Digital Imaging and Communications in Medicine (DICOM)

Supplement 156:

Planar MPR Volumetric Presentation State

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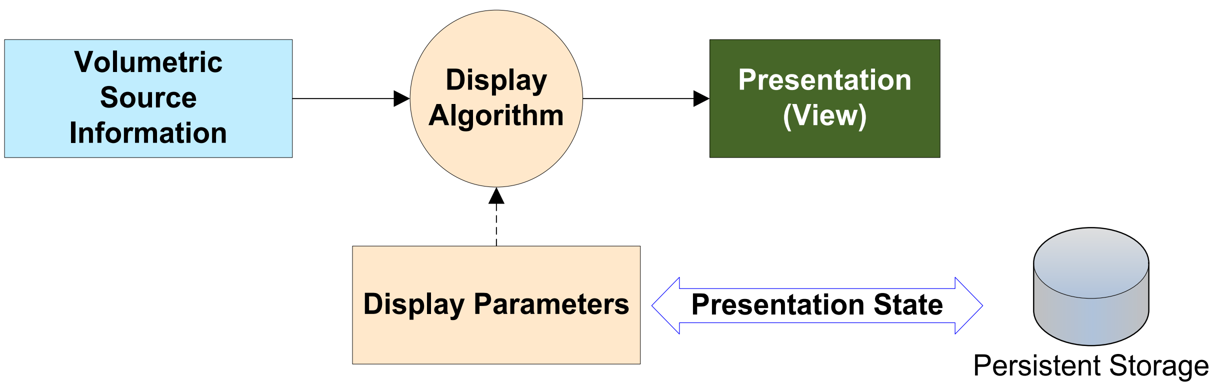
Scope and Field of Application

This supplement adds an IOD and two SOP Classes for a Planar MPR Volumetric Presentation State to the DICOM Standard.

The new SOP Classes allow rendering of 3D volumes or temporal sequences of 3D volumes (a.k.a., 4D), which may be represented as any of the following structures:

- SOP Classes in which a single instance may represent 3D or 4D volume datasets, such as XA-3D or many of the Enhanced SOP Classes
- SOP Classes that by convention allow a collection of instances within a common Frame of Reference to contain spatially and temporally related frames, which together comprise a 3D or 4D volume dataset. This is commonly the case with CT and MR.

3D and 4D data may be presented through a variety of display algorithms, such as frame-by-frame viewing, multi-planar reconstruction, surface rendering and volume rendering. When a volume presentation is created through the use of a Display Algorithm, it typically requires a set of Display Parameters that determine the specific presentation to be obtained from the volume data. Persistent storage of the Display Parameters used by a Display Algorithm to obtain a presentation from a set of volume-related data is called a Volumetric Presentation State (VPS).



The Volumetric Source Information consists of one or more volumes (3D or 4D) used to form the presentation.

Volumetric Presentation States can only be applied by systems capable of performing the processing described in the presentation. Volumetric Presentation State creators may also create Secondary Captures or other derived images to convey basic presentation information to systems without these capabilities (see PS 3.17 Annex Y.2).

Certain inputs may contain multiple data types at the same points in space and time, so Volumetric Presentation States include a definition of a blending pipeline for combining the different types of information into a single presentation, such as by distinguishing types by colors. Also, since more than one input may be used to form the presentation, Volumetric Presentation States address the problem of image fusion in two and three dimensions.

Each Volumetric Presentation State describes either a single view or an initial view and optional animation parameters. A Volumetric Presentation State may also indicate that a particular view is intended to be displayed alongside the views from other Volumetric Presentation States. However, descriptions of how multiple views should be presented are not part of a Volumetric Presentation State and should be specified by a Structured Display, a Hanging Protocol or by another means.

The result of application of a Volumetric Presentation State is not expected to be exactly reproducible on different systems. It is difficult to describe the display algorithms in enough detail in an interoperable manner, such that a presentation produced at a later time is indistinguishable from that of the original presentation. While Volumetric Presentation States use established DICOM concepts of grayscale and color matching (GSDF and ICC color profiles) and provides a generic description of the different types of display algorithms possible, variations in algorithm implementations within display devices are inevitable and an exact match of volume presentation on multiple devices cannot be guaranteed. Nevertheless, reasonable consistency is provided by specification of inputs, geometric descriptions of spatial views, type of processing to be used, color mapping and blending, input fusion, and many generic rendering parameters, producing what is expected to be a clinically acceptable result.

Examples of how the VPS can be used to represent various clinical scenarios are included.

Changes to NEMA Standards Publication PS 3.2

Digital Imaging and Communications in Medicine (DICOM)

Part 2: Conformance

Item #1: Add SOP Classes to PS3.2 Table A.1-2

Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.11.6	**Grayscale Planar MPR Volumetric Presentation State Storage SOP Class**	**Transfer**
1.2.840.10008.5.1.4.1.1.11.7	**Compositing Planar MPR Volumetric Presentation State Storage SOP Class**	**Transfer**

Changes to NEMA Standards Publication PS 3.3

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Part 3: Information Object Definitions

Item #2: Add reference to PS3.3 Section 2.6

2.6 Other References

[Porter-Huff, 1984] Porter, Thomas; Tom Duff (1984). "Compositing Digital Images". Computer Graphics 18 (3): 253–259.doi:10.1145/800031.808606. ISBN 0-89791-138-5

Item #3: Add definitions to PS3.3 Section 3.17

Multi-Planar Reconstruction (MPR): Also called Multi-Planar Reformatting. A data visualization created by sampling volume data, typically represented by a stack of image planes, that lies in the neighborhood of the intersection of the volume with a plane, curved plane, slab or curved slab.

Planar MPR: An MPR where the samples are centered on a single plane intersected with the volume.

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.

Volumetric Presentation State Reference Coordinate System (VPS-RCS): The Reference Coordinate System to which inputs to a Volumetric Presentation State are registered and to which Attribute Values of a Volumetric Presentation State are referenced (unless stated otherwise).

Volumetric Presentation View: A presentation, with two spatial dimensions, of volume data.

Item #4: Add IODs to PS3.3 Table A.1-1

IODs **Modules**	**Planar MPR Volumetric Presentation State**
Patient	**M**
Clinical Trial Subject	**U**
General Study	**M**
Patient Study	**U**
Clinical Trial Study	**U**
General Series	**M**
Clinical Trial Series	**U**
Presentation Series	**M**
Frame Of Reference	**M**
General Equipment	**M**
Enhanced General Equipment	**M**
Volumetric Presentation State Identification	**M**

Volumetric Presentation State Relationship	**M**
Volume Cropping	**U**
Presentation View Description	**M**
Multi-Planar Reconstruction Geometry	**M**
Volumetric Presentation State Display	**M**
Volumetric Graphic Annotation	**U**
Graphic Annotation	**U**
Graphic Layer	**C**
Presentation Animation	**U**
Common Instance Reference	**M**
SOP Common	**M**

Item #5: Add sections to PS3.3 Annex A

A.x VOLUMETRIC PRESENTATION STATE INFORMATION OBJECT DEFINITIONS

A.X.x1 PLANAR MPR VOLUMETRIC PRESENTATION STATE INFORMATION OBJECT DEFINITION

A.X.x1.1 Planar MPR Volumetric Presentation State Description

The Planar MPR Volumetric Presentation State Information Object Definition (IOD) specifies information that defines a Planar MPR presentation from volume datasets that are referenced from within the IOD.

It includes capabilities for specifying:

a. spatial registration of the input datasets
b. cropping of the volume datasets by a bounding box, oblique planes and segmentation objects
c. the generation geometry of thin and slab Multi-Planar Reconstructions
d. the method for rendering slab Multi-Planar Reconstructions
e. scalar to P-Value or RGB Value conversions
f. compositing of multiple renderings
g. clinical description of the specified view
h. volume and display relative annotations, including graphics, text and overlays

i. membership in a collection of related Volumetric Presentation States intended to be processed or displayed together
j. the temporal position within a set of temporally related Volumetric Presentation States
k. recommendations for animating the view
l. reference to an image depicting the view described by the Presentation State

The Planar MPR Volumetric Presentation State IOD is used in two SOP Classes as defined in PS3.4 Storage Service Class, a SOP Class for grayscale Presentation States intended for presenting a single input, and a SOP Class for Presentation States that composite multiple inputs into a single presentation. These are distinguished by their SOP Class UID and by the Enumerated Value of the mandatory Attribute in the Volumetric Presentation State Display Module, Pixel Presentation (0008,9205).

A.X.x1.2 Planar MPR Volumetric Presentation State IOD Module Table

Table A.X.x1-1
PLANAR MPR VOLUMETRIC 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
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Presentation State	Volumetric Presentation State Identification	C.11.x1	M
	Volumetric Presentation State Relationship	C.11.x2	M
	Volume Cropping	C.11.x3	U
	Presentation View Description	C.11.x4	M
	Multi-Planar Reconstruction Geometry	C.11.x5	M
	Volumetric Presentation State Display	C.11.x8	M

	Volumetric Graphic Annotation	C.11.x9	U
	Graphic Annotation	C.10.5	U
	Graphic Layer	C.10.7	C Required if Graphic Layer (0070,0002) is present in Volumetric Presentation State Relationship module, Volumetric Graphic Annotation, or Graphic Annotation module
	Presentation Animation	C.11.xA	U
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M

A.X.x1.3 Planar MPR Volumetric Presentation State IOD Content Constraints

A.X.x1.3.1 Presentation Input Restrictions

Presentation Input Type (0070,1202) shall have a value of VOLUME.

If the value of Pixel Presentation (0008,9205) is MONOCHROME, the Volumetric Presentation State Input Sequence (0070,1201) shall have only a single item.

A.X.x1.3.2 Multi-Planar Reconstruction Style

Multi-Planar Reconstruction Style (0070,1501) shall have a value of PLANAR.

A.X.x1.3.3 Graphic Annotation Module

The following attributes, if present, shall have a value of DISPLAY:

- Bounding Box Annotation Units (0070,0003)
- Anchor Point Annotation Units (0070,0004)
- Graphic Annotation Units (0070,0005)

The Display coordinates are relative to the Volumetric Presentation View produced by this Presentation State.

This module shall only be used to create annotations that have no spatial relationship to the current view as the annotation may continue to be displayed after the view is changed.

Note: See PS 3.17 Annex Y "Usage of Annotations in Volumetric Presentation States (Informative)" for guidance on usage of the graphic annotation styles available in this IOD.

A.X.x1.3.4 Volume Cropping Module

The values of Volume Cropping Method (0070,1302) shall be selected from the following list:

BOUNDING_BOX
OBLIQUE_PLANES

INCLUDE_SEG

EXCLUDE_SEG

A.X.x1.3.1.5 Volumetric Presentation State Reference Coordinate System

All SOP Instances referenced in the Volumetric Presentation State Relationship Module shall be implicitly or explicitly registered to the Volumetric Presentation State Reference Coordinate System. See C.11.x2.3.

Item #6: Update to PS3.3 Annex C as follows

C.11.17 Structured Display Image Box Module

Table C.11.17-1 describes the attributes of the Structured Display Image Box Module.

Table C.11.17-1
Structured Display Image Box Attributes

Attribute Name	Tag	Type	Attribute Description
Structured Display Image Box Sequence	(0072,0422)	1	The image display boxes defined in the display environment, together with the reference to the image to be displayed in each Image Box. One or more Items shall be included in this sequence.
…			
>Image Box Layout Type	(0072,0304)	1	Type of layout of the Image Box. The types are primarily distinguished by their interaction technique. Defined Terms: STACK: a single rectangle containing a steppable single frame, intended for user-controlled stepping through the image set, usually via continuous device interaction (e.g., mouse scrolling) or by single stepping (mouse or button click). CINE: a single rectangle, intended for ~~**video type play back**~~ **animation** where the user controls are play sequence, rate of play, and direction. **VOLUME_VIEW: a single rectangle, intended for volumetric display.** **VOLUME_CINE: a single rectangle, intended for animation of a volumetric view.** SINGLE: a single rectangle, intended for images and objects with no defined methods of interaction. Note: This value may also be used for non-image objects, such as waveforms and SR documents.

…			
>Referenced Presentation State Sequence	(0008,9237)	1C	Reference to a Softcopy Presentation State SOP Instance **or a Volumetric Presentation State SOP Instance** whose referenced images are to be displayed in the Image Box using the presentation controls of the referenced SOP Instance. ~~**Only a single Item**~~ **One or more items** shall be included in this sequence. **Multiple items are only permitted if the Image Box Layout Type (0072,0304) has a value of VOLUME_CINE.** Required if Referenced Image Sequence (0008,1140), Referenced Stereometric Instance Sequence (0008,1134), and Referenced Instance Sequence (0008,114A) are not present. See C.11.17.1.2.
>>Include 'SOP Instance Reference Macro' Table 10-11			
…			

Item #7: Modifications to PS3.3 Annex C

C.11.x1 Volumetric Presentation State Identification Module

Table C.11.x1-1 contains Attributes that describe the volume view type of this Presentation State.

Table C.11.x1-1
VOLUMETRIC PRESENTATION STATE IDENTIFICATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
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.
Include Content Identification Macro Table 10-12			Note: The Content Label 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.
Rendered Image Reference Sequence	(0070,1104)	3	A rendered representation of the view described by this Presentation State. Only one item shall be present in this sequence. See PS 3.17 Annex Y.2.
>Include 'Image SOP Instance Reference Macro' Table 10-3			
Presentation Display Collection UID	(0070,1101)	3	Unique identifier of a collection of Presentation State instances that are intended by the Presentation State creator to be processed or displayed together. See C.11.x1.1. Note: A Key Object Selection Document with document title code value "Sup156_xx01" could be used to reference all Volumetric Presentation States in a particular spatial collection.

Presentation Sequence Collection UID	(0070,1102)	1C	Unique identifier of a collection of Presentation State instances that are sequentially related. See C.11.x1.2. Required if Presentation Animation Style (0070,1A01) is present with a value of PRESENTATION_SEQ. May be present otherwise. Note: A Key Object Selection Document with document title code value “Sup156_xx01” could be used to reference all Volumetric Presentation States in a particular sequence collection.
Presentation Sequence Position Index	(0070,1103)	1C	Ordinal position of this Presentation State within a presentation sequence collection. Shall be a monotonically increasing integer, starting from 1, incrementing by 1, unique within the instances sharing the same value of Presentation Sequence Collection UID (0070,1102). See C.11.x1.2. Required if Presentation Sequence Collection UID (0070,1102) is present.

C.11.x1.1 Presentation Display Collection UID

Views that are intended to be displayed together can be associated by assigning them to a common Presentation Display Collection UID (0070,1101).

Note: Examples of a display collection include:

- a set of mutually-orthogonal views that are intended to be displayed together
- a set of slices that are intended to be displayed in a “light-box” format

Display applications applying a Presentation State that contains a Presentation Display Collection UID (0070,1101) may look for other Presentation States that share the same value of Presentation Display Collection UID (0070,1101) and choose to process or present them together.

See PS 3.17 Y.3.1 for an example of the use of this attribute.

C.11.x1.2 Presentation Sequence Collection UID

A set of Presentation States with the same value of Presentation Sequence Collection UID (0070,1102) defines a sequence of views. The Presentation Sequence Position Index (0070,1103) specifies the order of Presentation States within this presentation sequence.

Presentation States in such a collection may be used in an animation. In this form of animation, Presentation States in the set are applied in sequential order to produce a moving view. Typically, the same input(s) are used in each Presentation State of the set. See the PRESENTATION_SEQ animation style in section C.11.xA.

Note: Examples include:

- animation of a sequence of MPRs depicting the left ventricle of the heart at each point in a cardiac cycle with slightly different geometries
- animation of a sequence of views throughout the cardiac cycle in which a stent appears stationary in the middle of the view
- a sequence of parallel slices of an anatomical structure (that aren't necessarily going to be animated)

Presentation States in such a collection that are not used in an animation leave the style of presentation to the discretion of the display application, such as by display of all related presentations in a "light-box" format or in a single display frame with manual scrolling of the views.

All Presentation States with the same value of Presentation Sequence Collection UID (0070,1102) shall share the same Volumetric Presentation State Reference Coordinate System.

C.11.x2 Volumetric Presentation State Relationship Module

Table C.11.x2-1 contains Attributes that describe sets of inputs to a Presentation State and how each input is to be displayed in the presentation.

Table C.11.x2-1
VOLUMETRIC PRESENTATION STATE RELATIONSHIP MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Volumetric Presentation State Input Sequence	(0070,1201)	1	Inputs to the Presentation State. Each item represents one input. One or more items shall be included in this sequence.
>Volumetric Presentation Input Number	(0070,1207)	1	Identification number of the input. Values shall be ordinal numbers starting from 1 and monotonically increasing by 1 within the Volumetric Presentation State instance.

Attribute Name	Tag	Type	Attribute Description
>Presentation Input Type	(0070,1202)	1	Type of input. See C.11.x2.1. Enumerated Value: VOLUME
>Input Sequence Position Index	(0070,1203)	1C	Position of this input data within a set of sequential inputs. Multiple inputs may share the same value. Note: For example, CT and PET inputs. Distinct values shall be ordinal numbers starting from 1 and monotonically increasing by 1 within the Volumetric Presentation State instance. See C.11.x2.2. Required if Presentation Animation Style (0070,1A01) is present with a value of INPUT_SEQ. Note: The inputs of the sequence are typically temporally related.
>Referenced Image Sequence	(0008,1140)	1C	The set of images comprising this input volume. One or more items shall be included in this sequence. See C.11.x2.1 for constraints on objects referenced by this sequence. Required if Presentation Input Type (0070,1202) has a value of VOLUME.
>>Include 'Image SOP Instance Reference Macro' Table 10-3			
>Referenced Spatial Registration Sequence	(0070,0404)	1C	A reference to a Spatial Registration Instance that is used to register the referenced inputs. Only one item shall be included in this sequence. All images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation State Input Sequence (0070,1201) shall be referenced by the Spatial Registration instance. See C.11.x2.3. Required if the Frame of Reference UID (0020,0052) value of the Images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation State Input Sequence (0070,1201) does not match the Frame of Reference UID (0020,0052) value of this Presentation State instance. May be present otherwise.

Attribute Name	Tag	Type	Attribute Description
>>Include SOP Instance Reference Macro Table 10-11			
>Include VOI LUT Macro Table C.11-2b			
>Crop	(0070,1204)	1	Specifies whether to crop this input. Enumerated Values: YES NO
>Cropping Specification Index	(0070,1205)	1C	Values of Cropping Specification Number (0070,1309) of the item in the Volume Cropping Sequence (0070,1301) specifying the cropping methods to be applied to this input. Required if Crop (0070,1204) has a value of YES.
>Compositing Method	(0070,1206)	1C	The rendering method for this input. Enumerated values: AVERAGE_IP: A method that projects the mean intensity of all interpolated samples that fall in the path of each ray traced from the viewpoint to the plane of projection. MAXIMUM_IP: A method that projects the interpolated sample with maximum intensity that fall in the path of each ray traced from the viewpoint to the plane of projection. MINIMUM_IP: A method that projects the interpolated sample with minimum intensity that fall in the path of each ray traced from the viewpoint to the plane of projection. Required if MPR Thickness Type (0070,1502) has a value of SLAB.

C.11.x2.1 Presentation Input Type VOLUME Input Requirements

SOP instances with Presentation Input Type (0070,1202) value of VOLUME referenced by one item in Volumetric Presentation State Input Sequence (0070,1201) are a collection of image instances or frames within image instances that conforms to the following requirements:

- All image instances shall have the same values of
  - SOP Class UID (0008,0016)
  - Series Instance UID (0020,000E)
  - Frame of Reference UID (0020,0052) or Volume Frame of Reference UID (0020,9312)
- All instances or frames shall have the following attributes of the same value:
  - Samples per Pixel (0028,0002)
  - Photometric Interpretation (0028,0004)

- Rows (0028,0010)
- Columns (0028,0011)
- Bits Allocated (0028,0100)
- Bits Stored (0028,0101)
- High Bit (0028,0102)
- Pixel Representation (0028,0103)
- Pixel Spacing (0028,0030)

- Photometric Interpretation (0028,0004) shall be MONOCHROME2
- All Instances or Frames s have orthogonal row and column vectors
- A VOLUME input shall have more than one frame.
- No two Instances or Frames share the same Image Position (Patient) (0020,0032) or Image Position (Volume) (0020,9301). Two Instances or Frames should be treated as sharing the same position if the differences between their positions is sufficiently small.
- All Instances or Frames shall be parallel. Instances or Frames may be treated as parallel if the differences in their Image Orientation (Patient) (0020,0037) or Image Orientation (Volume) (0020,9302) are sufficiently small.
- All Instances or Frames shall be sufficiently aligned such that a single ray can pass through the upper-left hand corner of all Instances or Frames. That ray shall be orthogonal to the plane of the frame (i.e., normal to the input frames). Instances or Frames may be treated as aligned if the degree of misalignment between frames or relative to the normal is sufficiently small.
- A VOLUME input may have:
  - Variable spacing between slices
  - Overlapping slice thicknesses
  - Gaps between slice thicknesses

Note: The degree of tolerance for discrepancies in position and orientation may vary between applications.

