation may retrieve the state for later use. Alternatively, an automated algorithm may derive a state from analysis of image statistics, body part examined, or other characteristics.

How an SCP of this SOP Class chooses between multiple states that may apply to an image is beyond the scope of this standard, other than to state that a claim of conformance as an SCP of this SOP Class implies that the SCP shall make the presentation state available to the user of the device, and if selected by the user, shall apply all the transformations stored in the state in the manner in which they are defined in the standard.

Notes: 1. For example, an acquisition device may automatically store appropriate presentation states for series of images as they are reconstructed that represent adequate defaults. A user or algorithm may subsequently determine a more appropriate presentation state that more effectively displays the contents of an image, or record some annotation related directly to the image, and record that as another presentation state for an image. An application subsequently may display the image by automatically choosing to use the more recently saved or more specific presentation state, or may use the more general default presentation state for all images but notify the user that alternative presentation states are available.

2. Choice of the same presentation state to display an **grayscale** image on two devices claiming conformance to these SOP Classes implies through the definition of the P-Value space that the displayed image on both devices will be perceptually similar within the limits defined in PS 3.14 Grayscale Standard Display Function, regardless of the actual capabilities of the display systems.

3. Choice of the same presentation state to display a color image on two devices claiming conformance to these SOP Classes implies through the definition of the PCS-Value space that the displayed image on both devices will appear similar in color regardless of the actual capabilities of the display systems.

4. DICOM color images without an embedded optional ICC profile have no defined color space, regardless of their representation. The implementation creating a Color Softcopy Presentation State with an ICC profile is explicitly defining a color space in which to interpret that image, even if one was not known at the time that the image was created. Often a well-known color space such as sRGB will be used in the presentation state under such circumstances.

N.2 GRAYSCALE PIXEL TRANSFORMATION SEQUENCE

The **Grayscale** Softcopy Presentation State Storage SOP Classes supports a sequence of **grayscale** transformations that completely define the conversion of a stored image into a displayed image.

The sequence of **grayscale** transformations from stored pixel values into **the Grayscale Standard Display Function** P-Values **or PCS-Values** is explicitly defined in a conceptual model. The actual

sequence implemented may differ but must result in the same appearance. Figure N.2-1 describes this sequence of **grayscale** transformations.

- Notes:
1. Even though a Composite Image Storage SOP Class may not include some modules that are part of the described **grayscale** transformations, the **Grayscale** Softcopy Presentation State Storage SOP Classes **does** include them. For example, the CT Image Storage SOP Class includes Rescale Slope and Intercept in the CT Image Module, but does not include the Modality LUT Module, and hence is restricted to the description of linear transformations. A saved presentation state that refers to a CT Image Storage SOP Instance may include a Modality LUT, and hence may apply a non-linear transformation. **This is a feature of the extended functionality of the Grayscale Softcopy Presentation State Storage SOP Class.**
 2. For the shutter, annotation and spatial transformations, the order in which they are applied relative to the other transformations should not result in a different appearance. The one exception is when a spatial transformation is applied that involves magnification implemented with interpolation. In this case, whether the interpolation is performed before or after the contrast transformations (such as VOI LUT) may result in a slightly different appearance. It is not considered necessary to constrain this sequence more precisely.

The **grayscale** transformations defined in the **Grayscale** Softcopy Presentation State Storage SOP Classes **replace** those that may be defined in the Referenced Image SOP Instance. If a particular transformation is absent in the **Grayscale** Softcopy Presentation State Storage SOP Class, then it shall be assumed to be an identity transformation, and any equivalent transformation, if present, in the Referenced Image SOP Instance shall NOT be used instead.

Values of MONOCHROME1 and MONOCHROME2 for Photometric Interpretation (0028,0004) in the Referenced Image SOP Instance shall be ignored, since **its their effect is defined by the application of the grayscale **presentation state** transformations.**

Note: These requirements are in order to achieve complete definition of the entire **grayscale** transformation in the **Grayscale** Softcopy Presentation State Storage SOP Class, and not to depend on the content of the Referenced Image SOP Instance, which may change.

The Referenced Image Storage SOP Instance may also contain bit-mapped overlays and curves. The **Grayscale** Softcopy Presentation State Storage SOP Classes **specify** a mechanism for turning these on or off (i.e. displaying them or not).

