DICOM Correction Proposal

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CP-2170

Log Summary:
Fix inconsistent use of name “Blending Presentation State”

Name of Standard
PS3.3, PS3.4, PS3.17 2021c

Rationale for Correction:
The name “Blending Presentation State” (sometimes “Blended Presentation State”) is used for both IODs and SOP Classes throughout various parts of the DICOM standard. However, the official names are “Blending Softcopy Presentation State” and “Advanced Blending Presentation State”. It is proposed to use the official names consistently, depending on which one is meant.

Open issue:
In some sections, the standard text generally refers to “Presentation State” although this term is not defined, e.g. in PS3.3 Chapter 3. If this term would be introduced as a defined term, it would probably also make sense to introduce “Blending Presentation State” and refer to this in the standard text depending on the context (see comments on the following pages). There is a precedent with the "Volumetric Presentation State (VPS)”, which is defined in PS3.3 Section 3.17.

Correction Wording:

3 Definitions

For the purposes of this Standard the following definitions apply.

[...]

3.17 Multi-dimensional Definitions

[...]

Volumetric Presentation State (VPS)

A Presentation State that defines a transformation from 3D spatial input data (volume) to 2D spatial output data, with or without affecting other dimensions such as temporal.

Change PS3.3 Section A.1.2.3

A.1.2.3 Series IE

The Series IE defines the Attributes that are used to group Composite Instances into distinct logical sets. Each Series is associated with exactly one Study.

The following criteria group Composite Instances into a specific Series:

a. All Composite Instances within a Series must be of the same modality
b. Each Series may be associated with exactly one Frame of Reference IE, and if so associated all Composite Instances within the Series shall be spatially or temporally related to each other

c. All Composite Instances within the Series shall be created by the same equipment; therefore, each Series is associated with exactly one Equipment IE

d. All Composite Instances within a Series shall have the same Series information

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).

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.

Waveforms shall be grouped into Series without Images. A Frame of Reference IE may apply to both Waveform Series and Image Series.

SR Documents shall be grouped into Series without Images. The Frame of Reference IE may apply to both SR Document Series, for SR Documents that contain 3D spatial coordinates relative to one or more spatial Frames of Reference, or temporal coordinates that require a temporal Frame of Reference.

A.75.1 Parametric Map IOD Description

The Parametric Map Information Object Definition (IOD) specifies a multi-frame image representing pixels with real world values. Parametric Maps are either integer or floating point.

The Parametric Map IOD does not include the full set of acquisition parameters of any acquired images from which they were derived, e.g., cardiac phase. An application rendering or processing the Parametric Map may need to access the source images for such information.

The Parametric Map IOD requires the presence of VOI LUT (window) information with the intent that at a minimum the image be renderable without special processing. The output space is defined as P-Values to achieve consistency.

Note

• The VOI LUT mechanism specifically supports floating point values, and there is no expectation that it be limited to integer input or output ranges.

• Even though the output of the VOI LUT is not constrained to be integer values, implicit scaling of the output range to the input range of an integer-based Palette Color LUT can be used to apply pseudo-color for display. Pseudo-color mapping information may be encoded with the image. This may be applied at the discretion of the receiving application or it may use a separate DICOM Color Palette IOD or some other mechanism.

The Parametric Map IOD encodes one or more parameters as an image. Other Image IODs may be used to encode related information, and Instances of them may be referenced from the Parametric Map, as the source from which a parameter was derived, or some other relationship.

Note

• The Blending Softcopy Presentation State IOD may be used to describe how (selected frames of) a Parametric Map Instance may be superimposed on, say, frames of acquired images for anatomical reference encoded as Instances of other Image IODs, as well as the relative opacity and pseudo-color applicable to the overlying frames.

• Commonality of the same Frame of Reference UID also allows an application to relate Parametric Map Instances and other Image Instances, in the absence of explicit references.

• The Parametric Map IOD is not restricted to encoding only a single parameter in one instance. Since it is a multi-frame object, and since the type of parameter is encoded in the Real World Value Mapping Macro, which may vary on a per-frame basis, the parameter may also vary from frame-to-frame. In such cases, the Multi-frame Dimension Module may be used to highlight this, by specifying the Quantity Definition Sequence (0040,9220) as a Dimension Index.