C.11.x2.2 Input Sequence Position Index

A sequence of inputs may be used in an animation. In this form of animation, the Presentation State is applied to each input in a sequence of inputs to produce a moving view. The inputs belonging to the input sequence are identified by the inclusion of an Input Sequence Position Index (0070,1203) value for each included input. See the INPUT_SEQ animation style in section C.11.xA.

Note: Examples include:

- a sequence of cardiac volume acquisitions acquired through a heart cycle
- a sequence of volume acquisitions during multiple phases of passage of a contrast agent

There is another animation method “Presentation Sequence Animation” that may be used. See Section C.11.x1.2.

C.11.x2.3 Volumetric Presentation State Reference Coordinate System

The Volumetric Presentation State Reference Coordinate System (VPS-RCS) is identified by the Frame of Reference Module in C.7.4.1.

All SOP Instances specified in the Volumetric Presentation State Relationship Module shall be implicitly or explicitly registered to the Volumetric Presentation State Reference Coordinate System. Registration is implicit if the Frame of Reference of a particular input SOP Instance is chosen as the VPS-RCS. Explicit registration is required if the Frame of Reference UID value of one or more input SOP Instances are different from the Frame of Reference UID value of the Presentation State.

Note 1: If the Presentation State has a single source object, it is recommended that the Presentation State use the same Frame of Reference UID as the source object and not require explicit Spatial Registration.

Note 2: It should be recognized that not all objects with the same Frame of Reference UID values are precisely registered to the frame of reference implied by that UID (for example, successive scans of a patient by a CT/PET scanner where the patient may have moved somewhat between scans). In such a case, explicit registration may be necessary to achieve the precision of registration required by the clinical application.

C.11.x3 Volume Cropping Module

Table C.11.x3-1 contains the attributes of the Volume Cropping module. This Module limits the spatial extent of inputs in Volumetric Presentation State Input Sequence (0070,1201) that are used.

Table C.11.x3-1
VOLUME CROPPING MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Volume Cropping Sequence	(0070,1301)	1	Regions cropped from volumetric presentation inputs. One or more items shall be included in this sequence.
>Cropping Specification Number	(0070,1309)	1	Identification number of the cropping specification, as an ordinal number starting from 1 and monotonically increasing by 1 within the Volumetric Presentation State Instance.
>Volume Cropping Method	(0070,1302)	1	Method of volume cropping applied. Enumerated values: BOUNDING_BOX OBLIQUE_PLANES INCLUDE_SEG EXCLUDE_SEG See C.11.x3.1 for description of terms.
>Bounding Box Crop	(0070,1303)	1C	A cuboid containing the source volume data to be included. The axes of the cuboid are aligned to the axes of encoded source volume. The bounding box is defined by the (x,y,z) coordinates in mm of two opposite corners in the Volumetric Presentation State Reference Coordinate System. Note: If the source volume consists of gantry tilted slices (e.g., CT) then the bounding box will be a cuboid in the encoded image space, but a parallelepiped in the VPS-RCS. Required if Volume Cropping Method (0070,1302) has a value of BOUNDING_BOX.
>Oblique Cropping Plane Sequence	(0070,1304)	1C	Oblique cropping planes that contain the source volume data to be included. One or more items shall be included in this sequence. Required if Volume Cropping Method (0070,1302) has a value of OBLIQUE.
>>Plane	(0070,1305)	1	A plane described by a four-tuple (A,B,C,D) describing coordinates in mm of the plane equation Ax+By+Cz+D=0 relative to the Volumetric Presentation State Reference Coordinate System.

>>Plane Normal	(0070,1306)	1	Vector of the normal to the plane pointing outside of the volume to be included, encoded as x, y and z values of a unit vector (direction cosine) in the Volumetric Presentation State Reference Coordinate System.
>Referenced Image Sequence	(0008,1140)	1C	Instances of the Segmentation Storage SOP Class (1.2.840.10008.5.1.4.1.1.66.4) containing segments specifying the included or excluded source volume data. Each referenced Segmentation Instance shall have Segmentation Type (0062,0001) value of BINARY and shall share a Frame of Reference with one or more Input Volumes. One or more items shall be included in this sequence. Required if Volume Cropping Method (0070,1302) has a value of INCLUDE_SEG or EXCLUDE_SEG. Note: Surface Segmentation instances are not referenced by this element.
>>Include 'Image SOP Instance Reference Macro' Table 10-3			

C.11.x3.1 Volume Cropping

Cropping is an operation in which a portion of the source volume is ignored during subsequent volumetric processing, using one of the methods specified by Volume Cropping Method (0070,1302):

- BOUNDING_BOX — The source volume data within a bounding box are included in the View
- OBLIQUE_PLANES — The source volume data within a closed surface described by a set of arbitrarily-oriented planes are included in the View
- INCLUDE_SEG — Source volume data should be included in the View if and only if the data is within any of the referenced Segments that share its value of Input Sequence Position Index (0070,1203) (if specified)
- EXCLUDE_SEG — Source volume data should be included in the View if and only if the data is not within any of the referenced Segments that share its value of Input Sequence Position Index (0070,1203) (if specified)

C.11.x4 Presentation View Description Module

Table C.11.x4-1 contains Attributes that describe the view of this presentation in anatomical terms.

Note: For example, a Volumetric Presentation State derived from a whole-body CT source volume could be restricted to the left leg.

Table C.11.x4-1
PRESENTATION VIEW DESCRIPTION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include 'General Anatomy Required Macro' Table 10-6			No context group defined
View Code Sequence	(0054,0220)	2	Describes this view of the patient anatomy. No more than one item shall be included in this Sequence.
>*Include 'Code Sequence Macro' Table 8.8-1*.			Baseline CID 501 "Volumetric View Description".
>View Modifier Code Sequence	(0054,0222)	2	View modifier. Zero or more items shall be included in this Sequence.
>>*Include 'Code Sequence Macro' Table 8.8-1*.			Baseline CID 502 "Volumetric View Modifier".
Image Laterality	(0020,0062)	2	Laterality of (possibly paired) body part (as described in Anatomic Region Sequence (0008,2218)) examined. Enumerated Values: **R** – right **L** – left **U** – unpaired **B** – both left and right Shall be consistent with any laterality information contained in Primary Anatomic Structure Modifier Sequence (0008,2230), if present.

C.11.x5 Multi-Planar Reconstruction Geometry Module

Table C.11.x5-1 contains Attributes that describe the geometry of this Multi-Planar Reconstruction view.

Table C.11.x5-1
MULTI-PLANAR RECONSTRUCTION GEOMETRY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Multi-Planar Reconstruction Style	(0070,1501)	1	Style of the MPR view. Enumerated Value: PLANAR – defined by a Euclidean plane
MPR Thickness Type	(0070,1502)	1	Specifies whether the Multi-Planar Reconstruction surface has thickness. Enumerated Values: THIN – a rendering of nominally minimal but unspecified thickness SLAB – an orthographic rendering of a volume with a defined thickness See C.11.x5.1.
MPR Slab Thickness	(0070,1503)	1C	Thickness of the Multi-Planar Reconstruction slab as a value greater than zero, in mm. See C.11.x5.1. Required if MPR Thickness Type (0070,1502) has a value of SLAB.
MPR View Width Direction	(0070,1507)	1C	Direction cosine (x,y,z) indicating the direction within the VPS RCS of the top row of the MPR view. See C.11.x5.1 Required if Multi Planar Reconstruction Style (0070,1501) is PLANAR.
MPR View Width	(0070,1508)	1C	Width of the MPR view, in mm. See C.11.x5.1 Required if Multi Planar Reconstruction Style (0070,1501) is PLANAR.
MPR View Height Direction	(0070,1511)	1C	Direction cosine (x,y,z) indicating the direction within the VPS RCS of the leftmost column of the MPR view. See C.11.x5.1 Required if Multi Planar Reconstruction Style (0070,1501) is PLANAR.
MPR View Height	(0070,1512)	1C	Height of the MPR view, in mm. See C.11.x5.1 Required if Multi Planar Reconstruction Style (0070,1501) is PLANAR.

Attribute Name	Tag	Type	Attribute Description
MPR Top Left Hand Corner	(0070,1505)	1C	The 3D location in the Volumetric Presentation State – Reference Coordinate System of the upper left hand corner of the MPR View rectangle, in mm. See C.11.x5.1.1 Required if Multi-Planar Reconstruction Style (0070,1501) has a value of PLANAR.

C.11.x5.1 Multi-Planar Reconstruction Styles

A Multi-Planar Reconstruction (or MPR) is one of the styles described in this section.

C.11.x5.1.1 PLANAR Style

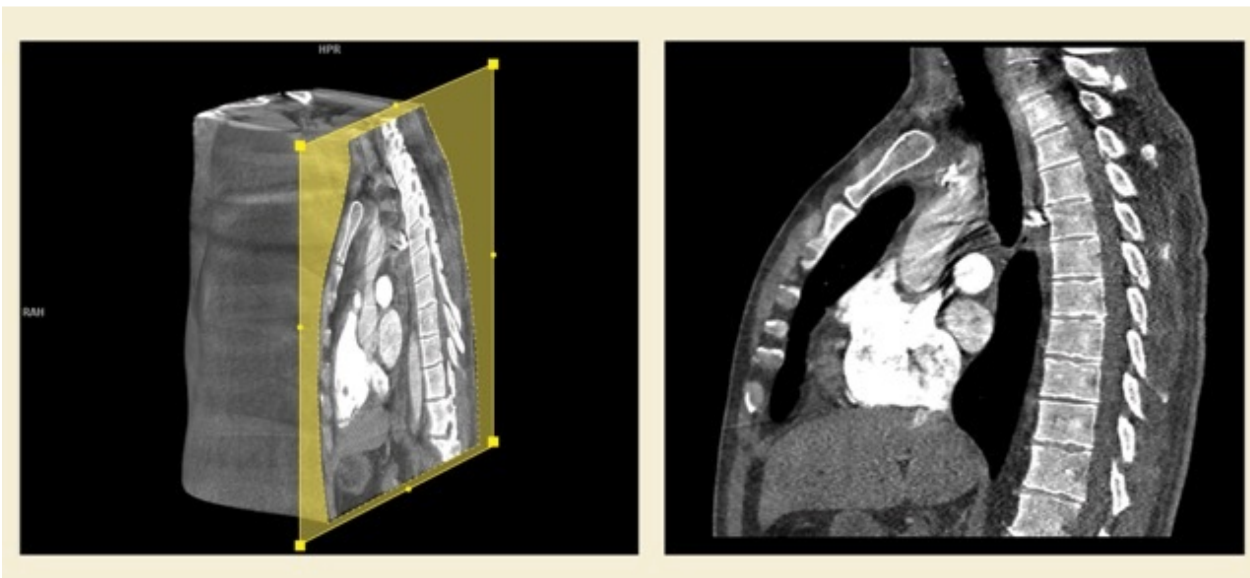


Figure C.11.x5-1:
Volume Rendering with visualization of MPR plane orientation and resulting PLANAR MPR rendering

A PLANAR MPR is a thin slice or thick slab of the input volume defined by a geometric plane as illustrated by Figure C.11.x5-1. Figures C.11.x5-2 and C.11.x5-3 depict the relationships between MPR Geometry Module attributes and Thin and Slab MPR views, respectively.

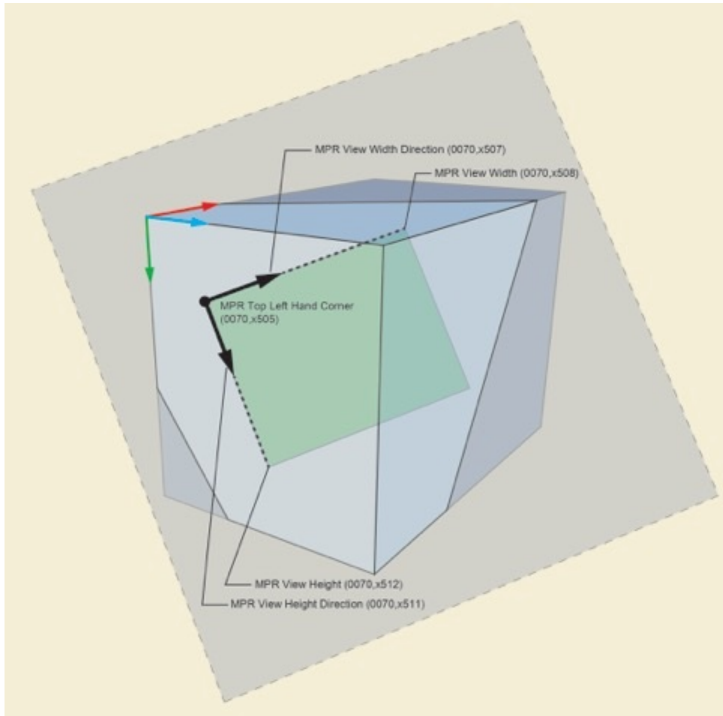


Figure C.11.x5-2: Planar MPR THIN Geometry

The following attributes describe the PLANAR MPR:

- MPR View Width Direction (0070,1507) and MPR View Height Direction (0070,1511) specify the orientation of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR View Width (0070,1508) and MPR View Height (0070,1512) specify the size of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR Top Left Hand Corner (0070,1505) species the position of the upper-left corner of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR Thickness Type (0070,1502) specifies whether the MPR is created by taking a single sample for each pixel (THIN) or by creating an orthographic rendering of a slab volume with a defined thickness using the method defined by Compositing Method (0070,1206) (SLAB). If the specified thickness is below an application-determined limit the resulting view shall be treated as a THIN MPR.
- MPR Slab Thickness (0070,1503) specifies the thickness of the slab if MPR Thickness Type (0070,1502) is SLAB. The slab volume is positioned such that the MPR view defined by MPR View Width Direction (0070,1507), MPR View Width (0070,1508), MPR View Height Direction (0070,1511), MPR View Height (0070,1512), and MPR Top Left Hand Corner (0070,1505) is at the midpoint of the slab thickness.

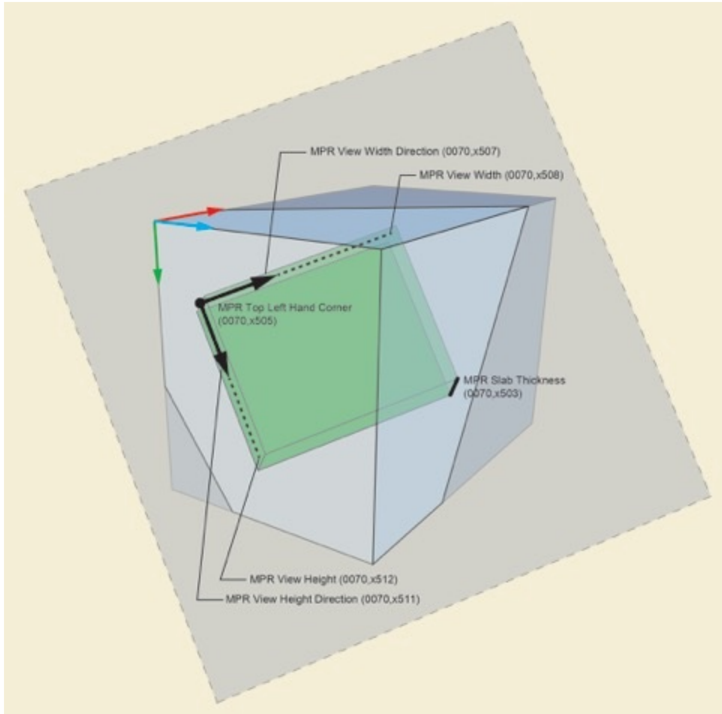


Figure C.11.x5-3: Planar MPR SLAB Geometry

C.11.x8 Volumetric Presentation State Display Module

Table C.11.x8-1 specifies the attributes that define the transformations of the processed Volumetric Presentation State inputs into a single VPS display space, as described in the Volumetric Presentation State pipeline in PS 3.4 Section X.2.1.

Table C.11.x8-1
VOLUMETRIC PRESENTATION STATE DISPLAY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Presentation	(0008,9205)	1	Grayscale or color space of the Presentation State output. Enumerated Values: MONOCHROME Output consists of P-Values TRUE_COLOR Output consists of PCS-Values

Presentation State Classification Component Sequence	(0070,1801)	2C	Sequence of classification components in which the order of items is significant. Each classification component converts one or two processed inputs into a single RGB output. One or more items shall be included in this sequence. See C.11.x8.2. Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR.
>Component Type	(0070,1802)	1	Type of component. Enumerated values: ONE_TO_RGBA TWO_TO_RGBA See C.11.x8.2 for description of the components corresponding to each selection.
>Component Input Sequence	(0070,1803)	1	Description of the input or inputs to this component. One item shall be present in this sequence if Component Type (0070,1802) has a value of ONE_TO_RGBA. Two items shall be present in this sequence if Component Type (0070,1802) has a value of TWO_TO_RGBA.
>> Volumetric Presentation Input Index	(0070,1804)	1	Value of Volumetric Presentation Input Number (0070,1207) for this input in the Volumetric Presentation State Input Sequence (0070,1201)
>>Bits Mapped to Color Lookup Table	(0028,1403)	3	The number of most significant bits of each value of Pixel Data (7FE0,0010) from this frame contributing to the Palette Color Lookup Table input. If absent, Bits Stored (0028,0101) bits of each value of Pixel Data (7FE0,0010) from this frame contributes to the Palette Color Lookup Table input. See C.7.6.23.3 for usage.

>RGB LUT Transfer Function	(0028,140F)	1	Specifies the mapping that takes place between the input value and RGB output. Enumerated values: EQUAL_RGB Output is R=G=B = input value TABLE Output is RGB LUT values See C.11.x8.1.
>Alpha LUT Transfer Function	(0028,1410)	1C	Specifies the transformation that is used to create the Alpha input a compositor component. Enumerated values: NONE Output = 1 (opaque) for all input values IDENTITY Output = input value TABLE Output = output of the Alpha LUT Required if the number of items in Presentation State Classification Component Sequence (0070,1801) is greater than 1. Note: When this condition is true, there will be one or more compositor components to follow this classification component.
>Red Palette Color Lookup Table Descriptor	(0028,1101)	1C	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.
>Green Palette Color Lookup Table Descriptor	(0028,1102)	1C	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.
>Blue Palette Color Lookup Table Descriptor	(0028,1103)	1C	Specifies the format of the Blue Palette Color Lookup Table Data (0028,1203). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.

>Alpha Palette Color Lookup Table Descriptor	(0028,1104)	1C	Specifies the format of the Alpha Palette Color Lookup Table Data. The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE.
>Palette Color Lookup Table UID	(0028,1199)	3	Palette Color Lookup Table UID. See C.7.9.1. Note: Including the UID in Presentation States that comprise a presentation collection is helpful to the display application that is rendering several related presentations together. The palettes and UIDs do not need to be the same in such a case.
>Red Palette Color Lookup Table Data	(0028,1201)	1C	Red Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE and Segmented Red Palette Color Lookup Table Data (0028,1221) is not present.
>Green Palette Color Lookup Table Data	(0028,1202)	1C	Green Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if Red Palette Color Lookup Table Data (0028,1201) is present.
>Blue Palette Color Lookup Table Data	(0028,1203)	1C	Blue Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if Red Palette Color Lookup Table Data (0028,1201) is present.
>Alpha Palette Color Lookup Table Data	(0028,1204)	1C	Alpha LUT contains the blending values for the data frames. See C.7.6.3.1.5. Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE and Segmented Alpha Palette Color Lookup Table Data (0028,1224) is not present.
>Segmented Red Palette Color Lookup Table Data	(0028,1221)	1C	Segmented Red Palette Color Lookup Table Data. See C.11.x8.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE and Red Palette Color Lookup Table Data (0028,1201) is not present.

>Segmented Green Palette Color Lookup Table Data	(0028,1222)	1C	Segmented Green Palette Color Lookup Table Data. See C.11.x8.5 Required if Segmented Red Palette Color Lookup Table Data (0028,1221) is present.
>Segmented Blue Palette Color Lookup Table Data	(0028,1223)	1C	Segmented Blue Palette Color Lookup Table Data. See C.11.x8.5 Required if Segmented Red Palette Color Lookup Table Data (0028,1221) is present.
>Segmented Alpha Palette Color Lookup Table Data	(0028,1224)	1C	Segmented Alpha Palette Color Lookup Table Data. See C.11.x8.5 Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE and Alpha Palette Color Lookup Table Data (0028,1204) is not present.
Presentation State Compositor Component Sequence	(0070,1805)	2C	Sequence of RGB Compositor components in which the order of items is significant. Each RGB Compositor component combines together pairs of RGB values to produce a single RGB value. If there is more than one compositor component, the components are chained such that the output of one compositor component is an input to the next compositor component. The number of items in this sequence shall be the number of items in Presentation State Classification Component Sequence (0070,1801) minus one. See C.11.x8.3. Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR.