The presentation related Attributes of the **Grayscale** Softcopy Presentation State Storage SOP Classes **are** immutable. They shall never be modified or updated; only a derived SOP Instance with a new SOP Instance UID may be created to represent a different presentation.

When a Supplemental Palette Color LUT is present in a grayscale Referenced Image Storage SOP Instance:

- **The grayscale pipeline in any applicable Grayscale Softcopy Presentation State Storage SOP Instance or Blended Softcopy Presentation State Storage SOP Instance shall be applied only to the range of grayscale stored pixel values, and the presentation state shall not affect the rendering of the indexed color values.**
- **A Color Softcopy Presentation State Storage SOP Instance shall not be applied.**
- **A Pseudo-color Softcopy Presentation State Storage SOP Instance may be applied, in which case the Supplemental Palette Color LUT information shall be ignored.**

- **No mechanism for separately specifying color consistency of the colors in the Supplemental Palette Color LUT is presently defined, only the optional inclusion of an ICC profile in the image instance.**

5

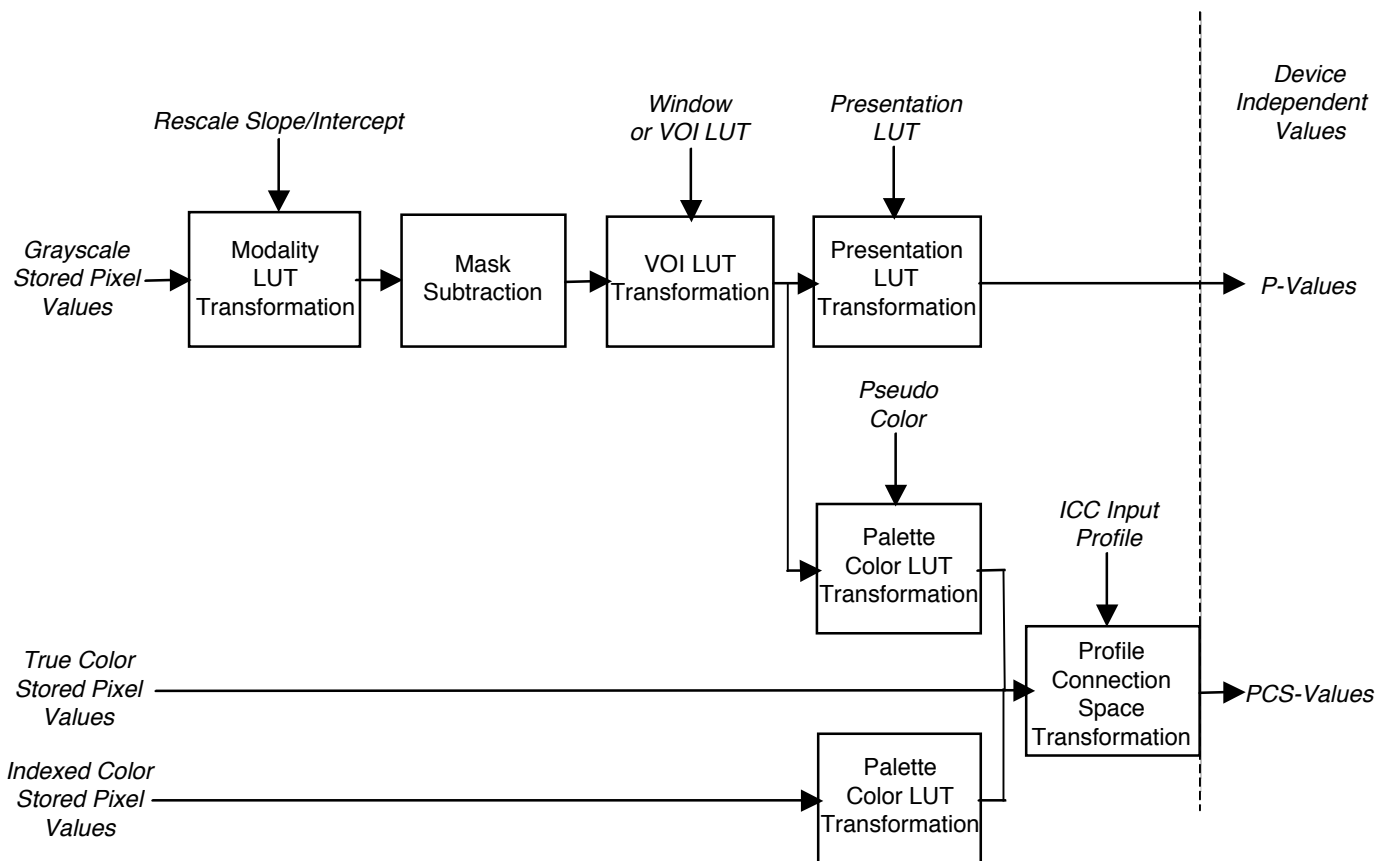


Figure N.2-1
Grayscale and Color Image Transformation Models

10

N.2.1 Grayscale Transformations

N.2.1.1 Modality LUT

The Modality LUT operation applies only to grayscale values.

15

The Modality LUT transformation transforms the manufacturer dependent pixel values into pixel values which are meaningful for the modality and which are manufacturer independent (e.g., Hounsfield number for CT modalities, Optical Density for film digitizers). These may represent physical units or be dimensionless. The Modality LUT in the Presentation State is modality dependent and is analogous to the same module in an Image .

Note: In some cases, such as the CT Image Storage SOP Class, the same conceptual step as the Modality LUT is specified in another form, for example as Rescale Slope and Rescale Intercept Attributes in the CT Image Module, though the Modality LUT Module is not part of the CT Image IOD.

5 In the case of a linear transformation, the Modality LUT is described by the Rescale Slope (0028,105“) and Rescale Intercept (0028,105“). In the case of a non-linear transformation, the Modality LUT is described by the Modality LUT Sequence. The rules for application of the Modality LUT are defined in PS 3.3 Modality LUT Module.