Commented [JR2]: This term needs to be defined (see above).

Commented [JR3]: Should we also mention the Advanced Blending Presentation State IOD here?
C.11.17.2 Referenced Image Sequence and Referenced Presentation State Sequence

Image SOP Instances, or frames from multi-frame SOP Instances, to be displayed in an Image Box may be identified either directly by the Referenced Image Sequence (0008,1140), or indirectly through the Referenced Presentation State Sequence (0008,9237).

Referenced Image Sequence (0008,1140) is permitted to be zero length, indicating an empty Image Box.

Note
1. The recommended display color for an empty Image Box is specified by Empty Image Box CIELab Value (0072,0421).
2. When displaying a standard template such as a dental full mouth series, an empty image box may be used to indicate that the corresponding view was not taken.

If images are identified indirectly through the Referenced Presentation State Sequence (0008,9237), all of the image frames identified in the top level Referenced Series Sequence (0008,1115) Attribute shall be displayed. For images identified indirectly through a Blending Softcopy Presentation State SOP Instance, all the image frames for which the Blending Position (0070,0405) value is UNDERLYING shall be displayed, with the relevant SUPERIMPOSED images blended as necessary.

If images are to be displayed, the number of frames referenced for display shall be consistent with the value of Image Box Layout Type (0072,0304). If the value of Image Box Layout Type is SINGLE, only a single frame shall be referenced, either directly or indirectly; if the value is CINE, only a single multi-frame SOP Instance shall be referenced.

If the value of Image Box Layout Type is STACK, more than one SOP Instance or frame may be referenced, and the frames constitute a stack to be displayed in the Image Box. For frames identified by the Referenced Image Sequence, the order of stepping through the stack shall be the order of Image SOP Instance references in that Sequence. If multiple frames are selected in Referenced Frame Number (0008,1160), those frames shall be stepped through in the order of their listing in that Attribute, within the order of display of their Image SOP Instance.

For a stack whose frames are selected indirectly through an Item of the Referenced Presentation State Sequence, the order of stepping through the stack shall be the order of SOP Instance references in the Referenced Series Sequence (0008,1115) of the referenced Presentation State. For a referenced Blending Softcopy Presentation State, this shall be the Referenced Series Sequence within the Blending Sequence (0070,0402) Item for which the Blending Position (0070,0405) value is UNDERLYING.

Note
1. Display of images using Blending Softcopy Presentation State must use indirect SOP Instance reference through the Referenced Presentation State Sequence (0008,9237) at the top level of Structured Display Image Box Sequence (0072,0422) Item, and cannot use the Referenced Presentation State Sequence within an Item of the Referenced Image Sequence (0008,1140).
2. A Blending Softcopy Presentation State that references a blending of a single underlying frame and a single superimposed frame may be associated with a SINGLE Image Box Layout.
3. A reference to a single display frame, either directly through Referenced Image Sequence or indirectly through Referenced Presentation State Sequence, may be associated with either a STACK or a CINE Image Box Layout as a degenerate case.
4. There is no requirement for the pixel matrix sizes of the images in the stack, or the image display area as selected by referenced Presentation State SOP Instances, to be identical, nor for the referenced images to be of the same SOP Class.
5. Referenced Presentation States are an initial presentation control. The rendering Application Entity might allow a user to interactively enable/disable graphic layers, or change the zoom, rotation, window width / window level, or other presentation controls. Any such Application Entity functionality is beyond the scope of the Standard.
N.1 Overview

N.1.1 Scope

The Softcopy Presentation State Storage SOP Classes extend 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 specify the information and behavior that may be used to present (display) images that are referenced from within the SOP Classes.

They include capabilities for specifying:

- the output grayscale space in P-Values
- the color output space as PCS-Values
- grayscale contrast transformations including modality, VOI and presentation LUT
- mask subtraction for multi-frame grayscale images
- selection of the area of the image to display and whether to rotate or flip it
- image and display relative annotations, including graphics, text and overlays
- the blending of two image sets into a single presentation

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 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 PS3.14 Grayscale Standard Display Function.

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.