>Weighting Transfer Function Sequence	(0070,1806)	1	Transfer functions each represented by the formula $f(Alpha_1, Alpha_2) = WeightingFactor$ used to derive the weighting factors for each of the two RGB inputs from both input Alphas. The function is specified in the form of a table. Two items shall be included in this sequence to produce weighting factors for RBG1 and RGB2 inputs, respectively. See C.11.x8.4.
>>LUT Descriptor	(0028,3002)	1	Specifies the format of the LUT Data (0028,3006) in this Sequence. The first value (number of entries in the LUT) shall be an even power of two or zero indicating 2^{16}, so that there are an even number of bits in the LUT input. The third value (number of bits in the LUT Data) shall be 8. See C.11.1.1.
>>LUT Data	(0028,3006)	1	LUT Data in this Sequence.
Presentation LUT Shape	(2050,0020)	1C	Presentation LUT transformation. Enumerated Values: IDENTITY No further translation necessary; input values are P-Values; INVERSE Output values after inversion are P-Values See C.11.6.1.2. Required if Pixel Presentation (0008,9205) has a value of MONOCHROME.
ICC Profile	(0028,2000)	1C	An ICC Profile encoding the transformation of device-dependent color stored pixel values into PCS-Values. When present, defines the color space of the output of the Volumetric Presentation State. See C.11.15.1.1 Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR.

C.11.x8.1 RGB LUT Transfer Function

If the value of RGB LUT Transfer Function (0028,140F) is "TABLE" then each input scalar value will be mapped to an RGB value specified by the specified red, green, and blue palette color lookup tables.

If the value of RGB LUT Transfer Function (0028,140F) is "EQUAL_RGB" then each input scalar value will used as the red, green and blue values of the output (i.e. the output will be grayscale).

C.11.x8.2 Classification Component Usage

If Pixel Presentation (0008,9205) is TRUE_COLOR, the Presentation State Classification Component Sequence (0070,1801) defines the transformations of processed VPS inputs into RGB data streams, a process known as "classification".

Each item of Presentation State Classification Component Sequence (0070,1801) describes one "classification component" in the Volumetric Presentation State Display Pipeline, as described in PS 3.4 Section X.2.1.3.1.1. At least one item is required in order for the Presentation State to generate a PCS-Value output. If there is more than one item in this sequence, the outputs of the multiple classification components are composited as described in C.11.x8.3.

Two types of classification components are defined:

- Component Type (0070,1802) value of ONE_TO_RGBA specifies that of one processed input value is transformed into the RGBA output value
- Component Type (0070,1802) value of TWO_TO_RGBA specifies that of two processed input values are transformed into the RGBA output value.

The internal structure of each classification component is described in PS 3.4 Section X.2.1.3.2.

C.11.x8.3 Compositor Component Usage

If Pixel Presentation (0008,9205) is TRUE_COLOR and there are more than one item in the Presentation State Classification Component Sequence (0070,1801), the Presentation State Compositor Component Sequence (0070,1805) defines the transformations of the multiple RGB data streams produced by the Classification components into one RGB output stream, a process known as "compositing".

> Note: If there is only one item in Presentation State Classification Sequence (0070,1801), Presentation State Compositor Sequence (0070,1801) is empty since there is only one RGB data stream so there is no need to composite.

Each item in Presentation State Compositor Component Sequence (0070,1805) describes one two-input "compositing component" in which two RGBA inputs are composited into one RGB output. The first compositor component in the sequence combines the outputs of the first two classification components to produce one RGB output. Subsequent compositor components combine the output of the previous compositor component with the output of the next classification component to produce one RGB output. This process continues until the RGB outputs of all classification components are composited into a single RGB output.

Each classification component produces a RGBA output, while each compositor component has two RGBA inputs to produce a RGB output. This means that all compositor components after the first in the sequence have only one Alpha input available, that is the Alpha value from the next classification component output to be composited. In this case, (1-Alpha) is used in place of the Alpha input missing from the previous compositing component.

> Note: Through the use of (1-$Alpha_2$) as $Alpha_1$ for the input from the previous Compositor, the Compositor performs standard Porter-Duff "A over B" compositing in all but the first compositor. [Porter-Huff 1984]

The internal structure and usage of the Compositor component is described in PS 3.4 Section X.2.1.3.2.2.

C.11.x8.4 Weighting Transfer Function

In some situations, it is desirable to consider both Alpha inputs to the compositor in determining the weight to be given to each of the two RGB inputs to the compositing operation. This is accomplished by providing two weighting transfer functions

$$f(Alpha_1, Alpha_2) = WeightingFactor_n$$

one for each of the two RGB inputs to the compositor.

In the degenerate (and common) case where simple additive compositing $(RGB_1 * Alpha_1) + (RGB_2 * (1 - Alpha_1))$ is desired, identity weighting transfer functions can be specified to just pass through the $Alpha_1$ and $(1\text{-}Alpha_1)$ values (or $Alpha_1$ and $Alpha_2$ values) to be the weighing factors for the RGB inputs.

For ease of specification of these transfer functions and for maximum flexibility, each of these weighting transfer functions is defined as a look-up table with inputs $Alpha_1$ and $Alpha_2$. Each LUT contains 8-bit integer values which are then normalized to the range 0.0 to 1.0 by dividing by 255 (2^8-1).

See PS 3.4 Section X.2.1.3.2.2 for details on the use of these weighting transfer functions, and see PS 3.17 Section Y.5 for clinical applications.

C.11.x8.5 Use of Segmented Palette Color Lookup Tables

Segmented Palette Color Lookup Tables provide a means for specifying lookup tables in a parametric manner rather than as a set of discrete mapping values.

> Note: Specifying tables using the segmented method may be preferred by color mapping implementations based on control points.

The value of Segmented Alpha Palette Color Lookup Table (0028,1224) is structured in the same manner as Segmented Red Palette Color Lookup Table Data (0028,1221), Segmented Green Palette Color Lookup Table Data (0028,1222), and Segmented Blue Palette Color Lookup Table Data (0028,1221) described in C.7.9.2.

C.11.x9 Volumetric Graphic Annotation Module

Table C.11.x9-1 contains Attributes that specify graphic annotation placed in the Volumetric Presentation State Reference Coordinate System coordinate space.

> Note: This module specifies literal text and/or graphic annotation only. Provision is made to reference external Structured Report measurement instances to provide context for the annotation, if desired.

Table C.11.x9-1
VOLUMETRIC GRAPHIC ANNOTATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Volumetric Annotation Sequence	(0070,1901)	1C	Graphic annotations described by coordinates in the Volumetric Presentation State Reference Coordinate System. One or more items shall be included in this sequence. Required if Volumetric Presentation Input Annotation Sequence (0070,1905) is not present. May be present otherwise.

Attribute Name	Tag	Type	Attribute Description
>Graphic Data	(0070,0022)	1	An ordered set of (x,y,z) triplets (in mm and may be negative) that define a region of interest in the Volumetric Presentation State Reference Coordinate System defined by Frame of Reference UID (0020,0052). See C.18.9.1.1.
>Graphic Type	(0070,0023)	1	See C.18.9.1.2 for Enumerated Values.
>Graphics Layer	(0070,0002)	1	The layer defined in the Graphic Layer Module C.10.7 in which the graphics or text is to be rendered.
>Annotation Clipping	(0070,1907)	1	Specifies whether the volumetric annotation should be displayed only when it intersects with the presentation view. Enumerated Values: YES NO See C.11.x9.1.
>Text Object Sequence	(0070,0008)	3	Sequence that describes a text annotation. One item shall be included in this sequence.
>>Unformatted Text Value	(0070,0006)	1	Displayed text associated with the input instance. See C.10.5.1.1.
>>Bounding Box Top Left Hand Corner	(0070,0010)	3	Recommended location of the Top Left Hand Corner (TLHC) of the bounding box in which Unformatted Text Value (0070,0006) is to be placed within a Volumetric Presentation View, specified as fractions of the view width and view height. Each value shall be within the range 0.0 to 1.0.
>>Bounding Box Bottom Right Hand Corner	(0070,0011)	1C	Recommended location of the Bottom Right Hand Corner (BRHC) of the bounding box in which Unformatted Text Value (0070,0006) is to be placed within a Volumetric Presentation View, specified as fractions of the view width and view height. Each value shall be within the range 0.0 to 1.0. Required if Bounding Box Top Left Hand Corner (0070,0010) is present.

Attribute Name	Tag	Type	Attribute Description
>>Bounding Box Text Horizontal Justification	(0070,0012)	1C	Location of the Unformatted Test Value (0070,0006) relative to the vertical edges of the bounding box. Enumerated values: LEFT Closest to the left edge RIGHT Closest to the right edge CENTER Centered Required if Bounding Box Top Left Hand Corner (0070,0010) is present.
>Referenced Structured Context Sequence	(0070,1903)	3	Reference to a node in a Structured Report instance providing context for this annotation. Only one item shall be present in this sequence. See C.11.x9.2.
>>Include SOP Instance Reference Macro Table 10-11			
>>Referenced Content Item	(0070,1904)	1	Reference to a Content Item in the referenced Structured Report specified as the Observation UID (0040,A171) of the Content Item.
Volumetric Presentation Input Annotation Sequence	(0070,1905)	1C	Annotations of inputs in Volumetric Presentation State Input Sequence (0070,1201). One or more items shall be included in this sequence. Required if Volumetric Annotation Sequence (0070,1901) is not present. May be present otherwise.
> Volumetric Presentation Input Index	(0070,1804)	1	Value of Volumetric Presentation Input Number (0070,1207) for this input in the Volumetric Presentation State Input Sequence (0070,1201). Note: The annotation is intended to refer to a cropped input volume.
>Graphics Layer	(0070,0002)	1	The layer defined in the Graphic Layer Module C.10.7 in which the graphic or text is to be rendered.
>Text Object Sequence	(0070,0008)	1	Sequence that describes a text annotation. One item shall be included in this sequence.
>>Unformatted Text Value	(0070,0006)	1	Displayed text associated with the input. See C.10.5.1.1.

Attribute Name	Tag	Type	Attribute Description
>>Bounding Box Top Left Hand Corner	(0070,0010)	3	Recommended location of the Top Left Hand Corner (TLHC) of the bounding box in which Unformatted Text Value (0070,0006) is to be displayed, as fractions of the specified presentation view width and height. Each value shall be within the range 0.0 to 1.0. See C.10.5.1.1.
>>Bounding Box Bottom Right Hand Corner	(0070,0011)	1C	Recommended location of the Bottom Right Hand Corner (BRHC) of the bounding box in which Unformatted Text Value (0070,0006) is to be displayed, as fractions of the specified presentation view width and height. Each value shall be within the range 0.0 to 1.0. See C.10.5.1.1. Required if Bounding Box Top Left Hand Corner (0070,0010) is present.
>>Bounding Box Text Horizontal Justification	(0070,0012)	1C	Location of the Unformatted Test Value (0070,0006) relative to the vertical edges of the bounding box. Enumerated values: LEFT Closest to the left edge RIGHT Closest to the right edge CENTER Centered See C.10.5.1.1. Required if Bounding Box Top Left Hand Corner (0070,0010) is present.
>Referenced Structured Context Sequence	(0070,1903)	3	Reference to a node in a Structured Report instance providing context for this annotation. Only one item shall be present in this sequence. See C.11.x9.2.
>>Include SOP Instance Reference Macro Table 10-11			
>>Referenced Content Item	(0070,1904)	1	Reference to a Content Item in the referenced Structured Report specified as the Observation UID (0040,A171) of the Content Item.

C.11.x9.1 Annotation Clipping

A graphic defined by the Volumetric Annotation Sequence (0070,1901) may contain data that falls outside the view defined by the Volumetric Presentation State geometry.

If the Volumetric Presentation State intends that an annotation be clipped where it falls outside the defined view, Annotation Clipping (0070,1907) shall have a value of YES.

If the Volumetric Presentation State intends that an annotation be displayed in its entirely even where it does not intersect the volume of interest then Annotation Clipping (0070,1907) shall have a value of NO.

Any visual clues used to indicate where the annotation does and does not intersect the volume of interest are not specified by the Volumetric Presentation State.

Note: For example, the projection of a 3D curve onto a plane could be done such that the curve would be a rendered differently depending on if it is above, below or on the defined plane.

C.11.x9.2 Referenced Structured Content Sequence

A volume annotation provides graphics and text to include in the presentation, but doesn't provide any context for the annotation. Context may be provided through an optional reference to a Structured Report concept. The structured concept could be in the form of a finding concept code or measurement from the Structured Report. It is an application-specific decision on whether to use this reference and how to make use of the information it provides.

C.11.xA Presentation Animation Module

Table C.11.xA-1 contains Attributes that describe animation of the presentation.

Table C.11.xA-1
PRESENTATION ANIMATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Presentation Animation Style	(0070,1A01)	1	Animation style intended by the source. Enumerated values: INPUT_SEQ PRESENTATION_SEQ CROSSCURVE See C.11.x9.1 for description of terms.
Recommended Animation Rate	(0070,1A03)	3	Recommended rate at which the inputs shall be displayed. Shall have a value greater than zero. See C.11.xA.1 for units.

Animation Curve Sequence	(0070,1A04)	1C	Curve describing the trajectory of a fly-through animation. Only a single Item shall be included in this sequence. Required if Presentation Animation Style (0070,1A01) has a value of CROSSCURVE.
>Number of Volumetric Curve Points	(0070,150C)	1	Number of (x,y,z) points in Volumetric Curve Points (0070,150D).
>Volumetric Curve Points	(0070,150D)	1C	Coordinates of points on the curve in the Volumetric Presentation State Reference Coordinate System, in mm. One triplet (x,y,z) shall be present for each point in the curve. Note: The points on the curve are samples. It is an implementation decision how the points are connected.
Animation Step Size	(0070,1A05)	1C	Distance in mm along the curve the display moves in one step. Required if Presentation Animation Style (0070,1A01) has a value of CROSSCURVE.

C.11.xA.1 Presentation Animation Style

The presence of Presentation Animation Style (0070,1A01) indicates that a form of view animation is intended by the creator of the Presentation State, and the value of the attribute indicates the nature of such animation. See PS 3.4 Section X.3.2 for further description of the various presentation animation styles.

Values of Presentation Animation Style (0070,1A01) are:

- INPUT_SEQ: A number of inputs are displayed sequentially using the same Presentation State. The inputs are described by items in Volumetric Presentation State Input Sequence (0070,1201) with values of Input Sequence Position Index (0070,1203). If Recommended Animation Rate (0070,1A03) is present, the animation occurs as values of the sequence position index are incremented at a rate specified by Recommended Animation Rate (0070,1A03) in units of steps per second. If Recommended Animation Rate (0070,1A03) is not present, the use of manual scrolling or animation rate is at the discretion of the display application. Inputs with the same Input Sequence Position Index (0070,1203) value are displayed simultaneously. If all values of Input Sequence Position Index (0070,1203) are the same, the presented view is not animated.
- PRESENTATION_SEQ: The animation is determined by two or more Presentation States sharing the same value of Presentation Sequence Collection UID (0070,1102). The Presentation States shall be applied sequentially in the order of Presentation Sequence Position Index (0070,1103) values as the index is varied at a rate specified by Recommended Animation Rate (0070,1A03) in units of steps per second, if present; otherwise, the use of manual scrolling or animation rate is at the discretion of the display application.
- CROSSCURVE: Indicates that the designated Planar MPR view shall be stepped along the curve defined in Animation Curve Sequence (0070,1A04) at the interval specified by Animation Step Size (0070,1A05). The rate is specified by Recommended Animation Rate (0070,1A03) in units of steps per second, if present; otherwise, the use of manual scrolling or animation rate is at the discretion of the display application.

  CROSSCURVE is permitted only if the following conditions are met:

  - Multi-Planar Reconstruction Style (0070,1501) is present with a value of PLANAR
  - The curve specified by Animation Curve Sequence (0070,1A04) intersects the MPR view defined by MPR View Width Direction (0070,1507), MPR View Width (0070,1508), MPR View Height Direction (0070,1511), MPR View Height (0070,1512), and MPR Top Left Hand Corner (0070,1505) and is approximately normal to it at the point of intersection.

  The original MPR Geometry parameters determine the view orientation and extent throughout the animation as follows:

  - The same point on the MPR plane intersects the curve at each step of the animation
  - The MPR x-directional vector remains unchanged from the initial MPR geometry throughout the animation
  - The cross-product of the x-direction vector and y-direction vector is the tangent to the curve at each point.

  See PS 3.17 Y.3.2 for an application of CROSSCURVE.

Changes to NEMA Standards Publication PS 3.4

Digital Imaging and Communications in Medicine (DICOM)

Part 4: Service Class Specifications

Item #8: Add SOP Classes to PS3.4 Annex B

B.5 Standard SOP Classes

Table B.5-1
Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification (defined in PS 3.3)
Grayscale Planar MPR Volumetric Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.6	Planar MPR Volumetric Presentation State
Compositing Planar MPR Volumetric Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.7	Planar MPR Volumetric Presentation State

B.5.1.x Planar MPR Volumetric Presentation State Storage SOP Classes

The requirements of Annex X apply to the following SOP Classes:

- Grayscale Planar MPR Volumetric Presentation State Storage
- Compositing Planar MPR Volumetric Presentation State Storage

The Grayscale Planar MPR Volumetric Presentation State Storage SOP Class shall use the Planar MPR Volumetric Presentation State IOD with an Enumerated Value of MONOCHROME for Pixel Presentation (0008,9205) and shall have only a single item in the Volumetric Presentation State Input Sequence (0070,1201).

The Compositing Planar MPR Volumetric Presentation State Storage SOP Class shall use the Planar MPR Volumetric Presentation State IOD with an Enumerated Value of TRUE COLOR for Pixel Presentation (0008,9205).

Item #9: Modifications to PS3.4 Annex I

I.4 Media Storage Standard SOP Classes

Table I.4-1
Media Storage Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification (defined in PS 3.3)
Grayscale Planar MPR Volumetric Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.6	Planar MPR Volumetric Presentation State
Compositing Planar MPR Volumetric Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.7	Planar MPR Volumetric Presentation State

Item #10: Append to PS3.4

Annex X VOLUMETRIC PRESENTATION STATE STORAGE SOP CLASSES (Normative)

X.1. Overview

X.1.1 Scope

The Volumetric 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 Volumetric Presentation State or record an existing Volumetric 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:

a. spatial registration on the input datasets
b. cropping of the volume datasets by a bounding box, oblique planes and segmentation objects
c. the generation geometry of volumetric views
d. scalar to P-Value or RGB Value conversions
e. compositing of multiple renderings
f. clinical description of the specified view
g. volume and display relative annotations, including graphics, text and overlays
h. membership to a collection of related Volumetric Presentation States intended to be processed or displayed together
i. the position within a set of related Volumetric Presentation States
j. animation of the view
k. reference to an image depicting the view described by the Presentation State

Each Volumetric Presentation State corresponds to a single view (equivalent to an Image Box in a Hanging Protocol or Structured Display). If multiple Volumetric Presentation States are intended to be displayed together (e.g. a set of orthogonal MPR views) these Presentation States can be grouped by assigning them to a Display Collection. However, any detailed information about how a set of views should be presented can only be described by a Structured Display instance or a Hanging Protocol.

The Planar MPR Volumetric Presentation State refers to the multi-planar geometry and grayscale or 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 presentation values (P-Values) or Profile Connection Space values (PCS-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. The PCS-Values are in a device independent space that is formally defined in the ICC Profiles as CIEXYZ or CIELab values.

How an SCP of these SOP Classes chooses between multiple Presentation State instances that may apply to an image is beyond the scope of this standard.

A claim of conformance as an SCP of the 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.

How an SCP of these SOP Classes chooses to display multiple states that are part of a Display Collection is beyond the scope of this standard.

Note: For example, if a user selects a state that is part of a four state Spatial Collection, an SCP may choose to display all four together, to display the single state selected by the user or to display two of the four states deemed appropriate by the SCP.

X.2 Volume Transformation Processes

X.2.1 Planar MPR Volumetric Transformation Process

The Planar MPR Volumetric Presentation State Storage SOP Classes support a set of transformations to produce derived volumetric views of volume input data.

The Grayscale Planar MPR Volumetric Presentation State Storage SOP Class defines a grayscale volumetric view from a single volume input. The sequence of transformations from volumetric inputs into P-Values is explicitly defined in the reference pipeline described in Figure X.2-1.

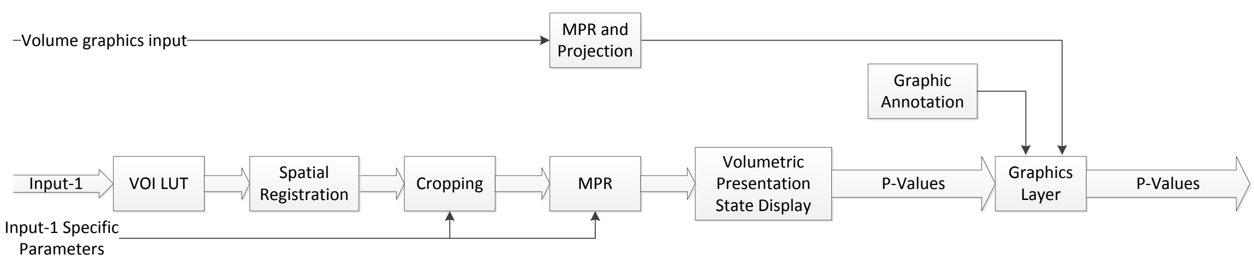


Figure X.2-1: Grayscale Planar MPR Volumetric Pipeline

The Compositing Planar MPR Volumetric Presentation State Storage SOP Class defines a true color volumetric view from one or more volume inputs. The sequence of transformations from volumetric inputs into PCS-Values is explicitly defined in the reference pipeline described in Figure X.2-2. The actual sequence implemented may differ (such as classifying and compositing prior to creating the MPR view) but must result in similar appearance.