10 If the Modality LUT or equivalent Attributes are part of both the Image and the Presentation State, then the Presentation State Modality LUT shall be used instead of the Image Modality LUT or equivalent Attributes in the Image. If the Modality LUT is not present in the Presentation State it shall be assumed to be an identity transformation. Any Modality LUT or equivalent Attributes in the Image shall not be used.

N.2.1.2 Mask

The Mask operation applies only to grayscale values.

15 The mask transformation may be applied in the case of multi-frame images for which other frames at a fixed frame position or time interval relative to the current frame may be subtracted from the current frame. Multiple mask frames may be averaged, and sub-pixel shifted before subtraction.

This transformation uses the Mask Module as used in the X-Ray Angiography Image Storage SOP Class, though it may be applied to any Image Storage SOP Instance that contains a multi-frame image.

20 In the case of X-Ray images, the subtraction is specified to take place in a space logarithmic to X-Ray intensity. If the stored pixel values are not already in such a space, an implementation-defined transformation to such a space must be performed prior to subtraction. If a Modality LUT Module is present as well as a Mask Module, then the Modality LUT shall specify a transformation into such a logarithmic space, otherwise it shall not be present (even though a Modality LUT may be present in the referenced
25 image(s) which shall be ignored).

Notes: 1. In the case of an XA or XRF image, if the Pixel Intensity Relationship (0028,104“) in the image is LOG, then even though a Modality LUT would be present in the image (to map pixel values back to linear to X-Ray intensity), no Modality LUT would be present in the presentation state (i.e. the Modality LUT would be an identity transformation) since log values are required for subtraction. See PS 3.3 C.8.7.1.1.2.

30 2. In the case of an XA or XRF image, if the Pixel Intensity Relationship (0028,104“) is LIN, then no Modality LUT would be present in the image, but a Modality LUT would need to be present in the presentation state since log values are required for subtraction.

35 3. In the case of an XA or XRF image, if the Pixel Intensity Relationship (0028,104“) in the image is DISP, then even though a Modality LUT may or may not be present in the image (to map pixel values back to linear to X-Ray intensity), a different Modality LUT would be present in the presentation state if the creator of the presentation state could create a transformation from DISP pixel values to a logarithmic space for subtraction, or the Modality LUT in the presentation state would be an identity transformation if the DISP pixel values were known to already be log values required for subtraction.