The blending softcopy and advanced 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.

The 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 apply must be a part of the same study that the stored state is a part of, and 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.

[...]

Commented [JR4]: Is this also true for the Advanced Blending Presentation State?

Commented [JR5]: Now, the three types of presentation states are written with a capital initial letter. Shouldn’t this mean that there is a definition of these terms?

Commented [JR6]: Alternatively, use “Blending Presentation State” if this would be a defined term.
N.2.2 Color Transformations

N.2.2.1 Profile Connection Space Transformation

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.

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.

Note
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
   • 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
     • 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 tool kits, 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 CIELab representation of the PCS is not dissimilar to the Barten model used in the GSDF, a reasonable approach would be to interpret it as a P-Value.

An ICC Profile is always present in a Color, Pseudo-Color or Blending 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.

Change PS3.4 Section N.2.4.2

N.2.4.2 Superimposed Image Pixels

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.

Change PS3.4 Section N.2.6

N.2.6 Advanced Blending Transformations

The advanced blending transformation model applies to multiple color inputs and uses foreground blending or equal blending.

Several transformations in this IOD affect the input prior to its use in blending as depicted in Figure N.2.6-1.

Grayscale inputs that have no associated Color LUT information shall have the normal grayscale processing and then be converted to a full color image by setting R equals G equals B.

![Diagram](image)

**Figure N.2.6-1. Color and Threshold Application**

Padding pixels in an input are given an opacity value zero and shall be set to 0 for Red, Green, and Blue.

The foreground method blends two inputs. The first input uses an opacity of Relative Opacity (0070,0403) and the second input uses an opacity of (1 - Relative Opacity (0070,0403) )

If both the inputs are padding values then the result is padding value.

If one of the values is padding value then the result is the non-padding value.

If both pixels have values then result is Relative Opacity * first value + (1 - Relative Opacity) * second value.

Commented [JR8]: Not sure whether the IOD(s) or SOP Class(es) should be mentioned here. As far as I can see, "Blending Presentation State" is not a defined term in the standard text (also see "Open Issue" on cover page).
The **equal** blending mode blends two or more inputs where for each pixel location the opacity is calculated as 1.0 divided by the number of non-padding pixels. The result pixel blends all non-padding pixels using the calculated opacity. If an input pixel value is the padding-value then the Relative Opacity for that input pixel is zero. If an input pixel value is not the padding value then the Relative Opacity for that pixel is 1 / (number of input pixels that are non-padding pixels). The result value is the sum for all input pixels of the input pixel value * Relative Opacity. If all the inputs pixels are padding values then the result is padding value.

### Change PS3.4 Section N.3

#### N.3 Behavior of an SCP

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

1. 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 Softcopy Presentation State Storage SOP Class is supported.

2. a display device that is acting as an SCP of these SOP Classes and that supports compound graphics types shall display the graphics described in the Compound Graphic Sequence (0070,0209) and shall not display the Items in the Text Object Sequence (0070,0008) and Graphic Object Sequence (0070,0009) that have the same Compound Graphic Instance ID (0070,0226) value.

   **Note**

   Though it is not required, a display device acting as an SCP of the Blending Softcopy Presentation State Storage SOP Class, or the Advanced Blending 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.
NNN.3 Corneal Topography Examples

Quantitative measurements of anterior corneal surface curvature (corneal topography) are made with the Placido ring approach. Patterns on an illuminated target take the form of mires or a grid pattern. Their reflection from the anterior corneal surface tear film, shown in Figure NNN.3-1, is captured with a video camera. Their positions relative to the instrument axis are determined through image analysis and these data are used to calculate anterior corneal curvature distribution.

Figure NNN.3-1. Placido Ring Image Example

Corneal curvature calculations are accomplished with three different methods that provide corneal powers. The axial power map, shown in Figure NNN.3-2, is most useful clinically for routine diagnostic use as the method of calculation presents corneal topography maps that match the transitions known for corneal shape—the cornea is relatively steep in its central area, flattening toward the periphery. This figure shows an example where the map is superimposed over the source image based upon the corneal vertex Frame of Reference. The Advanced Blending Presentation State SOP Class may be used to specify this superimposed processing.

[...]