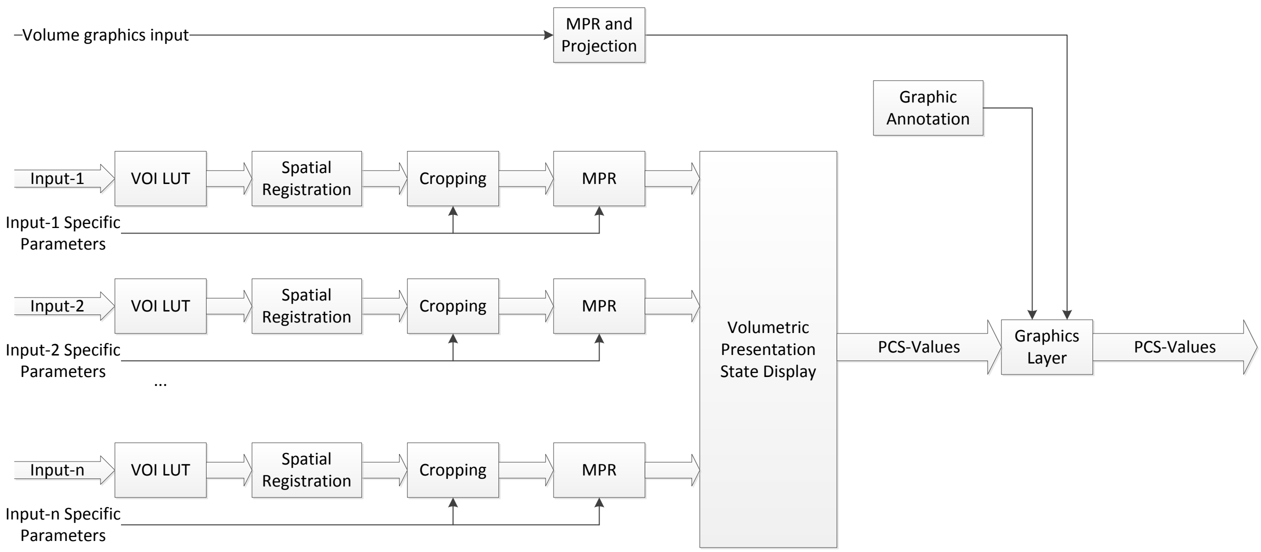


Figure X.2-2: Compositing Planar MPR Volumetric Pipeline

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

The presentation-related Attributes of the Planar MPR Volumetric 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.

X.2.1.1 Volumetric Inputs, Registration and Cropping

A Volumetric Presentation State can take multiple volumes as input. A volume is defined in PS 3.3 section C.11.x2.1. The same source data can be referenced in more than one input.

The VOI LUT is applied to the input data.

The input volumes may or may not be in the Volumetric Presentation State Reference Coordinate System (VPS-RCS). If they are not, they shall be registered into the VPS-RCS.

The input volumes shall be cropped as specified by the value of Crop (0070,1204) and items in the Volume Cropping Sequence (0070,1301).

X.2.1.2 Volumetric Transformations

X.2.1.2.1 Planar MPR Volumetric Presentation State

The planar MPR transformation requires a volume that is in the Volumetric Presentation State Reference Coordinate System (VPS-RCS).

MPR generation is based on the attributes of the Multi-Planar Reconstruction Geometry module (See PS 3.3 Section C.11.x5.1.1). If the MPR Thickness Type (0070,1502) is SLAB then the Compositing Method (0070,1206) is also used.

X.2.1.3 Volumetric Presentation State Display

X.2.1.3.1 Volumetric Presentation State Display Foundation

The Volumetric Presentation State Display Module defines the algorithms used to transform the result of the volumetric processing on the input data into an output of P-Values or PCS-Values for display.

If Pixel Presentation (0008,9205) is MONOCHROME, then Presentation LUT Shape (2050,0020) provides the transform to output P-Values.

If Pixel Presentation (0008,9205) is TRUE_COLOR, then Presentation State Classification Component Sequence (0070,1801) describes the conversion of each processed input into an RGB data stream, and Presentation State Compositor Component Sequence (0070,1805) describes the compositing of these separate RGBA data streams into a single RGB data stream. This single RGB data stream is then processed as described by ICC Profile (0028,2000) to produce output PCS-Values.

X.2.1.3.1.1 Classification Component Components

There are two classification component types currently defined for conversion from scalar input data to RGBA. The defined components are:

- One Input -> RGBA: This component accepts reconstructed data from one input in the Volumetric Presentation State Input Sequence (0070,1201) and generates an RGB and an Alpha output. This classification component would be specified in an item of the Presentation State Classification Component Sequence (0070,1801):

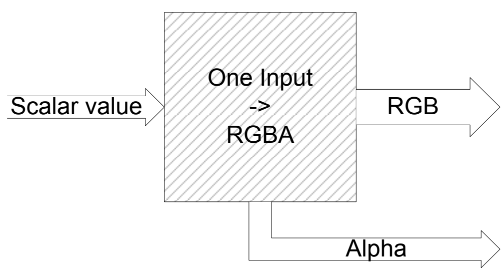


Figure X.2-3: One Input -> RGBA Component

- Two Inputs -> RGBA: This component accepts reconstructed data from two inputs in the Volumetric Presentation State Input Sequence (0070,1201) and generates an RGB and an Alpha output. This component is used in the case where a two-dimensional color mapping needs to be performed. This classification component would be specified in an item of the Presentation State Classification Component Sequence (0070,1801):

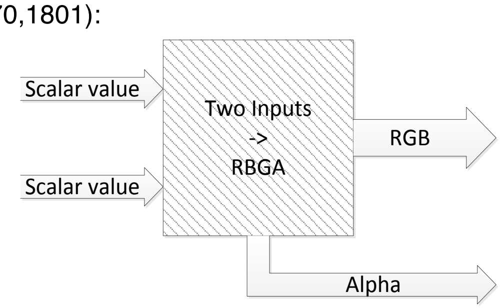


Figure X.2-4: Two Inputs ->RGBA Component

Note: An example for the use of this component is to combine Ultrasound Flow Velocity and Ultrasound Flow Variance to produce a color range from red-blue based on flow velocity and adding a yellow-green tinge based on flow variance)

X.2.1.3.1.2 Compositor Components

There is one compositor component type defined for compositing of two input RGBA (or one RGBA and one RGB) data sources into an RGB output. The defined component is:

- RGB Compositor: This component accepts two RGBA inputs (with one Alpha input optional) and composites the data into a single RGB output. Each item of Presentation State Compositor Component Sequence (0070,1805) specifies one RGB Compositor component:

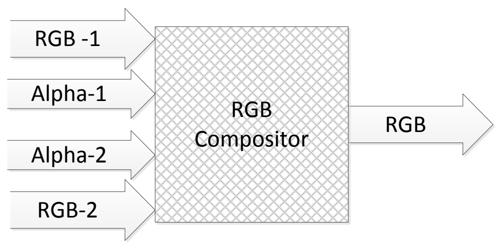


Figure X.2-5: RGB Compositor Component

The ICC Profile Connection Space Transform operation is performed after classification and compositing to generate output PCS-values using the specified ICC Color Profile (0028,2000)

X.2.1.3.2 Internal Structure of Components

X.2.1.3.2.1 Internal Structure of Classification Components

Component Type (0070,1802) specifies the component defined in each item of Presentation State Classification Component Sequence (0070,1801), which in turn controls by conditions the rest of the content of the item to provide the necessary specification of the component. The internal structure of each component in block diagram form is as follows:

- One Input -> RGBA: Specified by Component Type (0070,1802) = ONE_TO_RGBA:

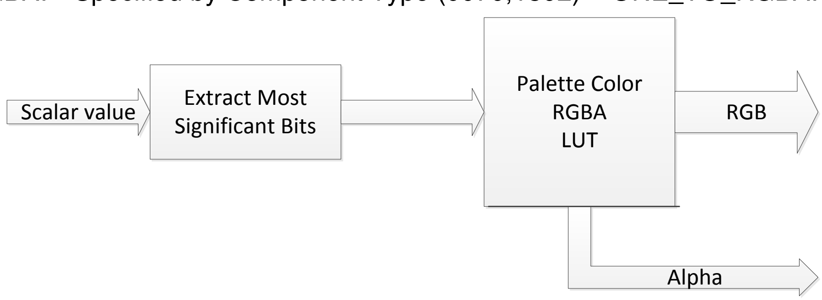


Figure X.2-6: Internal Structure of One Input -> RGBA Component

- Two Inputs -> RGBA: If Component Type (0070,1802) = TWO_TO_RGBA:

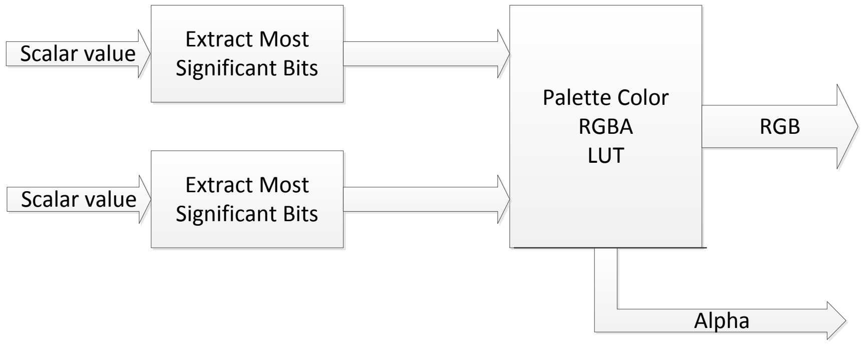


Figure X.2-7: Internal Structure of Two Input -> RGBA Component

The number of most significant bits extracted from each input is specified by the value of Bits Mapped to Color Lookup Table (0028,1403) in the Component Input Sequence (0070,1803) item for that input.

If Component Type (0070,1802) = TWO_TO_RGBA, there shall be two items in Component Input Sequence (0070,1803) with the first item defining the source of the most significant bits of the Palette Color Lookup Table input and the second item defining the source of the least significant bits of the Palette Color Lookup Table input

X.2.1.3.2.2 Internal Structure of RGB Compositor Component

Weighting transfer functions that compute the weighting factors used by the Compositor Function as a function of $Alpha_1$ and $Alpha_2$ values are specified as weighting look-up tables (LUTs) in the RGB Compositor component:

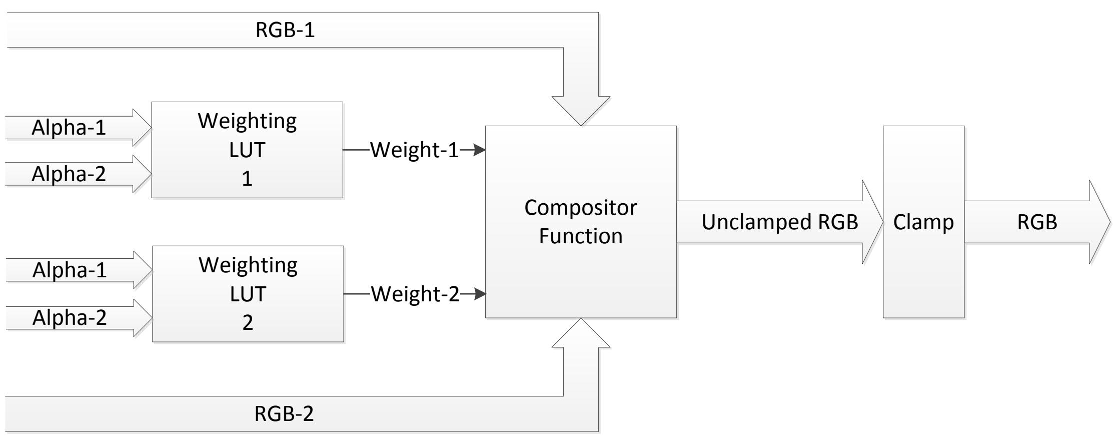


Figure X.2-8: Internal Structure of RGB Compositor Component

Because each Weighting LUT uses both Alpha values in determining a weighting factor, they allow compositing functions that would not be possible if each weighting factor were based only on that input's Alpha value. See PS 3.17 Section Y.5 for typical usage of the Weighting LUTs.

The input bits to the Weighting LUTs are obtained by combining the two Alpha inputs, with half the input bits obtained from each Alpha input:

- In the case of the first compositor component corresponding to the first item in Presentation State Compositor Component Sequence (0070,1805), the Alpha from the classification component corresponding to the first item in the Presentation State Classification Component Sequence

(0070,1805) provides the most significant bits of the Weighting LUT inputs, while the Alpha from the classification component corresponding to the second item in the Presentation State Classification Component Sequence (0070,1805) provides the least significant bits of the Weighting LUT inputs.

- In the case of subsequent compositor components, the Alpha from the classification component corresponding to the next item in the Presentation State Classification Component Sequence (0070,1805) provides the least significant bits of the Weighting LUT inputs, while the most significat bits of the Weighting LUT inputs are computed as one minus the Alpha from the classification component corresponding to the next item in the Presentation State Classification Component Sequence (0070,1805).

The integer outputs of the Weighting LUTs are normalized to the range 0.0 to 1.0, and the Compositor Function combines the normalized R, G, and B (each component called "Color" = C_x) input values as follows:

$$C_{out} = (C_1 * Weight_1) + (C_2 * Weight_2)$$

The sum of the normalized $Weight_1$ and $Weight_2$ shall be no greater than 1.0.

The color input values are normalized because the number of output bits from the RGB Palette Color Lookup Tables may be different in each classification component.

The output of the compositor shall be range-limited ("clamped") to ensure that the outputs are guaranteed to be within a valid range of color values regardless of the validity of the weighting transfer functions. This isolates subsequent compositor components and the Profile Connection Space Transform from overflow errors.

X.3 Additional Volumetric Considerations

X.3.1 Annotations in Volumetric Presentations States

The Volumetric Presentation States provide two ways for annotating views:

- Annotations on the Volumetric Presentation View
- Annotations described by coordinates in the Volumetric Presentation State Reference Coordinate System (VPS-RCS) with optional references to Structured Reports providing context.

Annotations on the view provide the application of free unformatted text or vector graphics as described in the Graphic Annotation Module C.10.5. Since the Graphics Annotation Module allows only the addition of graphics to the 2D view defined by the Presentation State without attached clinical meaning, Volumetric Graphic Annotations provide a mechanism to create annotations in the VPS-RCS with optional references to other objects which can have structured context attached.

Volumetric Graphic Annotations can be specified in two variants: either via Graphic Types with 3D coordinates, as defined in PS3.3 Section C.18.9.1.2, or via a reference to inputs of the Presentation State. The latter is intended to be used to display annotation labels for segmentations of the volume data set; for example, when a lesion has been marked via a Segmentation IOD and this segmentation is rendered together with the anatomical data.

Since annotations which are added via the Graphics Annotation Module are defined within the display space, they should not be used to point to clinical relevant structures which would be positioned on a different anatomy after manipulation.

In contrast since Volumetric Graphic Annotations have coordinates in the VPS-RCS, applications can still show them after a user has manipulated the initial view which has been defined by the Presentation State.

The exact visual representation of the annotations is at the discretion of the display application, as well as the mechanisms which may be employed to ensure that Volumetric Graphic Annotations are sufficiently visible, even if the location in the volume is not visible in the current view. E.g. for a Graphic Type POINT a display application might render a crosshair at the specified position in the volume or a sphere with an arrow pointing to it instead of rendering Volumetric Graphic Annotations directly within the volume a projection of the annotations may be rendered as an overlay on top of the view.

However, annotations can be grouped into Graphics Layers and it is suggested that applications provide mechanisms to define rendering styles per Graphics Layer.

See PS3.17 Section Y3.4 and Section Y3.5 for examples of Volumetric Graphic Annotations.

X.3.2 Volumetric Animation

Several different styles of animation are defined in Volumetric Presentation States. In general, an animation style will vary either the input, processing, or view geometry in order to produce a varying presentation view. This section describes each of the animation styles and how it produces an animated view.

X.3.2.1 Input Sequence Animation

A Presentation Animation Style (0070,1A01) value of INPUT_SEQ indicates that Input Sequence Animation is being specified. In this animation style, a single Volumetric Presentation State is defined which includes input items in the Volumetric Presentation State Input Sequence (0070,1201) with different values of Input Sequence Position Index (0070,1203). The animated presentation view is produced by sequencing through values of Input Sequence Position Index (0070,1203) at a specified animation rate Animation Rate (0070,1A03), where each value of the index produces one 'frame' of the animated view from inputs that have that value of Input Sequence Position Index (0070,1203). See Figure X.3.2-1.

> Note: For example, a set of inputs could be temporally related volumes of a moving anatomical structure like the heart.

There may be more than one input item in Volumetric Presentation State Input Sequence (0070,1201) with the same value of Input Sequence Position Index (0070,1203), in which case the inputs are processed together to produce the frame of the animated view.

> Note: For example, pairs of input items could represent the same volume input at a point in time with two different segmentation croppings (representing different organ structures) that are blended together into a single view.

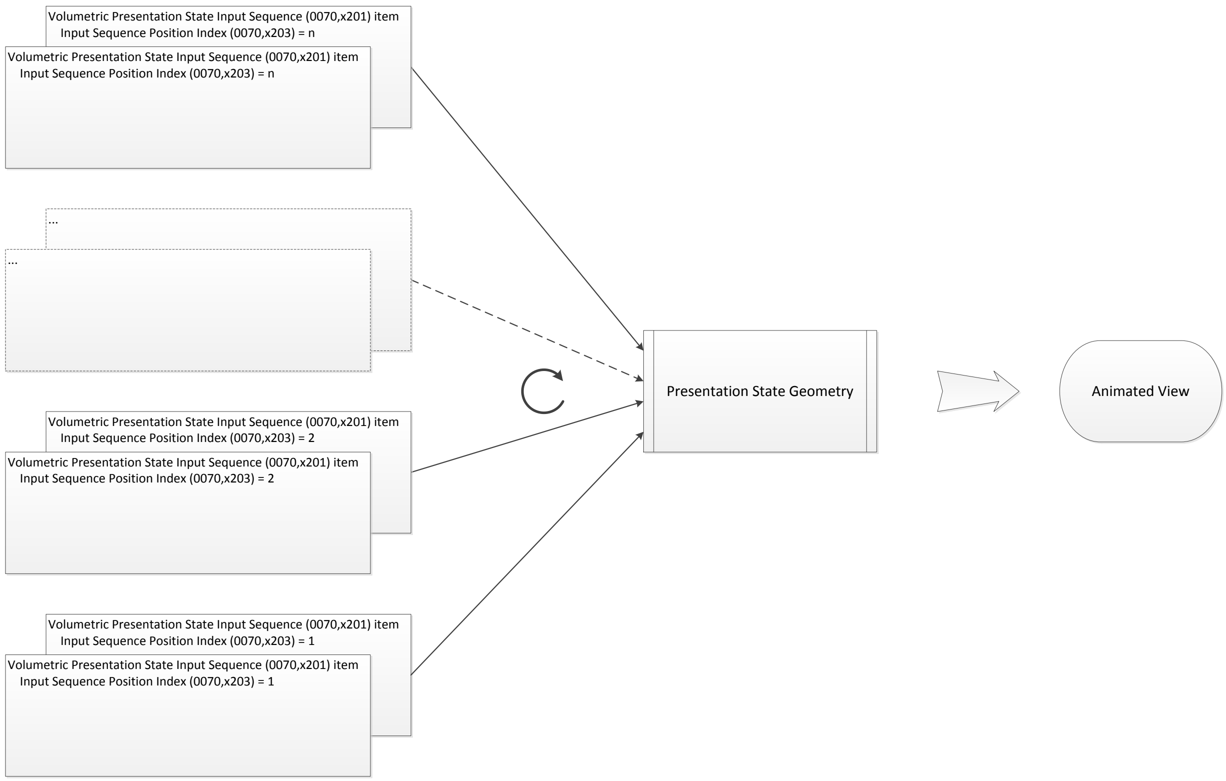


Figure X.3.2-1: Input Sequence Animation

X.3.2.2 Presentation Sequence Animation

A Presentation Animation Style (0070,1A01) value of PRESENTATION_SEQ indicates that Presentation Sequence Animation is being specified. In this animation style, a set of Volumetric Presentation States are applied sequentially. See Figure X.3.2-2.

> Note: One example of the use of presentation sequence animation is a view of a moving heart wherein a stent is at a stationary position at the center of the view. Because the geometry of each view frame is slightly different, separate Volumetric Presentation State instances are required for each view frame.

Each Volumetric Presentation State of the set is identified by having the same value of Presentation Sequence Collection UID (0070,1102). The order of application of these Presentation States is determined by the value of Presentation Sequence Position Index (0070,1103) defined in the Presentation State. The animated presentation view is produced by sequencing through values of presentation sequence position index at a specified animation rate Animation Rate (0070,1A03), where each value of the index produces one ‘frame’ of the animated view produced by that Volumetric Presentation State.