40 The result will be a signed value with a bit length one longer than the source frames.

When there is no difference between corresponding pixel values, the subtracted image pixel will have a value of 0.

If a pixel in the current frame has a greater value than in the mask frame, then the resulting frame shall have a positive value. If it has a lesser value, then the resulting frame shall have a negative value.

N.2.1.3 VOI LUT

The VOI LUT operation applies only to grayscale values.

The value of interest (VOI) LUT transformation transforms the modality pixel values into pixel values which are meaningful for the user or the application.

- 5 Note: Photometric Interpretation (0028,000“) is ignored, since its effect is defined by the application of the grayscale transformations.

The Softcopy VOI LUT Module in the Presentation State is analogous to the VOI LUT Module in an Image.

- 10 In the case of a linear transformation, the VOI LUT is described by the Window Center (0028,105“) and Window Width (0028,105“). In the case of a non-linear transformation, the VOI LUT is described by the VOI LUT Sequence. The rules for application of the VOI LUT are defined in PS 3.3 Softcopy VOI LUT Module.

The VOI LUT may have sections with negative slope.

- 15 Note: In the Basic Print Service Class a VOI LUT may not have negative slope.

If a VOI LUT is part of both the Image and the Presentation State then the Presentation State VOI LUT shall be used instead of the Image VOI LUT. If a VOI LUT (that applies to the Image) is not present in the Presentation State, it shall be assumed to be an identity transformation. Any VOI LUT or equivalent values in the Image shall not be used.

N.2.1.4 Presentation LUT

The Presentation LUT operation applies only to grayscale values.

The Presentation LUT transformation transforms the pixel values into P-Values, a device independent perceptually linear space as defined in PS 3.14 Grayscale Display Function Standard. It may be an identity function if the output of the VOI LUT transformation is in P-Values.

- 25 Note: If the Presentation LUT and VOI LUT step are identity transformations, and the Mask Module is absent, then the output of the Modality LUT must be, by definition, P-Values.

No output space other than P-Values is defined for the Grayscale Softcopy Presentation State Storage SOP Classes.

- 30 In the case of a linear transformation, the Presentation LUT is described by the Presentation LUT Shape (2050,002“). In the case of a non-linear transformation, the Presentation LUT is described by the Presentation LUT Sequence. The rules for application of the Presentation LUT are defined in PS 3.3 Softcopy Presentation LUT Module.

- 35 Notes: 1. Since the grayscale transformation pipeline fully defines all transformations applied to the stored pixel values in the referenced image object, the value of Photometric Interpretation (0028,000“) in the referenced image object is ignored and overridden. This implies that either the creator of the presentation state chose a pipeline that reflects the Photometric Interpretation (0028,000“) , or chose to ignore or override the Photometric Interpretation, and invert the image relative to what is specified by Photometric Interpretation. If the Modality LUT and VOI LUT do not have a negative slope, one can achieve the effect of inversion of the polarity of an image by choosing Presentation LUT Shape of IDENTITY or INVERSE that displays the minimum pixel value as white rather than black in the case of a Photometric Interpretation of MONOCHROME2, or black rather than white in the case of a Photometric Interpretation of MONOCHROME1. If Presentation LUT Data is sent, then one can invert the **ordervalue** of the entries in the LUT table to achieve inversion of polarity.
- 40

2. The minimum P-Value (zero) always commands that the lowest intensity be displayed.
3. No separate Polarity transformation is defined.

5 A Softcopy Presentation LUT Module is always present in a Presentation State. If a Presentation LUT is present in the Image then the Presentation State Presentation LUT shall be used instead of the Image Presentation LUT.

N.2.2 Color Transformations

N.2.2.1 Profile Connection Space Transformation

10 **The Profile Connection Space Transformation operation applies only to color images, including true color (e.g., RGB) and pseudo-color (e.g., PALETTE COLOR) images, grayscale images for which a Palette Color LUT has been specified in the Presentation State, and the RGB output values of a blending operation.**

The ICC Profile is an Input Profile. That is, it describes the color characteristics of a (possibly hypothetical) device that was used to generate the input color values.