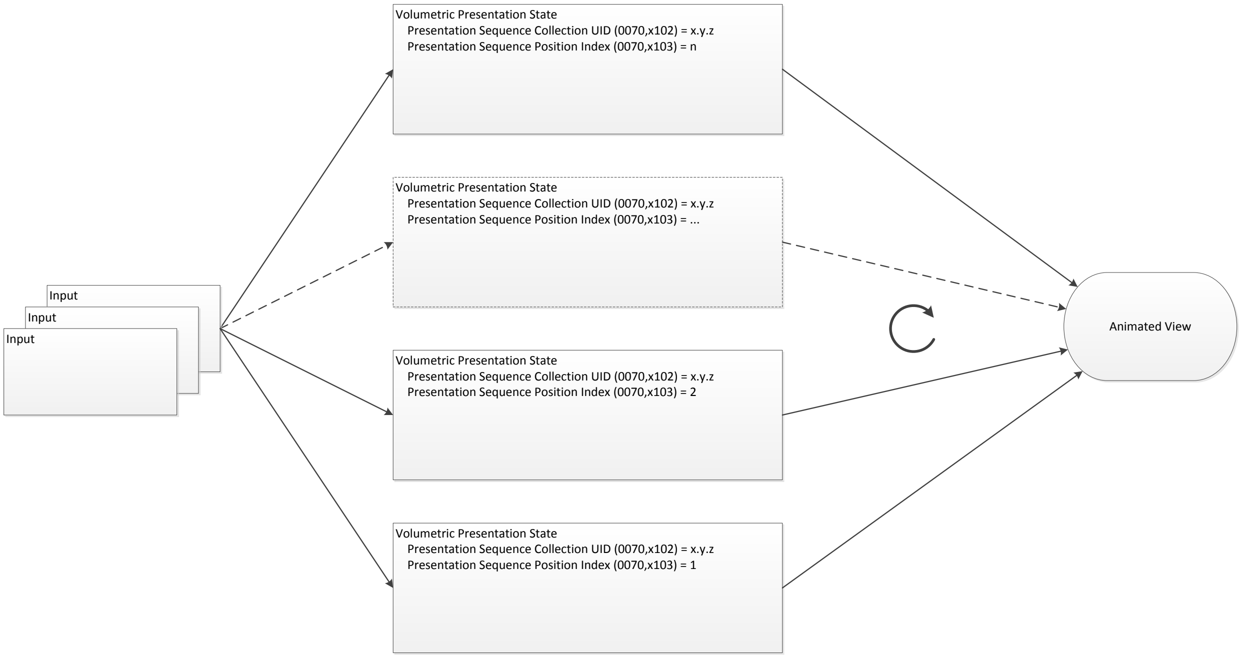


Figure X.3.2-2: Presentation Sequence Animation

X.3.2.3 Crosscurve Animation

A Presentation Animation Style (0070,1A01) value of CROSSCURVE indicates that Crosscurve Animation is being specified. In this animation style, a Presentation State defines a Planar MPR view at the beginning of a curve defined in Animation Curve Sequence (0070,1A04). The Planar MPR view is stepped a distance Animation Step Size (0070,1A05) along the curve defined in Animation Curve Sequence (0070,1A04) at the rate specified by Recommended Animation Rate (0070,1A03) in steps per second. See Figure X.3.2-3.

Note: A typical application of this animation style is motion along a curve centered within the colon or a blood vessel.

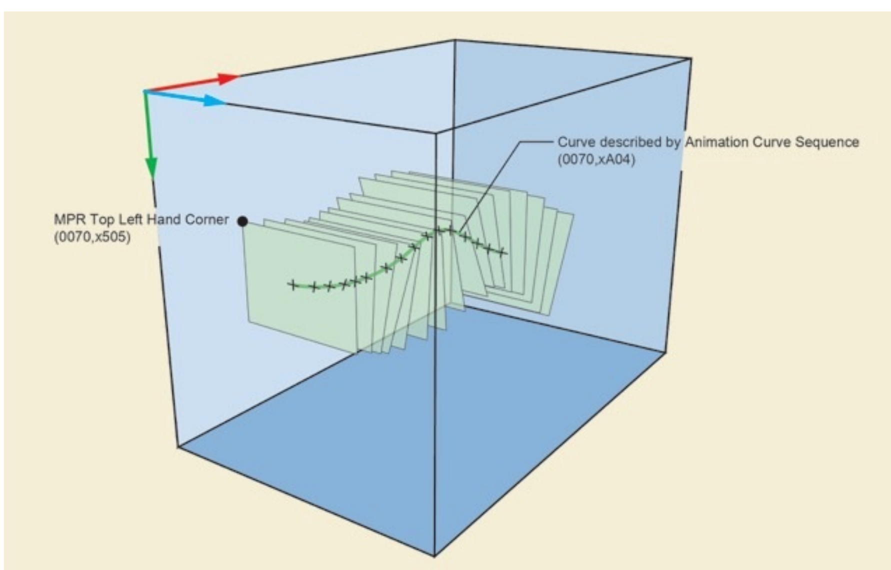


Figure X.3.2-3: Crosscurve Animation

X.3.3 Display Layout

The layout of multiple Volumetric Presentation States is not specified by the Planar MPR Volumetric Transformation Process. However, there are attributes within Volumetric Presentation States that can influence the overall display layout.

For instance:

- Anatomic Region Sequence (0008,2218) specifies the anatomic region covered by the Volumetric Presentation State
- View Code Sequence (0054,0220) describes the view of the anatomic region of interest (e.g. Coronal, Oblique transverse, etc.)
- Presentation Display Collection UID (0070,1101) identifies the Presentation State as one of a set of views intended to be displayed together
- SOP Class UID (0008,0016) identifies that the Presentation State describes a Planar MPR view

The use of these attributes allows a display application to create an appropriate presentation of multiple Volumetric Presentation States, whether through the application of a Hanging Protocol instance, a Structured Display instance or by means of an application-specific algorithm.

For an example of their use, see PS 3.17 Annex Y.

X.4 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 Volumetric 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 volumetric data at the discretion of the display device user, for all Image Storage SOP Classes defined in the Conformance Statement for which the Volumetric Presentation State Storage SOP Class is supported.
- a display device acting as an SCP of the Volumetric Presentation State Storage SOP Classes shall support the Segmentation SOP Class for cropping and the Spatial Registration SOP Class for registration.
- a display device acting as an SCP of the Volumetric Presentation State Storage SOP Classes is not required to support the Presentation Animation Module.
- a display device acting as an SCP of any of the Volumetric Presentation State Storage SOP Classes is not required to support Structured Reporting Storage SOP Classes.

X.5 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 Volumetric Presentation State Storage SOP Classes:

X.5.1 Conformance Statement for An SCU

The following behavior shall be documented in the Conformance Statement of any implementation claiming conformance to a Volumetric Presentation State Storage SOP Class as an SCU:

- For an SCU of a Volumetric 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.
- For an SCU of a Volumetric 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 Volumetric Presentation State Storage SOP Class.

X.5.2 Conformance Statement for An SCP

The following behavior shall be documented in the Conformance Statement of any implementation claiming conformance to a Volumetric Presentation State Storage SOP Class as an SCP:

- For an SCP of a Volumetric 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.
- For an SCP of a Volumetric 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 Volumetric Presentation State Storage SOP Class.
- For an SCP of a Volumetric Presentation State Storage SOP Class, whether the Presentation Animation Module is supported, and if not supported, any notifications or lack of notifications to the user that the context information is not displayed.
- For an SCP of a Volumetric Presentation State Storage SOP Class, whether references to Structured Report instances are supported, and if not supported, any notifications or lack of notifications to the user that the context information is not displayed.

Changes to NEMA Standards Publication PS 3.6
Digital Imaging and Communications in Medicine (DICOM)
Part 6: Data Dictionary

Item #11: Add the following rows to PS3.6 Section 6

6 Registry of DICOM data elements

Note: For attributes that were present in ACR-NEMA 1.0 and 2.0 and that have been retired, the specifications of Value Representation and Value Multiplicity provided are recommendations for the purpose of interpreting their values in objects created in accordance with earlier versions of this standard. These recommendations are suggested as most appropriate for a particular attribute; however, there is no guarantee that historical objects will not violate some requirements or specified VR and/or VM.

Tag	Name	Keyword	VR	VM
(0028,1224)	Segmented Alpha Palette Color Lookup Table Data	SegmentedAlphaPaletteColorLookupTableData	OW	1
(0070,1101)	Presentation Display Collection UID	PresentationDisplayCollectionUID	UI	1
(0070,1102)	Presentation Sequence Collection UID	PresentationSequenceCollectionUID	UI	1
(0070,1103)	Presentation Sequence Position Index	PresentationSequencePositionIndex	US	1
(0070,1104)	Rendered Image Reference Sequence	RenderedImageReferenceSequence	SQ	1
(0070,1201)	Volumetric Presentation State Input Sequence	VolumetricPresentationStateInputSequence	SQ	1
(0070,1202)	Presentation Input Type	PresentationInputType	CS	1
(0070,1203)	Input Sequence Position Index	InputSequencePositionIndex	US	1
(0070,1204)	Crop	Crop	CS	1
(0070,1205)	Cropping Specification Index	CroppingSpecificationIndex	US	1-n
(0070,1206)	Compositing Method	CompositingMethod	CS	1
(0070,1207)	Volumetric Presentation Input Number	VolumetricPresentationInputNumber	US	1
(0070,1208)	Image Volume Geometry	ImageVolumeGeometry	CS	1
(0070,1301)	Volume Cropping Sequence	VolumeCroppingSequence	SQ	1
(0070,1302)	Volume Cropping Method	VolumeCroppingMethod	CS	1
(0070,1303)	Bounding Box Crop	BoundingBoxCrop	FD	6
(0070,1304)	Oblique Cropping Plane Sequence	ObliqueCroppingPlaneSequence	SQ	1
(0070,1305)	Oblique Cropping Plane	ObliqueCroppingPlane	FD	4
(0070,1306)	Oblique Cropping Plane Normal	ObliqueCroppingPlaneNormal	FD	3
(0070,1309)	Cropping Specification Number	CroppingSpecificationNumber	US	1
(0070,1501)	Multi-Planar Reconstruction Style	MultiPlanarReconstructionSt	CS	1

		yle		
(0070,1502)	MPR Thickness Type	MPRThicknessType	CS	1
(0070,1503)	MPR Slab Thickness	MPRSlabThickness	FD	1
(0070,1505)	MPR Top Left Hand Corner	MPRTopLeftHandCorner	FD	3
(0070,1507)	MPR View Width Direction	MPRViewWidthDirection	FD	3
(0070,1508)	MPR View Width	MPRViewWidth	FD	1
(0070,150C)	Number of Volumetric Curve Points	NumberOfVolumetricCurveP oints	UL	1
(0070,150D)	Volumetric Curve Points	VolumetricCurvePoints	OD	1
(0070,1511)	MPR View Height Direction	MPRViewHeightDirection	FD	3
(0070,1512)	MPR View Height	MPRViewHeight	FD	1
(0070,1801)	Presentation State Classification Component Sequence	PresentationStateClassificati onComponentSequence	SQ	1
(0070,1802)	Component Type	ComponentType	CS	1
(0070,1803)	Component Input Sequence	ComponentInputSequence	SQ	1
(0070,1804)	Volumetric Presentation Input Index	VolumetricPresentationInputI ndex	US	1
(0070,1805)	Presentation State Compositor Component Sequence	PresentationStateComposito rComponentSequence	SQ	1
(0070,1806)	Weighting Transfer Function Sequence	WeightingTransferFunctionS equence	SQ	1
(0070,1807)	Weighting Lookup Table Descriptor	WeightingLookupTableDescr iptor	US	3
(0070,1808)	Weighting Lookup Table Data	WeightingLookupTableData	OB	1
(0070,1901)	Volumetric Annotation Sequence	VolumetricAnnotationSequen ce	SQ	1
(0070,1903)	Referenced Structured Context Sequence	ReferencedStructuredContex tSequence	SQ	1
(0070,1904)	Referenced Content Item	ReferencedContentItem	UI	1
(0070,1905)	Volumetric Presentation Input Annotation Sequence	VolumetricPresentationInput AnnotationSequence	SQ	1
(0070,1907)	Annotation Clipping	AnnotationClipping	CS	1
(0070,1A01)	Presentation Animation Style	PresentationAnimationStyle	CS	1
(0070,1A03)	Recommended Animation Rate	RecommendedAnimationRat e	FD	1
(0070,1A04)	Animation Curve Sequence	AnimationCurveSequence	SQ	1
(0070,1A05)	Animation Step Size	AnimationStepSize	FD	1

Item #12: Add the following rows to PS3.6 Annex A Table A-1

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.11.6	Grayscale Planar MPR Volumetric Presentation State Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.11.7	Compositing Planar MPR Volumetric Presentation State Storage	SOP Class	PS 3.4

Item #13: Add the following rows to PS3.6 Annex A Table A-3

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.1057	CID 501	Volumetric View Description
1.2.840.10008.6.1.1058	CID 502	Volumetric View Modifier

Changes to NEMA Standards Publication PS 3.15

Digital Imaging and Communications in Medicine (DICOM)

Part 15: Security and System Management Profiles

Item #14: Modifications to PS3.15 Annex C

C.2 Creator RSA Digital Signature Profile

…

a. the SOP Class and Instance UIDs
b. the SOP Creation Date and Time, if present
c. the Study and Series Instance UIDs
d. any attributes of the General Equipment module that are present
e. any attributes of the Overlay Plane, Curve or Graphic Annotation modules that are present
f. any attributes of the General Image and Image Pixel modules that are present
g. any attributes of the SR Document General and SR Document Content modules that are present
h. any attributes of the Waveform and Waveform Annotation modules that are present
i. any attributes of the Multi-frame Functional Groups module that are present
j. any attributes of the Enhanced MR Image module that are present
k. any attributes of the MR Spectroscopy modules that are present
l. any attributes of the Raw Data module that are present
m. any attributes of the Enhanced CT Image module that are present
n. any attributes of the Enhanced XA/XRF Image module that are present
?. any attributes the Volumetric Graphic Annotation module that are present

C.3 Authorization RSA Digital Signature Profile

…

a. the SOP Class and Instance UIDs
b. the Study and Series Instance UIDs
c. any attributes whose Values are verifiable by the technician or physician (e.g., their Values are displayed to the technician or physician)
d. any attributes of the Overlay Plane, Curve or Graphic Annotation modules that are present
e. any attributes of the General Image and Image Pixel modules that are present
f. any attributes of the SR Document General and SR Document Content modules that are present
g. any attributes of the Waveform and Waveform Annotation modules that are present
h. any attributes of the Multi-frame Functional Groups module that are present
i. any attributes of the Enhanced MR Image module that are present
j. any attributes of the MR Spectroscopy modules that are present
k. any attributes of the Raw Data module that are present
l. any attributes of the Enhanced CT Image module that are present
m. any attributes of the Enhanced XA/XRF Image module that are present
?. any attributes the Volumetric Graphic Annotation module that are present

Item #15: Add the following table rows to PS3.15 Table E1-1

Attribute Name	Tag	Retired (from PS3.6)	In Std. Comp. IOD (from PS3.3)	Basic Profile	Retain Safe Private Option	Retain UIDs Option	Retain Device Ident. Option	Retain Patient Chars. Option	Retain Long. Full Dates Option	Retain Long. Modif. Dates Option	Clean Desc. Option	Clean Struct. Cont. Option	Clean Graph. Option
Presentation Display Collection UID	(0070,1101)	N	Y	U		K							
Presentation Sequence Collection UID	(0070,1102)	N	Y	U		K							

Changes to NEMA Standards Publication PS 3.16
Digital Imaging and Communications in Medicine (DICOM)
Part 16: Content Mapping Resource

Item #16: Add Coded Concepts to PS 3.16 Annex B

CID 7010 Key Object Selection Document Title

Context ID 7010
Key Object Selection Document Title
Type: Extensible Version: 20081028

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
…		
DCM	113022	Collection of Presentation States

Item #17: Add CID Tables to PS 3.16 Annex B

CID 501 Volumetric View Description

Context ID 501
Volumetric View Description

Coding Scheme Designator (0008,0102)	**Code Value (0008,0100)**	**Code Meaning (0008,0104)**
Include CID 6 “Transducer Orientation”		
Include CID 26 “Nuclear Medicine Projections”		
Include CID 4010 “DX View”		
Include CID 12226 “Echocardiography Image View”		

CID 502 Volumetric View Modifier

Context ID 502
Volumetric View Modifier

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
Include CID 6 “Transducer Orientation”		
Include CID 23 “Cranio-Caudad Angulation”		
Include CID 4011 “DX View Modifier”		

Item #18: Add Coded Concepts to PS 3.16 Annex D

Annex D DICOM Controlled Terminology Definitions (Normative)

This Annex specifies the meanings of codes defined in DICOM, either explicitly or by reference to another part of DICOM or an external reference document or standard.

DICOM Code Definitions (Coding Scheme Designator “DCM” Coding Scheme Version “01”)

Code Value	Code Meaning	Definition	Notes
…			
113022	**Collection of Presentation States**	**This Key Object Selection Document references Presentation State instances that are related, which may or may not share a value of Presentation Display Collection UID (0070,1101) or Presentation Sequence Collection UID (0070,1102).**	
…			

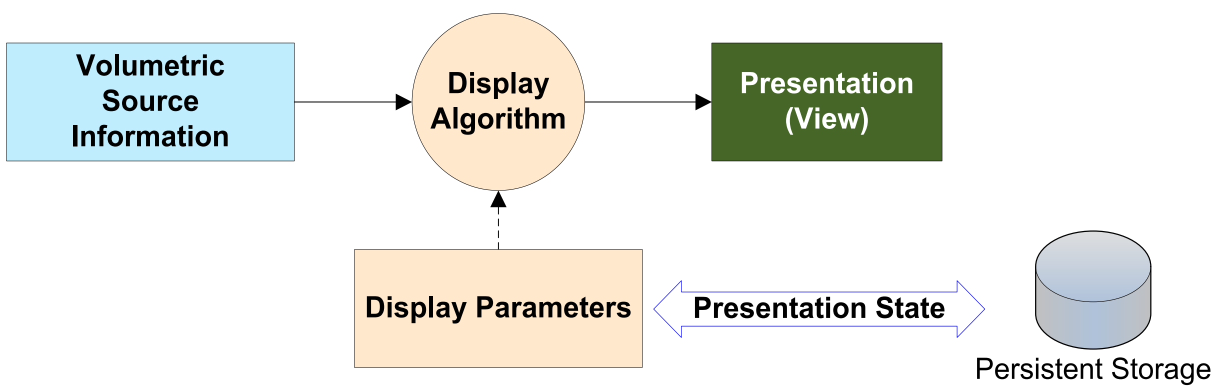
Changes to NEMA Standards Publication PS 3.17
Digital Imaging and Communications in Medicine (DICOM)
Part 17: Explanatory Information

Item #19: Add New Annex "Y" to Part 17

Annex Y VOLUMETRIC PRESENTATION STATES (INFORMATIVE)

Y.1 Scope of Volumetric Presentation States

Volume data may be presented through a variety of display algorithms, such as frame-by-frame viewing, multi-planar reconstruction, surface rendering and volume rendering. The Volumetric Source Information consists of one or more volumes (3D or 4D) used to form the presentation. When a volume Presentation View is created through the use of a Display Algorithm, it typically requires a set of Display Parameters that determine the specific presentation to be obtained from the volume data. Persistent storage of the Display Parameters used by a Display Algorithm to obtain a presentation from a set of volume-related data is called a Volumetric Presentation State (VPS):



Each Volumetric Presentation State describes a single view with optional animation parameters. A Volumetric Presentation State may also indicate that a particular view is intended to be displayed alongside the views from other Volumetric Presentation States. However, descriptions of how multiple views should be presented are not part of a Volumetric Presentation State and should be specified by a Structured Display, a Hanging Protocol or by another means.

The result of application of a Volumetric Presentation State is not expected to be exactly reproducible on different systems. It is difficult to describe the rendering algorithms in enough detail in an interoperable manner, such that a presentation produced at a later time is indistinguishable from that of the original presentation. While Volumetric Presentation States use established DICOM concepts of grayscale and color matching (GSDF and ICC color profiles) and provides a generic description of the different types of display algorithms possible, variations in algorithm implementations within display devices are inevitable and an exact match of volume presentation on multiple devices cannot be guaranteed. Nevertheless, reasonable consistency is provided by specification of inputs, geometric descriptions of spatial views, type of processing to be used, color mapping and blending, input fusion, and many generic rendering parameters, producing what is expected to be a clinically acceptable result.

Y.1.1 Volumetric Presentation States vs. Softcopy Presentation States

A Volumetric Presentation State is different from Softcopy Presentation States in several ways:

1. Unlike Softcopy Presentation States, a Volumetric Presentation State describes the process of creating a new image rather than parameters for displaying an existing one

2. Volumetric Presentation State may not be displayed exactly the same way by all display systems due to differences in the implementations of rendering algorithms.

Y.1.2 Image Creation Process

While both Volumetric Presentation States and Softcopy Presentation States reference source images, a display application applying a Volumetric Presentation State will not directly display the source images. Instead, it will use the source data to construct a volume and then create a new view of the volume data to be displayed. Depending on the specific Volumetric Presentation State parameters, it is possible that some portion of the inputs may not contribute to the generated view.

Y.1.3 Volumetric Presentation State Display Consistency

Some types of volumetric views may be significantly influenced by the hardware and software used to create them, and the industry has not yet standardized the volume rendering pipelines to any great extent.

While volume geometry is consistent, other display characteristics such as color, tissue opacity and lighting may vary slightly between display systems.

The use of the Rendered Image Reference Sequence (0070,1104) to associate the Volumetric Presentation State with a static rendering of the same view is encouraged to facilitate the assessment of the view consistency (see Y.2.3).

Y.2 Volumetric Presentation States vs. Static Derived Images

A Volumetric Presentation State creator is likely to be capable of also creating a derived static image (such as a secondary capture image) representing the same view. Depending on the use case, either a Volumetric Presentation State or a Secondary Capture image or both may be preferred.

Y.2.1 Static Derived Images

Static derived images are intended for direct viewing, and have the following advantages:

- supported by a wide variety of viewers
- minimal display consistency issues – particularly when paired with a Softcopy Display Presentation State
- no volumetric processing is required

and the following disadvantages

- cannot be used to re-create the view from the volume data and then interactively manipulate the view
- dynamic views may require the creation of a large number of individual instances

Y.2.2 Volumetric Presentation States

Volumetric Presentation States have the following advantages:

- can be used to re-create the view and allow interactive creation of additional views
- supporting artifacts, such as Segmentation instances, are preserved and can be re-used
- allows collaboration between dissimilar clinical applications (e.g. a radiology application could create a view to be used as a starting point for a surgical planning application)

- measurements and annotations can be linked to machine-readable structured context to allow integration with reporting and analysis applications
- compact representation of dynamic views

and the following disadvantages

- not yet supported by legacy systems
- consistency of presentation may vary
- requires access to the original volumetric data and any associated objects (such as segmentation or spatial registration instances)

Y.2.3 Both Volumetric Presentation States and Linked Static Images

A Volumetric Presentation State (VPS) creator can create a static derived image at the same time and link it to the VPS by using the Rendered Image Reference Sequence (0070,1104). This approach yields most of the advantages of the individual formats. Additionally, it allows the static images to be used to assess the display consistency of the view.

This approach also allows for a staged review where the static image is reviewed first and the Volumetric Presentation State is only processed if further interactivity is needed.

The main disadvantage to this approach is that it may add a significant amount of data to an imaging study.

Y.3 Use Cases

This section includes examples of volumetric views and how they can be described with the Volumetric Presentation States to allow recreation of those views on other systems. The illustrated use cases are examples only and are by no means exhaustive.

Each use case is structured in three sections:

1) **User Scenario**: Describes the user needs in a specific clinical context, and/or a particular system configuration and equipment type.
2) **Encoding Outline**: Describes the Volumetric Presentation States related to this scenario, and highlights key aspects.
3) **Encoding Details**: Provides detailed recommendations of the key attributes of the Volumetric Presentation States to address this particular scenario. The tables are similar to the IOD tables of the DICOM Part 3. Only attributes with specific recommendation in this particular scenario have been included.

Y.3.1 Simple Planar MPR View

Y.3.1.1 User Scenario

A grayscale planar MPR view created from one input volume without cropping is the most basic application of the Planar MPR VPS.

Y.3.1.2 Encoding Outline

To create this view, the Volumetric Presentation State Relationship Module refers to one input volume, and uses the Volumetric Presentation State Display Module with a minimum set of attributes, generating this simple pipeline:

Figure Y.3.1-1: Simple Planar MPR Pipeline

The parameters for computing the Multi-Planar Reconstruction are defined in the Multi-Planar Reconstruction Geometry Module.

Y.3.1.3 Encoding Details

Y.3.1.3.1 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.1-1
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation State Input Sequence	(0070,1201)	Set one item in this sequence.
>Presentation Input Type	(0070,1202)	Set to ‘VOLUME’.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume.
>Window Center	(0028,1050)	Set either Window Center and Window Width or VOI LUT Sequence (0028,3010).
>Window Width	(0028,1051)	
>Crop	(0070,1204)	Set to ‘NO’.

Y.3.1.3.2 Volumetric Presentation State Display Module Recommendations

Table Y.3.1-2
Volumetric Presentation State Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to ‘MONOCHROME’
Presentation LUT Shape	(2050,0020)	Set to ‘IDENTITY’ or ‘INVERSE’

Y.3.2 Spatially related views (e.g. Orthogonal)

Y.3.2.1 User Scenario

Planar MPR views are often displayed together with other spatially related Planar MPR views. For example, a very common setup are three orthogonal MPRs showing a lesion in transverse, coronal and sagittal views of the data set.

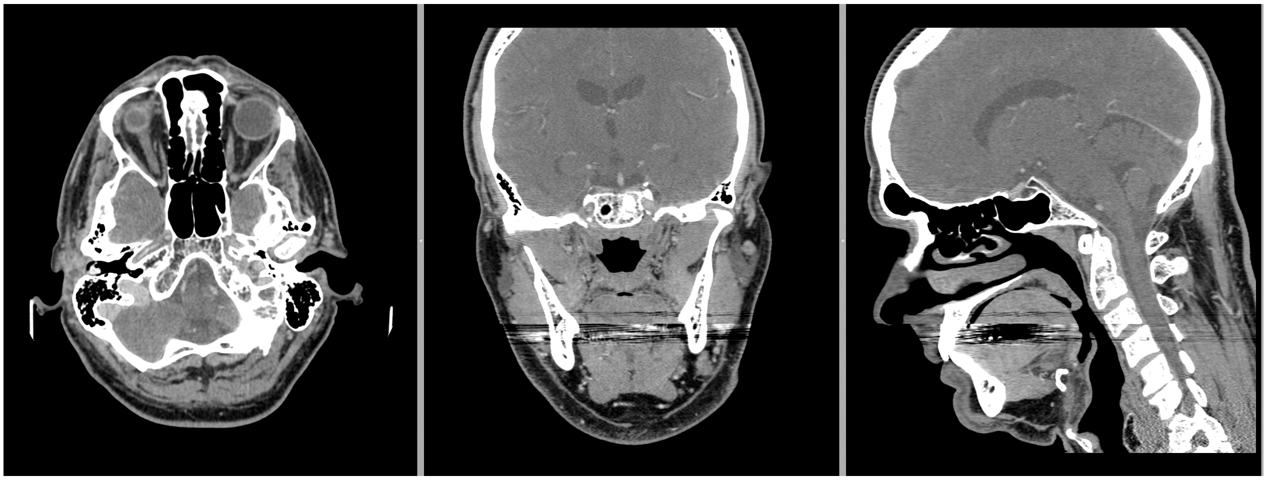


Figure Y.3.2-1.
Three orthogonal MPR views. From left to right: transverse, coronal, sagittal

Y.3.2.2 Encoding Outline

The storage of the view shown in figure Y.3.x-1 requires the generation of three Planar MPR VPS SOP instances and normally a Basic Structured Display SOP instance which references the Planar MPR VPS SOP instances.

In order to enable display applications which do not support the Basic Structured Display SOP Class to create similar views of multiple related Planar MPRs the Planar MPR VPS SOP Class supports marking instances as spatially related in the Volumetric Presentation State Identification Module.

This allows display applications to identify Volumetric Presentation State instances for viewing together. Additionally, via the View Modifier Code Sequence (0054, 0222) in the Presentation View Description Module, display applications can determine which Volumetric Presentation State instance to show at which position on the display depending on the user preferences. Refer to Section Y.4 for display layout considerations.

Y.3.2.3 Encoding Details

Y.3.2.3.1 Volumetric Presentation State Identification Module Recommendations

Table Y.3.2-1
Volumetric Presentation State Identification Module Recommendations

Attribute Name	Tag	Comment
Presentation Display Collection UID	(0070,1101)	Set to the same UID in all three Planar MPS VPS SOP Instances.

Y.3.2.3.2 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.2-2
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment

Volumetric Presentation State Input Sequence	(0070,1201)	
>Referenced Image Sequence	(0008,1140)	In this particular scenario usually all three VPS instances reference the same instances that create the volume from which the respective MPR is rendered.

Display applications may want to implement mechanisms for detecting when VPS SOP Instances reference exactly the same image instances within their Volumetric Presentation State Input Sequence item which creates the volume. This saves memory by loading the image instances that create the volume only once.

The Volumetric Presentation States provide no mechanism to explicitly specify the sharing of a volume by multiple VPS SOP instances.

Y.3.2.3.3 Presentation View Description Module Recommendations

Table Y.3.2-3
Presentation View Description Module Recommendations

Attribute Name	Tag	Comment
View Code Sequence	(0054,0220)	For this particular example, CID 2 “Anatomic Modifier” provides applicable values:
>Code Value	(0008,0100)	Set to “G-A138”, “G-A145”, or “G-A117”
>Coding Scheme Designator	(0008,0102)	Set to “SRT”
>Code Meaning	(0008,0104)	Set to “Coronal”, “Sagittal”, or “Transverse”, respectively

Y.3.3 Replacing Set of Derived Images with Multiple Volumetric Presentation States

Y.3.3.1 User Scenario

In the clinical routine radiologists often create a set of derived images from Planar MPR views that cover a specific anatomic region. For example from a head scan a range of oblique transverse Planar MPR views are defined. These views are rendered into separate derived CT or Secondary Capture SOP Class instances for conveying the relevant information to the referring clinician.

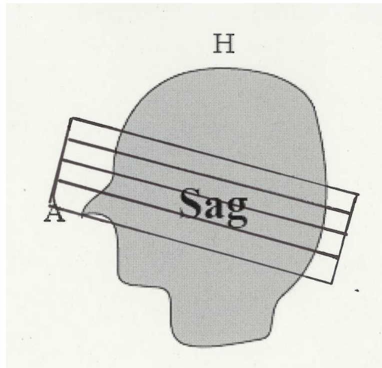


Figure Y.3.3-1.
Definition of a range of oblique transverse Planar MPR views on sagittal view of head scan for creation of derived images

However, these derived images depicting the specific anatomy cannot be changed by the display application. The referring clinician cannot view other anatomy not shown by the derived images and cannot alter the orientation of the Planar MPR views.

Alternatively, a set of Planar MPR VPS SOP Instances can be created to depict the slices through the volume. To indicate that these Volumetric Presentation State instances are sequentially related, the Presentation Sequence Collection UID (0070,1102) is used to associate the instances to show the instances are to be displayed in sequence, and each VPS instance is given a Presentation Sequence Position Index (0070,1103) value to indicate the order in which the instances occur in the collection (in this case, a spatial sequence). In this usage, no animation is specified and it is at the discretion of the display application how these views are to be presented, such as by frames in a light-box format or by a manual control stepping through the presentations in one display window.

Y.3.3.2 Encoding Outline

For Planar MPR views which can be moved or rotated by the display application no special encodings in the Planar MPR VPS SOP Instance are necessary.

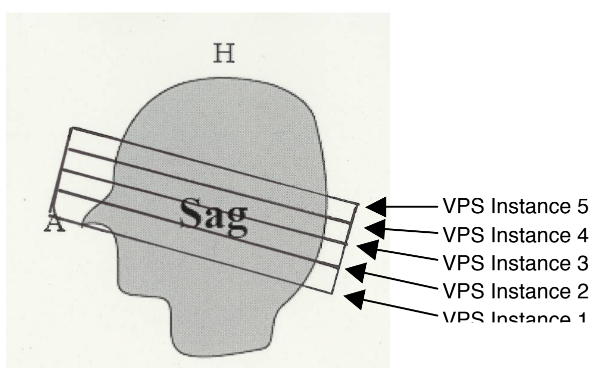


Figure Y.3.3-2.
One Volumetric Presentations States is created for each of the MPR views. The VPS Instances have the same value of Presentation Display Collection UID (0070,1101)

In general, the individual VPS instances may have any orientation and be in any location.

Y.3.3.3 Encoding Details

Y.3.3.3.1 Volumetric Presentation State Identification Module Recommendations

Table Y.3.3-1
Volumetric Presentation State Identification Module Recommendations

Attribute Name	Tag	Comment
Presentation Sequence Collection UID	(0070,1102)	Set to the same UID value in each of the Presentation State instances indicating the views are sequentially ordered.
Presentation Sequence Position Index	(0070,1103)	Set to a number indicating the order of each VPS view in the sequentially-ordered set.

Y.3.4 Replacing Set of Derived Images with Single VPS using Crosscurve Animation

Y.3.4.1 User Scenario

Another technique for depicting a set of derived images is to have a single Planar MPR VPS SOP Instance that describes an initial Planar MPR view, and specify cross-curve animation to generate the other related views. A straight-line curve is specified that begins at the center of the initial Planar MPR view and ends at the intended center of the last Planar MPR view of the set. A step size is specified to be the distance between the first and last points of the line divided by the number of desired slices minus one. A Recommended Animation Rate (0070,1A03) is specified if the creator wishes to provide a hint to the display application to scroll through the slices in the set, or could be omitted to leave the animation method to the discretion of the display application.

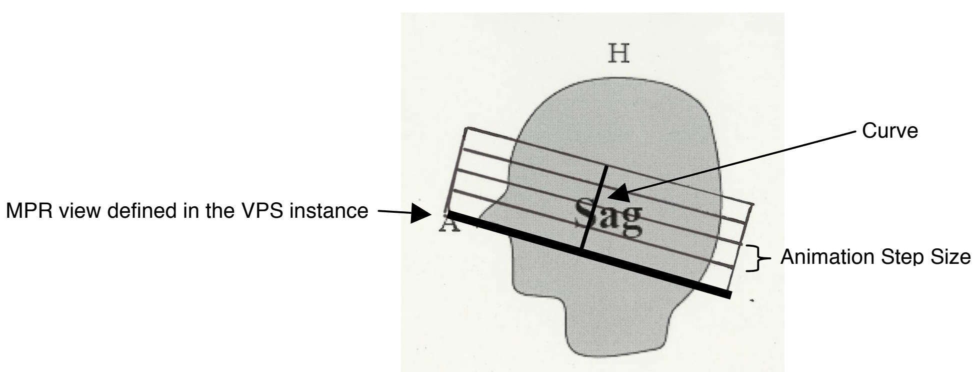


Figure Y.3.4-2.
Additional MPR views are generated by moving the view which is defined in the VPS in Animation Step Size (0070,1A05) steps perpendicular along the curve

Y.3.4.2 Encoding Outline

For this case, the curve is a straight line. In general, however, the curve may have any form such as a circular curve to create radial MPR views.

Y.3.4.3 Encoding Details

Y.3.4.3.1 Presentation Animation Module Recommendations

Table Y.3.4-1
Presentation Animation Module Recommendations

Attribute Name	Tag	Comment
Presentation Animation Style	(0070,1A01)	Set to “CROSSCURVE”
Recommended Animation Rate	(0070,1A03)	Set to provide a hint to the display application to automatically move the Planar MPR view along the curve through the volume, or omitted to leave the animation method to the discretion of the display application.
Animation Curve Sequence	(0070,1A04)	Set to the start point and end point of the straight-line curve.
Animation Step Size	(0070,1A05)	Set to (line length / (number of slices – 1)) as the distance between MPR views along the straight-line curve.

Y.3.5 Volumetric Annotations (example: Trajectory Planning)

Y.3.5.1 User Scenario

The Planar MPR Volumetric Presentation State makes it easy for the receiving display application to enable the user to modify the initial view for viewing nearby anatomy. This requires that display relative annotations need to be removed when the initial view gets manipulated. Otherwise there would be the risk that the annotations point to the wrong anatomy.

To give the display application more control over when to show annotations, the Planar MPR Volumetric Presentation State defines annotations described by coordinates in the VPS-RCS.

As an example, during intervention trajectory planning one or more straight lines representing the trajectories of a device (e.g. needle) to be introduced during further treatment (e.g. cementoplasty, tumor ablation…) are drawn by the user on a planar MPR view.

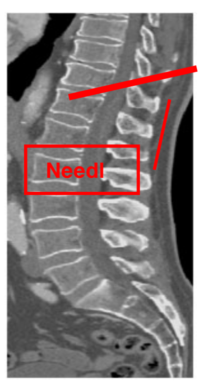


**Figure Y.3.5-1.
Needle trajectory on a Planar MPR view**

The Planar MPR VPS does not define how to render the text associated with the annotation or how to connect it to the graphical representation of the annotation. This is an implementation decision.

The creating application derives the 3D coordinates of the needle trajectory from the Planar MPR view and creates a Planar MPR VPS SOP instance with the needle trajectory as Volumetric Graphic Annotation. When a user viewing the Presentation State manipulates the initial Planar MPR view, the display application could control the visibility of the needle trajectory based on the visibility of the part of the volume which is crossed by the needle trajectory (e.g. by fading the trajectory in and out, since the intersection of the graphic with the plane may only appear as one point). Annotation Clipping (0070,1907) controls whether the out-of-view portion of the 3D annotation is displayed or not; see PS 3.3 Section C.11.x9.1 for details.

For handling multiple annotations in different areas of the volume, applications might provide a list of the annotations which are referenced in the Presentation State. When a user selects one of the annotations the Planar MPR view could automatically be adjusted to optimally show the part of the volume containing the annotation.

Y.3.5.2 Encoding Outline

The Volumetric Presentation State provides the Volumetric Annotation Sequence (0070,1901) for defining annotations by coordinates in the VPS-RCS.

The needle trajectory is encoded as a line described by coordinates in the VPS-RCS. Optionally a Structured Report can be referenced in order to allow the display application to access additional clinical context.

Y.3.5.3 Encoding Details

Y.3.5.3.1 Volumetric Graphic Annotation Module Recommendations

**Table Y.3.5-1
Volumetric Graphic Annotation Module Recommendations**

Attribute Name	Tag	Comment
Volumetric Annotation Sequence	(0070,1901)	Set multiple items in this sequence for multiple needle trajectories, one item for each needle trajectory.
>Graphic Data	(0070,0022)	Set to two (x,y,z) triplets, one for the start and one for the end of the needle trajectory line
>Graphic Type	(0070,0023)	Set to “POLYLINE”
>Graphics Layer	(0070,0002)	Set the same layer for all annotations of the same style.
>Annotation Clipping	(0070,1907)	Set to YES if only the portion of the 3D Annotation within the MPR slice or slab is to be displayed. Set to NO if the 3D Annotation outside the MPR slice or slab should also be projected into the view.
>Unformatted Text Value	(0070,0006)	Set “Needle” as the text to show as a label next to the graphic annotation.

>Referenced Structured Context Sequence	(0070,1903)	Set to a reference to a Structured Report and a Content Item providing clinical meaning of the annotation. The display application could make additional text from the referenced Structured Report concept separately available to the user (e.g. on mouse-over).

Y.3.6 Highlighting Areas of Interest in MPR View

Y.3.6.1 User Scenario

Lung nodules in a volume have been classified by a Computer Aided Detection mechanism into different categories. E.g. small, medium, large. In planar MPR views the nodules are colorized according to their classification.

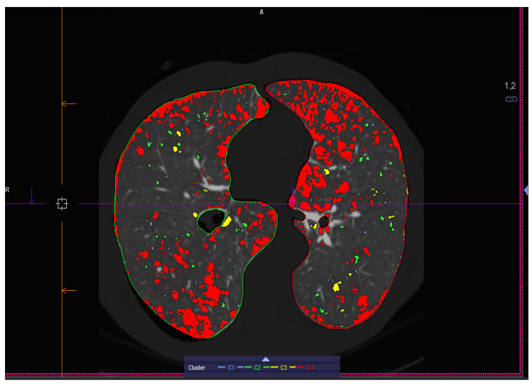


Figure Y.3.6-1
Planar MPR View with Lung Nodules Colorized by Category

Y.3.6.2 Encoding Outline

The classification of the lung nodules is stored in one or multiple Segmentation IOD instances. For each lung nodule category one Segmentation marks the corresponding areas in the volume.

For example, to create a Planar MPR view which shows 3 lung nodule categories in different colors the Planar MPR VPS IOD instance defines via the Volumetric Presentation State Display Module a volumetric pipeline with 4 inputs.

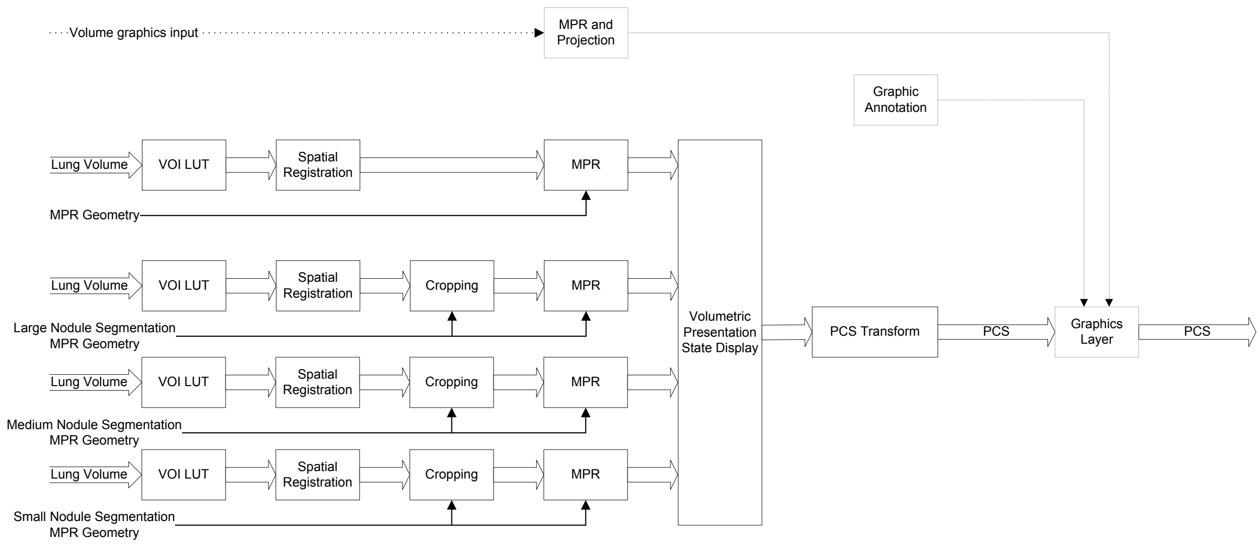


Figure Y.3.6-2
Planar MPR VPS Pipeline for Colorizing the Lung Nodule Categories

The same volume data set of the lung is used as input for all sub pipelines:

The first input to the Volumetric Presentation State (VPS) Display module provides the full (uncropped) MPR view of the anatomy in the display, which will be left as grayscale in the VPS Display module. This will provide the backdrop to the colorized segmented inputs to be subsequently overlaid by compositor components of the Volumetric Presentation State Display pipeline.