15 **The intent is that a rendering device will use this information to achieve color consistency. Typically this will be performed by calibration of the output device to create an ICC Display or Output Profile, the conversion of pixel values using the ICC Input Profile into Profile Connection Space, followed by conversion using the ICC Display or Output Profile into values suitable for rendering on the output device. However, the exact mechanisms used are beyond the scope of the standard to define.**

Notes: 1. The means of achieving color consistency depends to a large extent on the nature of the material and the intent of the application. The process is more complicated than simply achieving colorimetric accuracy, which is trivial but does not produce satisfactory results. The transformations may take into account such matters as

- 25 • **physical factors such as the ambient light of the viewing environment (viewing flare) and the nature of different illuminants**
- **psychovisual factors in the observer**
- **the preferences of the observer**
- **the consistency intent, whether it be to reproduce the colors perceived by an observer of**
 - 30 ○ **the original scene,**
 - **the media being reproduced, such as a print or transparency, as viewed under specified conditions.**

2. Implementations of color management schemes are typically provided in operating systems, libraries and toolkits, and the exact details are usually beyond the control of the DICOM application developer. Accordingly, it is normally sufficient to define a source of pixel values, and a corresponding ICC Input Profile for the device that captured or generated them.

3. When a color image is rendered on grayscale display, the behavior is not defined. Since the L* value of a CIE Lab representation of the PCS is not dissimilar to the Barten model used in the GSDP, a reasonable approach would be to interpret it as a P-Value.

40 **An ICC Profile is always present in a Color, Pseudo-Color or Blended Presentation State. If an ICC Profile is present in the Image then the Presentation State ICC Profile shall be used instead of the Image ICC Profile.**

N.2.2.2 White Point (Informative)

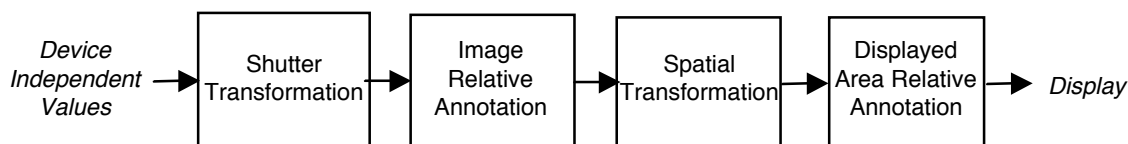
D50 means black body radiation of an object at 5000 degrees K, and includes lots of red, which looks “natural”. D65 is bluer, more like “cloudy days”, but human eyes are more sensitive to blue. While monitors seem to be in the D50-D100 range, light boxes are about D110 (11000K).

5 **The ICC PCS always uses a white point of D50.**

10 **In an ICC Input Profile, the chromaticAdaptationTag encodes a conversion of an XYZ color from the actual illumination source to the PCS illuminant (D50), and may be useful if the actual illumination source is not D50. The actual illumination source may also be defined in the mediaWhitePointTag. However, with a perceptual rendering intent, neither of these tags are required to be used by the color management system, nor do they have any specified rendering behavior (as opposed to their use with absolute and relative colorimetric rendering intents).**

It is beyond the scope of DICOM to define a required or suggested white point for rendering, since an appropriate choice depends on a knowledge of the display device or media characteristics and the viewing environment.

15 **N.2.3 Common Spatial and Annotation Transformations**



**Figure N.2-2
Common Spatial and Annotation Transformation Model**

20 **The common spatial and annotation transformations apply to any device-independent values, whether they be grayscale P-Values or color PCS-Values, for any type of presentation state.**

The values with which to render annotations are encoded as device-independent values, either as grayscale P-Values or as color PCS-Values. In the case of PCS-Values, CIE Lab values are encoded, and defined by reference to a D50 illuminant.

25 **Grayscale presentation states may specify annotations in color for rendering on a color output device.**

The mechanism for mapping grayscale P-Values and color PCS-values to the same display is implementation-dependent and not defined by the standard.

N.2.3.15 Shutter

30 The Shutter transformation provides the ability to exclude the perimeter outside a region of an image. A gray level may be specified to replace the area under the shutter.

One form of this transformation uses the Display Shutter Module as used in the X-Ray Angiography Image Storage SOP Class, though it may be applied to any Image Storage SOP Instance, including single frame images.

Another form uses a bit-mapped overlay to indicate arbitrary areas of the image that should be excluded from display by replacement with a specified gray level, as described in the Bitmap Display Shutter Module.

- Notes:
1. Since annotations follow the shutter operation in the pipeline, annotations in shuttered regions are not obscured and are visible.
 2. Any shutter present in the referenced image object is ignored (i.e. not applied).

N.2.3.26 Pre-Spatial Transformation Annotation

The Pre-Spatial Transformation Annotation transformation includes the application of bit-mapped overlays as defined in the Overlay Plane Module, and free unformatted text or vector graphics as described in the Graphic Annotation Module that are defined in the image pixel space (as opposed to the displayed area space).

N.2.3.37 Spatial Transformation

Some modalities may not deliver the image in the desired rotation and need to specify a rotation into the desired position for presentation. This transformation, specified in the Spatial Transformation Module, includes a rotation of 90, 180, 270 degrees clockwise followed by a horizontal flip (L <--> R). Rotation by an arbitrary angle is not supported.

In addition, selection of a region of the image pixel space to be displayed is specified in the Displayed Area Module. This may have the effect of magnifying (or minifying) that region depending on what physical size the display is instructed to render the selected region. If so, the method of interpolation (or sub-sampling) is implementation dependent.

- Note: In particular the number of displayed pixels may be different from the number of image pixels as a result of:
- minification (e.g. 1 display pixel for 4 image pixels),
 - magnification (4 display pixels for each image pixel),
 - interpolation (display pixels derived from values other than those in the image pixels), and
 - sub-sampling.

N.2.3.48 Post-Spatial Transformation Annotation

The Post-Spatial Transformation Annotation transformation includes the application of free unformatted text or vector graphics as described in the Graphic Annotation Module that are defined in the displayed area space (as opposed to the image pixel space).

This implies that the displayed area space is defined as being the image after all Spatial Transformations have been applied.

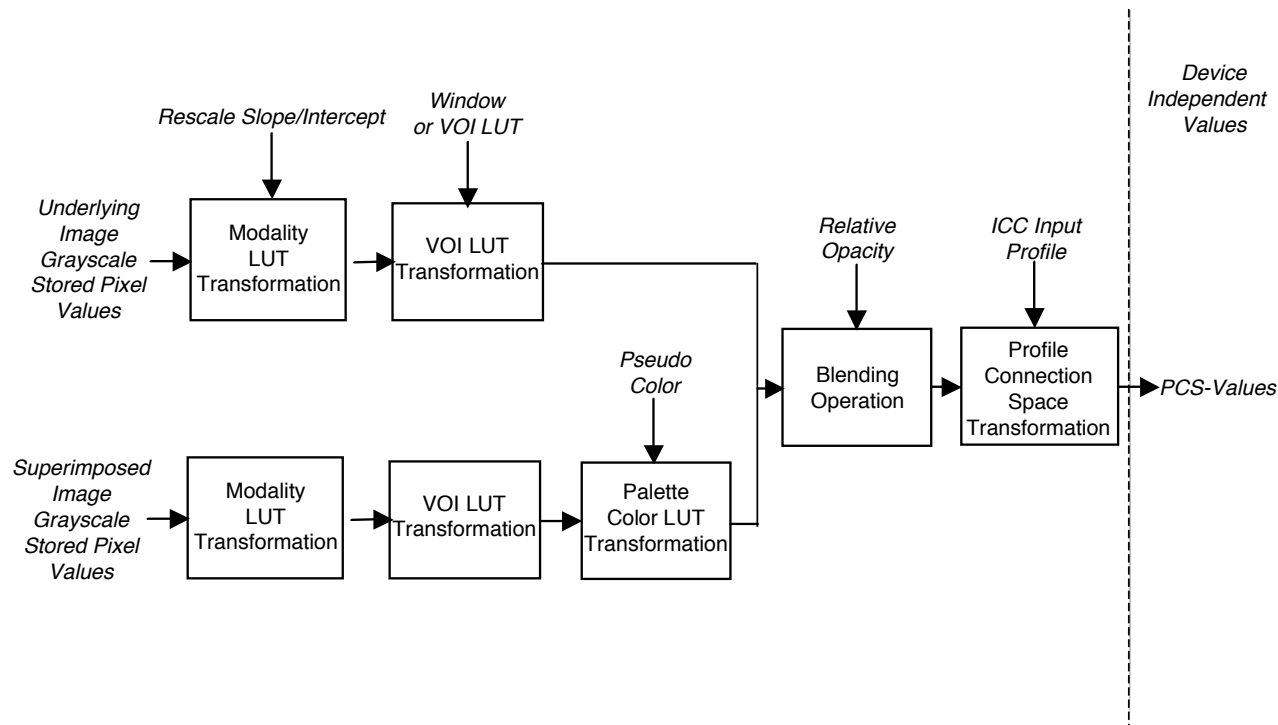
These annotations are rendered in the displayed space, though they may be anchored to points in either the displayed area or image pixel space.