The same input data and a single set of MPR geometry parameters defined in the Multi-Planar Reconstruction Geometry module are used to generate each VPS Display module input; only the cropping is different. The Volume Cropping module for each of the other inputs specifies the included segments used to crop away all parts of the volume which do not belong to a nodule of the corresponding nodule category.

From these cropped volumes Planar MPR views are generated, which are then colorized and overlaid on the grayscale background within the Volume Presentation State Display module. (see PS3.4 Section X.2.1.3.1.1) .

In the Volumetric Presentation State Display Module the Presentation State Classification Component Sequence (0070,1801) defines scalar-to-RGB transformations for mapping each MPR view to RGBA. The first MPR (anatomy) view is mapped to grayscale RGB by a RGB LUT Transfer Function (0028,140F) value of EQUAL_RGB. Alpha LUT Transfer Function (0028,1410) is set to NONE; i.e., the anatomy will be rendered as completely opaque background.

For each of the three lung nodule MPR views an RGB transfer function maps the view to the color corresponding the respective nodule category. Alpha is set to 0 for black pixels, making them completely transparent. Alpha for all other pixels is set to 1 (or a value between 0 and 1, if some of the underlying anatomy shall be visible through the nodule segmentation).

Presentation State Compositor Component Sequence (0070,1805) in the Volumetric Presentation State Display Module then creates a chain of three RGB Compositor Components which composite the four MPR views into one. The first RGB Compositor performs “Partially Transparent A over B” compositing as described in Section Y.5.2 by passing through the Alpha of input 2 as Weight-2 and 1-Alpha of input 2 as Weight-1.

The remaining two Compositor Components then perform “Pass Through” compositing as described by Section Y.5.3 by using Weighting LUTs which simply pass through Alpha-1 as Weight-1 and Alpha-2 as Weight-2, since the output of the previous Compositor Components contains no Alpha, and therefore Alpha-1 will automatically be set to one minus Alpha-2 by the Compositor.

Figure Y.3.6-3 shows the complete pipeline for the lung nodule example:

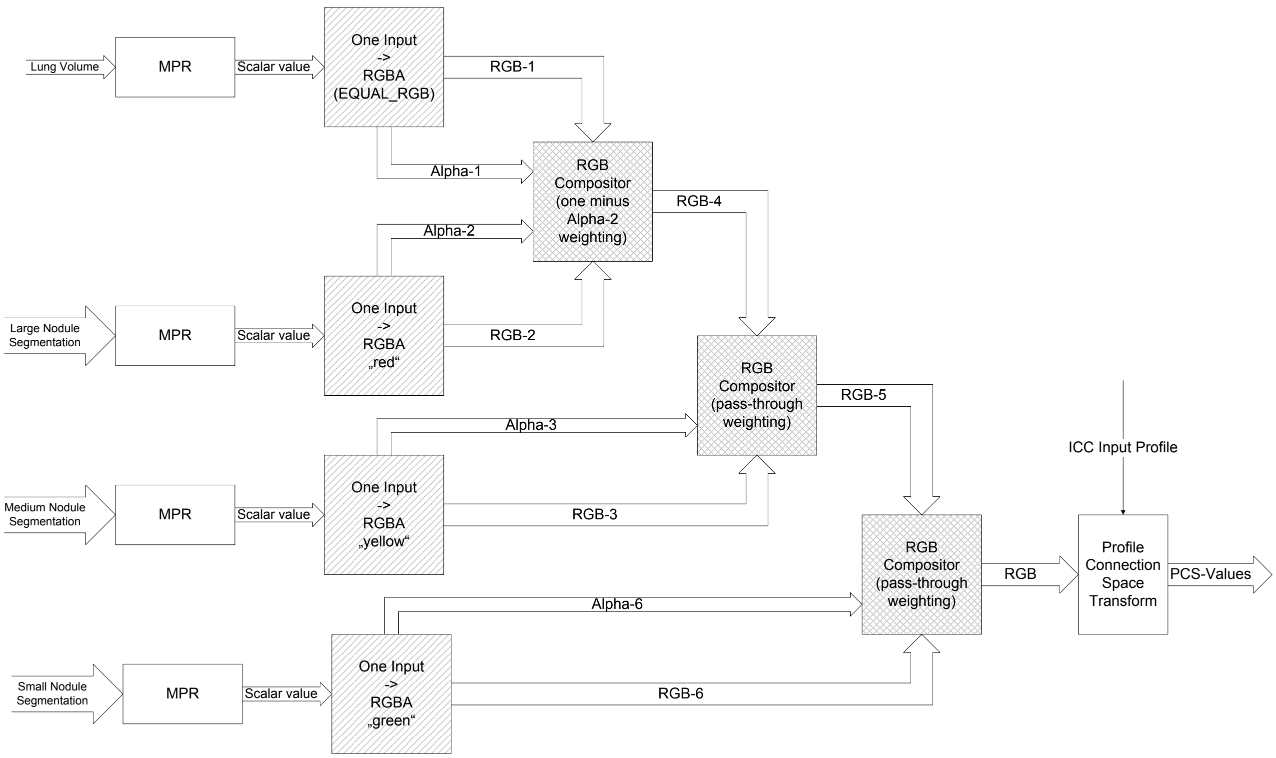


Figure Y.3.6-3
Lung nodule example pipeline

It is envisioned that display applications provide user interfaces for manipulating the Alpha LUT Transfer Functions for each input of the pipeline, allowing the user to control the visibility of the highlighting of each lung nodule category.

Y.3.6.3 Encoding Details

Y.3.6.3.1 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.6-1
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment

Volumetric Presentation State Input Sequence	(0070,1201)	Four items are this sequence. Most attributes of all 4 items are set to exactly the same values, except Crop (0070,1204) is set to 'YES' for the last three items, and the segmentations for the different lung nodule classifications are referenced via the corresponding Cropping Specification Index (0070,1205).
>ITEM 1		
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume.
>Crop	(0070,1204)	Set to 'NO'.
>ITEM 2		
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume.
>Crop	(0070,1204)	Set to 'YES'.
>Cropping Specification Index	(0070,1205)	Set to '1' to identify the segmentation cropping of the large nodules.
>ITEM 3		
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume.
>Crop	(0070,1204)	Set to 'YES'.
>Cropping Specification Index	(0070,1205)	Set to '2' to identify the segmentation cropping of the medium nodules.
>ITEM 4		
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume.
>Crop	(0070,1204)	Set to 'YES'.
>Cropping Specification Index	(0070,1205)	Set to '3' to identify the segmentation cropping of the small nodules.

Y.3.6.3.2 Volumetric Presentation State Cropping Module Recommendations

Table Y.3.6-2
Volumetric Presentation State Cropping Module Recommendations

Attribute Name	Tag	Comment

Volume Cropping Sequence	(0070,1301)	The sequence contains three items, one for each segmented nodule type. For brevity only the first item of the sequence is shown in this table.
>Volume Cropping Method	(0070,1302)	Set to 'INCLUDE_SEG'
> Referenced Image Sequence	(0008,1140)	Set references to segments depicting the areas that make up the nodules marked by the segmentation.
>>Referenced SOP Class UID	(0008,1150)	Set to "1.2.840.10008.5.1.4.1.1.66.4" (Segmentation Storage SOP Class UID)
>>Referenced SOP Instance UID	(0008,1155)	Set to the SOP Instance UID of the instance that contains the Segmentation.
>>Referenced Segment Number	(0062,000B)	Set to the identifier of the relevant segment within the Segmentation instance (e.g. "Large Nodules").
…		

Y.3.6.3.3 Volumetric Presentation State Display Module Recommendations

Table Y.3.6-3
Volumetric Presentation State Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to 'TRUE_COLOR'
Presentation State Classification Component Sequence	(0070,1801)	Include four items, one for each classification component.
>ITEM 1		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Set only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '1' for the anatomy view.
>RGB LUT Transfer Function	(0028,140F)	Set to "EQUAL_RGB' to map to grayscale RGB values.
>Alpha LUT Transfer Function	(0028,1410)	Set to "NONE". The anatomy is completely opaque.
>ITEM 2		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Set only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '2' for the large nodules segmentation.
>RGB LUT Transfer Function	(0028,140F)	Set to "TABLE' to be able to map to "red" colors.
>Alpha LUT Transfer Function	(0028,1410)	Set to 'TABLE' to be able to set a transparency for the segmentation.

…		Definitions of lookup tables left out for brevity.
>ITEM 3		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Set only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '3' for the large nodules segmentation.
>RGB LUT Transfer Function	(0028,140F)	Set to "TABLE' to be able to map to "yellow" colors.
>Alpha LUT Transfer Function	(0028,1410)	Set to 'TABLE' to be able to set a transparency for the segmentation.
…		Definitions of lookup tables left out for brevity.
>ITEM 4		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Set only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '4' for the small nodules segmentation.
>RGB LUT Transfer Function	(0028,140F)	Set to "TABLE' to be able to map to "green" colors.
>Alpha LUT Transfer Function	(0028,1410)	Set to 'TABLE' to be able to set a transparency for the segmentation.
…		Definitions of lookup tables left out for brevity.
Presentation State Compositor Component Sequence	(0070,1805)	Include three items that define the chain of RGB Compositor components.
>ITEM 1		
>Weighting Transfer Function Sequence	(0070,1806)	Contains the two Weighting LUTs from section Y.5.2 to create the "Partially Transparent A over B" composting from two RGBA inputs.
…		Definitions of lookup tables left out for brevity.
>ITEM 2		
>Weighting Transfer Function Sequence	(0070,1806)	Contains the two Weighting LUTs from section Y.5.3 to create the "A over B" composting from one RGB and one RGBA input.
…		Definitions of lookup tables left out for brevity.
>ITEM 3		
>Weighting Transfer Function Sequence	(0070,1806)	Contains the two Weighting LUTs from section Y.5.3 to create the "A over B" composting from one RGB and one RGBA input.
…		Definitions of lookup tables left out for brevity.
ICC Profile	(0028,2000)	Set to an ICC Profile describing the transformation of the resulting RGB image into PCS-Values.

Y.3.7 Ultrasound Color Flow MPR

Y.3.7.1 User Scenario

Ultrasound images and volumes are able to depict both anatomic tissue information (usually shown as a grayscale image) along with functional tissue motion or blood flow information (usually shown in colors representing motion towards or away from the ultrasound transducer).

The sample illustration in Figure Y.3.7-1 is comprised of three Color Flow MPR presentations that are approximately mutually orthogonal in the VPS Reference Coordinate System. Each presentation is described by one Planar MPR Volumetric Presentation State instance, with layout and overlay graphics provided by a Hanging Protocol instance. The three VPS instances share the same value of Presentation Display Collection UID (0070,1101) indicating that they are intended to be displayed together.

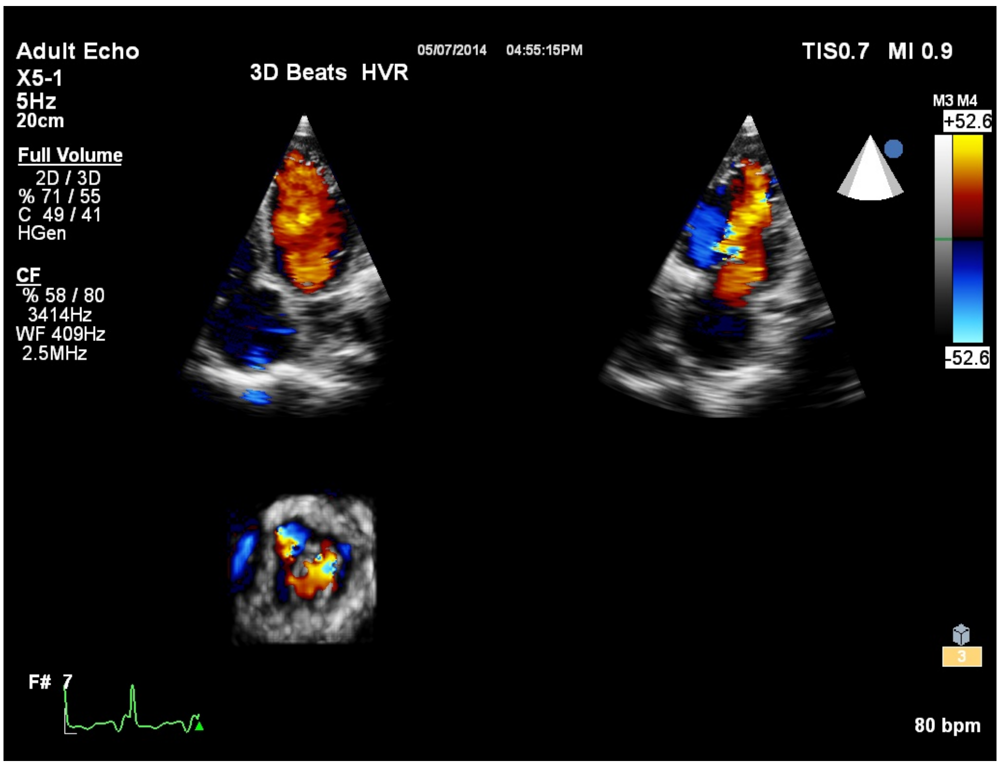


Figure Y.3.7-1
Planar MPR Views of an Ultrasound Color Flow Volume

Y.3.7.2 Encoding Outline

Each of the planar MPR presentations in the display is specified by one Planar MPR Volumetric Presentation State instance. The source volume in this case is stored in an Enhanced US Volume instance, which uses two sets of frames to construct the volume: one set contains tissue intensity frames and one set contains flow velocity frames. Each set of frames comprise one input to the VPS instance and is referenced in one item of Volumetric Presentation State Input Sequence (0070,1201), wherein the Referenced Image Sequence (0008,1140) contains one item per frame of the Enhanced US Volume instance. Spatial Registration is not necessary since both frame sets share the same Volume Frame of Reference in the source instance. Cropping is usually not necessary for multi-planar reconstruction, and both inputs use the same MPR geometry specification.

Classification of the two data types is accomplished using Pixel Presentation (0008,9205) of TRUE_COLOR and two items in Presentation State Classification Component Sequence (0070,1801). The tissue intensity MPR frame is classified using Component Type (0070,1802) of ONE_TO_RGBA and RGB LUT Transfer Function (0028,140F) of EQUAL_RGB to create a grayscale image, while the flow velocity MPR frame is colorized by using Component Type (0070,1802) of ONE_TO_RGBA and RGB LUT Transfer Function (0028,140F) of TABLE and mapping to colors in an RGB color lookup table. Both inputs use Alpha LUT Transfer Function (0028,1410) of IDENTITY so that the alpha represents the magnitude of the input value.

Compositing of the two classified data streams is accomplished using one RGB compositor component, specified by one item in Presentation State Compositor Component Sequence (0070,1805). The Weighting Transfer Function Sequence (0070,1806) is used to accomplish “Threshold Compositing” as described in Y.5.4, a common method used for ultrasound color flow compositing.

Figure Y.3.7-2 shows the complete pipeline for Ultrasound Color Flow Planar MPR.

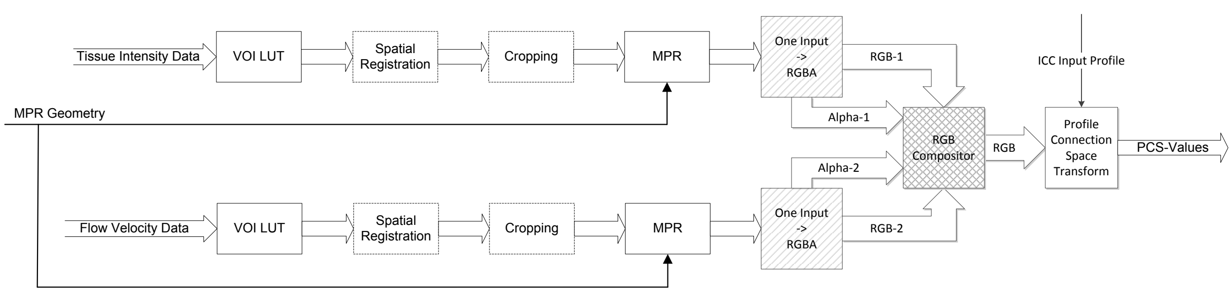


Figure Y.3.7-2
Planar MPR VPS Pipeline for Ultrasound Color Flow

Y.3.7.3 Encoding Details

Y.3.7.3.1 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.7-1
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation State Input Sequence	(0070,1201)	Two items are this sequence referencing one volume for each data type
>ITEM 1		
>Volumetric Presentation Input Number	(0070,1207)	Set to 1
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Sequence of frames with Data Type (0018,9808) value of TISSUE_INTENSITY
>>Include 'Image SOP Instance Reference Macro' Table 10-3		
>Crop	(0070,1204)	Set to 'NO'.
>ITEM 2		
>Volumetric Presentation Input Number	(0070,1207)	Set to 2
>Presentation Input Type	(0070,1202)	Set to 'VOLUME'.
>Referenced Image Sequence	(0008,1140)	Sequence of frames with Data Type (0018,9808) value of FLOW_VELOCITY
>>Include 'Image SOP Instance Reference Macro' Table 10-3		
>Crop	(0070,1204)	Set to 'NO'.

Y.3.7.3.2 Presentation View Description Module Recommendations

Table Y.3.7-2
Presentation View Description Module Recommendations

Attribute Name	Tag	Comment
Anatomic Region Sequence	(0008,2218)	Set to (SRT, T-32000, Heart)
View Code Sequence	(0054,0220)	Set to the code triplet for the view. Typical coded values: (SRT, G-A19C, Apical four chamber) (SRT, G-A19B, Apical two chamber) (SRT, R-40B0E, Transesophageal short axis view)

Y.3.7.3.3 Multi-Planar Reconstruction Geometry Module Recommendations

Table Y.3.7-3
Multi-Planar Reconstruction Geometry Module Recommendations

Attribute Name	Tag	Comment
Multi-Planar Reconstruction Style	(0070,1501)	Set to PLANAR
MPR Thickness Type	(0070,1502)	Set to THIN
MPR View Width Direction	(0070,1507)	Set to the direction of the top row of the MPR view in the VPC-RCS
MPR View Width	(0070,1508)	Set to the width of the top row of the MPR view in the VPC-RCS
MPR View Height Direction	(0070,1511)	Set to the direction of the leftmost column of the MPR view in the VPC-RCS
MPR View Height	(0070,1512)	Set to the width of the leftmost column of the MPR view in the VPC-RCS
MPR Top Left Hand Corner	(0070,1505)	Set to an (x,y,z) point in the VPC-RCS of the upper left corner of the MPR view

Y.3.7.3.4 Volumetric Presentation State Display Module Recommendations

Table Y.3.7-4
Volumetric Presentation State Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to 'TRUE_COLOR'
Presentation State Classification Component Sequence	(0070,1801)	Contains two items, one for each classification component.
>ITEM 1		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '1' for the MPR slice of the TISSUE_INTENSITY data
>RGB LUT Transfer Function	(0028,140F)	Set to "EQUAL_RGB' to map to grayscale RGB values.
>Alpha LUT Transfer Function	(0028,1410)	Set to "IDENTITY"
>ITEM 2		
>Component Type	(0070,1802)	Set to 'ONE_TO_RGBA'
>Component Input Sequence	(0070,1803)	Only one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to '2' for the MPR slice of the FLOW_VELOCITY data

>RGB LUT Transfer Function	(0028,140F)	Set to 'TABLE' to be able to map to colors representing the flow velocities towards and away from the ultrasound transducer
>Alpha LUT Transfer Function	(0028,1410)	Set to 'IDENTITY'
…		Definitions of lookup tables left out for brevity.
Presentation State Compositor Component Sequence	(0070,1805)	Set to one item that defines the threshold compositing of the two data types
>Weighting Transfer Function Sequence	(0070,1806)	Contains the two Weighting LUTs from Section Y.5.4 to create the threshold composting from two RGBA inputs: • If the magnitude of the FLOW_VELOCITY input is greater than the magnitude of the TISSUE_INTENSITY input, display the MPR of the FLOW_VELOCITY data. • Otherwise, display the MPR of the TISSUE_INTENSITY data
…		Definitions of lookup tables left out for brevity.
ICC Profile	(0028,2000)	Set to an ICC Profile describing the transformation of the resulting RGB image into PCS-Values.