N.2.4 Blending Transformations

The grayscale to color blending transformation model applies only to a pair of grayscale values, one of which is first mapped to color and then superimposed upon the other. The resulting values are device independent color PCS-Values. This process is illustrated in Figure N.2-3.

For the purpose of this section, pixels are referred to as stored pixel values and transformations are defined as point operations on these values. However, it is likely that pixels from either or both

the superimposed and underlying image sets will have been spatially resampled and hence interpolated or replicated. Such operations do not affect the conceptual pipeline.



5

Figure N.2-3
Grayscale to Color Blending Transformation Model

N.2.4.1 Underlying Image Pixels

10 **The Modality LUT and VOI LUT transformations are applied to the stored pixel values of the underlying image.**

15 **The output range of the VOI LUT transformation depends either on the width of the linear window or the range of output values of the LUT defined by the LUT Descriptor. Conceptually, for the purpose of describing the succeeding blending operation, the smallest pixel value from the range is mapped to 0.0 and the largest pixel value is mapped to 1.0 and all intermediate values are linearly mapped to the [0.0..1.0] interval.**

N.2.4.2 Superimposed Image Pixels

20 **The Modality LUT and VOI LUT transformations are applied to the stored pixel values of the superimposed image.**

The full output range of the preceding VOI LUT transformation is implicitly scaled to the entire input range of the Palette Color LUT Transformation.

The output range of the RGB values in the Palette Color LUT Transformation depends on the range of output values of the LUT defined by the LUT Descriptors. Conceptually, for the purpose of

describing the succeeding blending operation, a LUT entry of 0 is mapped to 0.0 and the largest LUT entry possible is mapped to 1.0 and all intermediate values are linearly mapped to the [0.0..1.0] interval.

Note: In practice, the Palette Color LUT output for the superimposed images is encoded in 8 or 16 bits and hence will have a range of 0 to 0xFF or 0xFFFF.

The Palette Color LUT used is that encoded in the Blending Presentation State; any Palette Color LUTs or Supplemental Palette Color LUTs in the image instances are ignored.

N.2.4.3 Blending Operation

The inputs to the blending operation are grayscale values from 0.0 to 1.0 from the underlying image (Y_u) and RGB values from 0.0 to 1.0 from the superimposed image (RGB_s), and an opacity value from 0.0 to 1.0 (A).

The output is a single image containing RGB values (RGB_o) blended as:

$$R_o = R_s * A + Y_u * (1-A)$$

$$G_o = G_s * A + Y_u * (1-A)$$

$$B_o = B_s * A + Y_u * (1-A)$$

N.2.4.4 Conversion to Profile Connection Space

The output of the blending operation is implicitly scaled to the gamut of the hypothetical device described by the ICC Input Profile, resulting in PCS-Values.

N.3 BEHAVIOR OF AN SCP

In addition to the behavior for the Storage Service Class specified in B.2.2 Behavior of an SCP, the following additional requirements are specified for the **Grayscale** Softcopy Presentation State Storage SOP Classes:

- a display device acting as an SCP of these SOP Classes shall make all mandatory presentation attributes available for application to the referenced images at the discretion of the display device user, for all Image Storage SOP Classes defined in the Conformance Statement for which the **Grayscale** Softcopy Presentation State Storage SOP Class is supported.

Note: Though it is not required, a display device acting as an SCP of the Blending Softcopy Presentation State Storage SOP Class may support the Spatial Registration Storage SOP Class in order to transform one Frame of Reference into another or to explicitly identify the relationship between members of two sets of images, and may be able to resample underlying and superimposed sets of images that differ from each other in orientation and in-plane and between-plane spatial resolution.

N.4 CONFORMANCE

In addition to the Conformance Statement requirements for the Storage Service Class specified in B.4.3, the following additional requirements are specified for the **Grayscale** Softcopy Presentation State Storage SOP Classes:

N.4.1 Conformance Statement for An SCU

The following issues shall be documented in the Conformance Statement of any implementation claiming conformance to the **Grayscale** Softcopy Presentation State Storage SOP Class as an SCU:

- For an SCU of a ~~Grayscale~~ Softcopy Presentation State Storage SOP Class that is creating a SOP Instance of the Class, the manner in which presentation related attributes are derived from a displayed image, operator intervention or defaults, and how they are included in the IOD.
- 5 — For an SCU of a ~~Grayscale~~ Softcopy Presentation State Storage SOP Class, the Image Storage SOP Classes that are also supported by the SCU and which may be referenced by instances of the ~~Grayscale~~ Softcopy Presentation State Storage SOP Class.

N.4.2 Conformance Statement for An SCP

10 The following issues shall be documented in the Conformance Statement of any implementation claiming conformance to the ~~the Grayscale~~ Softcopy Presentation State Storage SOP Class as an SCP:

- For an SCP of a ~~Grayscale~~ Softcopy Presentation State Storage SOP Class that is displaying an image referred to by a SOP Instance of the Class, the manner in which presentation related attributes are used to influence the display of an image.
- 15 — For an SCP of a ~~Grayscale~~ Softcopy Presentation State Storage SOP Class, the Image Storage SOP Classes that are also supported by the SCP and which may be referenced by instances of the ~~Grayscale~~ Softcopy Presentation State Storage SOP Class.

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PART 6 Addendum

Data Dictionary

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Section 6: Add the following entries in the table as indicated:

Tag	Name	VR	VM	
(0018,1624)	Shutter Presentation Color CIELab Value	US	3	
(0028,2000)	ICC Profile	OB	1	
(0070,0401)	Graphic Layer Recommended Display CIELab Value	US	3	
(0070,0402)	Blending Sequence	SQ	1	
(0070,0403)	Relative Opacity	FL	1	
(0070,0404)	Referenced Spatial Registration Sequence	SQ	1	
(0070,0405)	Blending Position	CS	1	

Annex A: Add the following entry to the table:

UID Value	UID Name	UID Type	Part
<u>1.2.840.10008.5.1.4.1.1.11.2</u>	<u>Color Softcopy Presentation State Storage SOP Class</u>	<u>SOP Class</u>	<u>PS 3.4</u>
<u>1.2.840.10008.5.1.4.1.1.11.3</u>	<u>Pseudo-Color Softcopy Presentation State Storage SOP Class</u>	<u>SOP Class</u>	<u>PS 3.4</u>
<u>1.2.840.10008.5.1.4.1.1.11.4</u>	<u>Blending Softcopy Presentation State Storage SOP Class</u>	<u>SOP Class</u>	<u>PS 3.4</u>

In PS 3.14 add text to Scope and Field of Applications

3.14 DICOM GRAYSCALE STANDARD DISPLAY FUNCTION

1. Scope and Field of Application

5 PS 3.14 specifies a standardized Display Function for display of grayscale images. It provides examples
of methods for measuring the Characteristic Curve of a particular Display System for the purpose of either
altering the Display System to match the Grayscale Standard Display Function, or for measuring the
conformance of a Display System to the Grayscale Standard Display Function. Display Systems include
10 such things as monitors with their associated driving electronics and printers producing films which are
placed on light-boxes or alternators.

PS 3.14 is neither a performance nor an image display standard. PS 3.14 does not define which
Luminance and/or Luminance Range or optical density range an image presentation device must provide.
PS 3.14 does not define how the particular picture element values in a specific imaging modality are to be
presented.

15 PS 3.14 does not specify functions for display of color images, as the specified function is limited to the
display of grayscale images. Color Display Systems may be calibrated to the Grayscale Standard Display
Function for the purpose of displaying grayscale images. **Color images, whether associated with an
ICC Profile or not, may be displayed on standardized grayscale displays, but there are no
normative requirements for the display of the luminance information in a color image using the
20 GSDF.**