Y.3.8 Blending with Functional Data e.g. PET/CT or Perfusion Data

Y.3.8.1 User Scenario

To aid in the exact localization of functional data, e.g. the accumulation of a radioactive tracer which is measured with a position emission tomography (PET) scan, the colorized functional data is blended with e.g. a CT scan which shows the corresponding anatomy in detail.

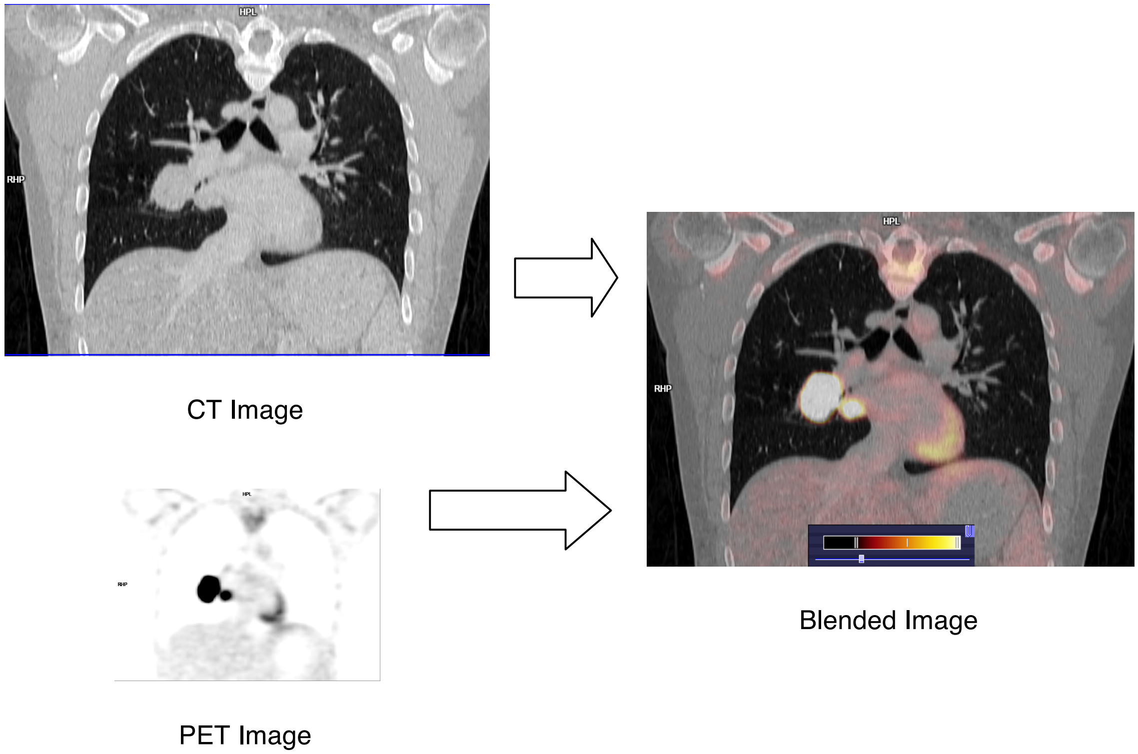


**Figure Y.3.8-1.
Blending with Functional Data**

Y.3.8.2 Encoding Outline

To create a Planar MPR view which shows the colorized PET data blended with the grayscale CT data the Planar MPR VPS IOD instance defines via the Volumetric Presentation State Display Module a volumetric pipeline with 2 inputs.

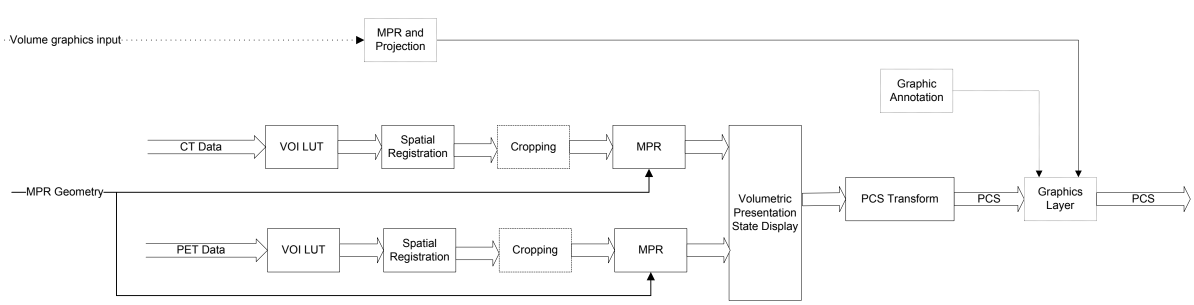


**Figure Y.3.8-2
Planar MPR VPS Pipeline for PET/CT Blending**

The first input to the Volumetric Presentation State (VPS) Display pipeline provides the MPR view of the anatomy in the display, which will be left as grayscale in the VPS Display pipeline. This will provide the backdrop to the colorized PET input to be subsequently overlaid in the second stage of the VPS pipeline.

Since PET and CT datasets usually have different resolutions and are not aligned (even if they reference the same Frame of Reference IOD instance) the datasets are spatially registered to the Volumetric Presentation State RCS. From these registered volumes grayscale Planar MPRs are generated using the same MPR geometry.

The Volume Presentation State Display pipeline then blends the MPRs into one view (see PS3.4 Section X.2.1.3.1.1).

In the Volumetric Presentation State Display Module the Presentation State Classification Component Sequence (0070,1801) defines classification components for mapping the MPRs to RGBA.

The first MPR (CT) view is mapped to grayscale RGBA by an EQUAL_RGB RGB LUT Transfer Function (0028,140F). Alpha LUT Transfer Function (0028,1410) is set to NONE, since the anatomy will be rendered as completely opaque background.

For the second MPR (functional, PET) view an RGBA transfer function maps the tracer intensity values to a color range. Alpha-2 is set to 0 for black pixels, making them completely transparent. Alpha-2 for all other pixels is set to a single value between 0 and 1, depending on the intended transparency of the functional data.

It is envisioned that display applications provide mechanisms to the user for manipulating the Alpha-2 value which has been set in the Presentation State, thereby allowing the user to control the visibility of the anatomy vs. the functional data.

The RGB Compositor then performs “Partially Transparent A over B” compositing as described in Y.5.2 by passing through Alpha-2 as Weight-2 and (1- Alpha-2) as Weight-1

Figure Y.3.8-3 shows details of the classification and compositing for the blended PET/CT Planar MPR:

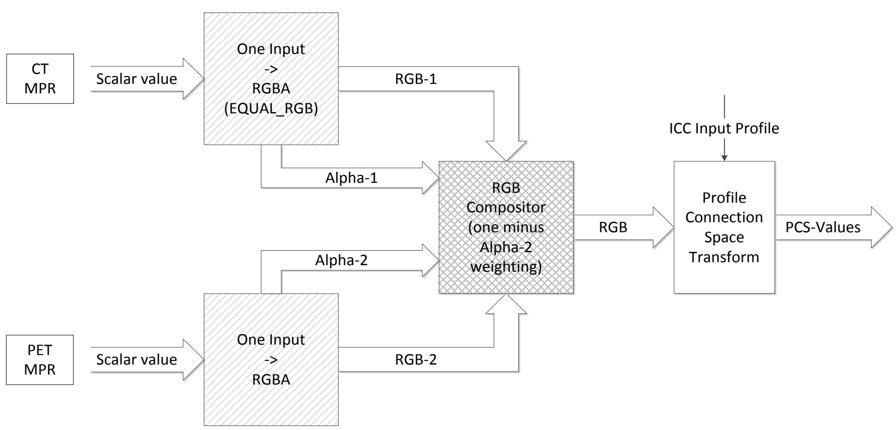


Figure Y.3.8-3
PET/CT Classification and Compositing details

Y.3.8.3 Encoding Details

Y.3.8.3.1 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.8-1
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment

Volumetric Presentation State Input Sequence	(0070,1201)	Contains two items: one for the CT volume input and one for the PET volume input.
>ITEM 1		
>Presentation Input Type	(0070,1202)	Set to ‘VOLUME’.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make(s) up the CT input volume.
>Referenced Spatial Registration Sequence	(0070,0404)	Set to reference the Spatial Registration instance which registers the CT input to the VPS RCS.
>Window Center	(0028,1050)	Set either Window Center and Window Width or VOI LUT Sequence (0028,3010).
>Window Width	(0028,1051)	
>Crop	(0070,1204)	Set to ‘NO’.
>ITEM 2		
>Presentation Input Type	(0070,1202)	Set to ‘VOLUME’.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make(s) up the PET input volume.
>Referenced Spatial Registration Sequence	(0070,0404)	Set reference to the Spatial Registration instance which registers the PET input to the VPS RCS.
>Window Center	(0028,1050)	Set either Window Center and Window Width or VOI LUT Sequence (0028,3010).
>Window Width	(0028,1051)	
>Crop	(0070,1204)	Set to ‘NO’.

Y.3.8.2.3 Volumetric Presentation State Display Module Recommendations

Table Y.3.8-3
Volumetric Presentation State Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to ‘TRUE_COLOR’
Presentation State Classification Component Sequence	(0070,1801)	Contains two items, one for classifying the CT data and one for classifying the PET data.
>ITEM 1		
>Component Type	(0070,1802)	Set to ‘ONE_TO_RGBA’
>Component Input Sequence	(0070,1803)	Contains one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to ‘1’ for the anatomy view.
>RGB LUT Transfer Function	(0028,140F)	Set to “EQUAL_RGB’ to map to grayscale RGB values.
>Alpha LUT Transfer Function	(0028,1410)	Set to ‘NONE’. The anatomy is completely opaque.
>ITEM 2		
>Component Type	(0070,1802)	Set to ‘ONE_TO_RGBA’

>Component Input Sequence	(0070,1803)	Contains one item in this sequence since the component has only one input.
>>Input Set Index	(0070,1804)	Set to ‘2’ for the functional view.
>RGB LUT Transfer Function	(0028,140F)	Set to “TABLE’ to be able to map functional data to a color range.
>Alpha LUT Transfer Function	(0028,1410)	Set to ‘TABLE’ to be able to set a transparency for the segmentation.
…		Definitions of lookup tables left out for brevity.
Presentation State Compositor Sequence	(0070,1805)	Contains one item
>Weighting Transfer Function Sequence	(0070,1806)	Contains the two Weighting LUTs from Section Y.5.2 to create the “Partially Transparent A over B” composting of two RGBA inputs.
…		Definitions of lookup tables left out for brevity.
ICC Profile	(0028,2000)	Set to an ICC Profile describing the transformation of the resulting RGB image into PCS-Values.

Y.3.9 Stent Stabilization

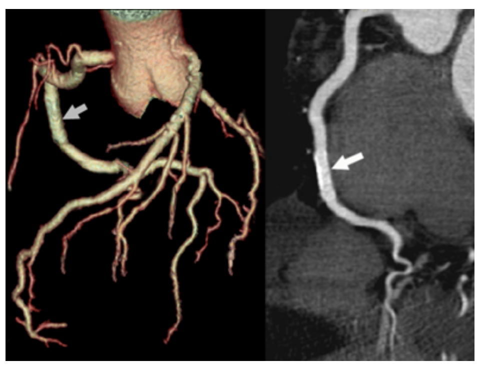


Figure Y.3.9-1.
Stent Stabilization

Y.3.9.1 User Scenario

When evaluating the placement of a coronary artery stent, the stent is often viewed in each phase of a multiphase cardiac CT. An oblique Planar MPR MIP slab is typically used. Because of cardiac motion the oblique plane must be repositioned for each phase in order to yield the best view of the stent in that phase, resulting in a sequence of Planar MPR views with different geometry but identical display parameters.

Y.3.9.2 Encoding Outline

The storage of the view shown in figure Y.3.9-1 requires the generation of one Planar MPR Volumetric Presentation State per cardiac phase in the input data. These presentation states form a Sequence Collection.

Y.3.9.3 Encoding Details

Y.3.9.3.1 Volumetric Presentation State Identification Module Recommendations

Table Y.3.9-1
Volumetric Presentation State Identification Module Recommendations

Attribute Name	Tag	Comment
Presentation Sequence Collection UID	(0070,1102)	Set to the same UID value in each of the Presentation State instances indicating the views are sequentially ordered.
Presentation Sequence Position Index	(0070,1103)	Set to “1” for first phase, “2” for second phase, etc.

Y.3.9.3.2 Volumetric Presentation State Relationship Module Recommendations

Table Y.3.9-2
Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation State Input Sequence	(0070,1201)	Each VPS contains a single Input Sequence item referencing a single phase within a multiphase acquisition.
>Referenced Image Sequence	(0008,1140)	Set reference(s) to the image(s) that make up the input volume for this phase.

Y.3.9.3.3 Presentation View Description Module Recommendations

This module is replicated in each of the created Volumetric Presentation States.

Table Y.3.9-3
Presentation View Description Module Recommendations

Attribute Name	Tag	Comment
View Code Sequence	(0054,0220)	For this particular example, CID 2 “Anatomic Modifiers” provides applicable values:
>Code Value	(0008,0100)	Set to “G-A472”
>Coding Scheme Designator	(0008,0102)	Set to “SRT”
>>Code Meaning	(0008,0104)	Set to “Oblique”

Y.3.9.3.4 Presentation Animation Module Recommendations

This module is replicated in each of the created Volumetric Presentation States.

Table Y.3.9-4
Presentation Animation Module Recommendations

Attribute Name	Tag	Comment
Presentation Animation Style	(0070,1A01)	Set to “INPUT_SEQ”
Recommended Animation Rate	(0070,1A03)	Set to “4” (steps per second)

Y.4 USES OF PRESENTATION VIEW DESCRIPTION IN THE IDENTIFICATION MODULE

Y.4.1 Hanging Protocols

A Hanging Protocol Instance could select a set of orthogonal MPRs by use of the Image Sets Sequence (0072,0020).

Table Y.4.1-1
Hanging Protocol Image Set Sequence Recommendations

Attribute Name	Tag	Comment
Image Sets Sequence	(0072,0020)	
>Image Set Selector Sequence	(0072,0022)	
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”
>>Selector Attribute	(0072,0026)	Set to “0008,0016”, the SOP Class UID attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “UI”, the SOP Class UID attribute VR
>>Selector UI Value[i]	(0072,XXXX)	Set to “1.2.840.10008.5.1.4.1.1.11.6”, SOP Class UID of the Planar MPR VPS SOP Class
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”
>>Selector Attribute	(0072,0026)	Set to “0054,0220”, the View Code Sequence attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “SQ”, the View Code Sequence attribute VR
>>Selector Code Value	(0072,0080)	Set to (G-A138, SRT, Coronal)
>>Image Set Number	(0072,0032)	Set to “1” for Image Set 1
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”
>>Selector Attribute	(0072,0026)	Set to “0008,0016”, the SOP Class UID attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “UI”, the SOP Class UID attribute VR
>>Selector UI Value	(0072,XXXX)	Set to “1.2.840.10008.5.1.4.1.1.11.6”, SOP Class UID of the Planar MPR VPS SOP Class
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”

[i] A Change Proposal CP1402 to add this missing element has been assigned

>>Selector Attribute	(0072,0026)	Set to “0054,0220”, the View Code Sequence attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “SQ”, the View Code Sequence attribute VR
>>Selector Code Value	(0072,0080)	Set to (G- A145, SRT, Sagittal)
>>Image Set Number	(0072,0032)	Set to “2” for Image Set 2
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”
>>Selector Attribute	(0072,0026)	Set to “0008,0016”, the SOP Class UID attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “UI”, the SOP Class UID attribute VR
>>Selector UI Value	(0072,XXXX)	Set to “1.2.840.10008.5.1.4.1.1.11.6”, SOP Class UID of the Planar MPR VPS SOP Class
>>Image Set Selector Usage Flag	(0072,0024)	Set to “MATCH”
>>Selector Attribute	(0072,0026)	Set to “0054,0220”, the View Code Sequence attribute tag
>>Selector Attribute VR	(0072,0050)	Set to “SQ”, the View Code Sequence attribute VR
>>Selector Code Value	(0072,0080)	Set to (G-A117, SRT, Transverse)
>>Image Set Number	(0072,0032)	Set to “3” for Image Set 3

The display application would look for three Planar MPR Volumetric Presentation States – one Coronal, one Sagittal and one Transverse – and associate them with Image Sets in the view.

Y.4.2 Structured Displays

A Structured Display Instance could select a set of one or more Volumetric Presentation States by defining an image box whose Image Box Layout Type (0072,0304) has a Value of “VOLUME_VIEW” or “VOLUME_CINE” and by specifying one or more Volumetric Presentation States using the Referenced Presentation State Sequence (see PS 3.3 Table C.11.17-1).

Y.4.3 Ad Hoc Display Layout

Layout could be accomplished in a display application by using the Presentation Display Collection UID (0070,1101) to identify the presentations to be displayed together, and the View Code Sequence (0054,0220) to determine which presentation to display in each display slot. This requires some clinical context at the exam level, which can be obtained from the source images (for example, Performed Protocol Code Sequence (0040,0260)).

Y.5 Compositing and the use of Weighting Transfer Functions

The RGB Compositor described in PS 3.4 Section X.2.1.3.2.2 utilizes two weighting transfer functions of Alpha-1 and Alpha-2 to control the Compositor Function, allowing compositing functions that would not be possible if each weighting factor were based only on that input’s Alpha value. These weighting transfer functions are implemented as Weighting Look-Up Tables (LUTs). Several examples of the use of these Weighting LUTs are described in this section. The format of the examples is in the form of a graph whose horizontal axis is the Alpha-1 input value and whose vertical axis is the Alpha-2 input value. The Weight output value is represented as a gray level, where 0.0=black and 1.0=white.

Section Y.3 references these different weighting function styles from real clinical use cases.

Y.5.1 Fixed Proportional Compositing

In this example, a fixed proportion (in this case $^{2}/_{3}$) of RGB-1 is added to a fixed proportion (in this case $^{1}/_{3}$) of RGB-2. Note that the weighting factors are independent of Alpha values in this case:

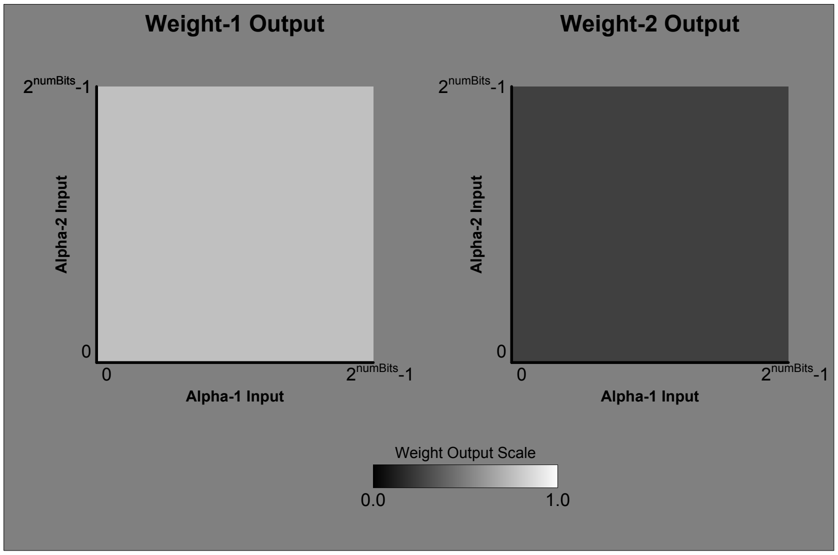


**Figure Y.5-1:
Weighting LUTs for Fixed Proportional Composting**

Y.5.2 Partially Transparent A Over B Compositing

In this example, the Compositor Component performs a Porter-Duff “Partially Transparent A over B” compositing.

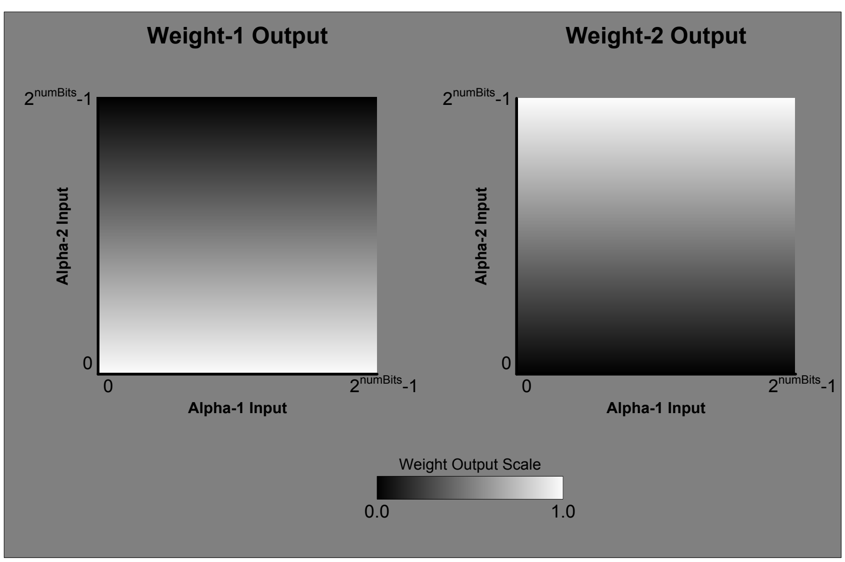


Figure Y.5-2
Weighting LUTs for Partially Transparent A Over B Compositing

Y.5.3 Pass-Through Compositing

In this example, each channel's Alpha value becomes the weighting factor for that channel.

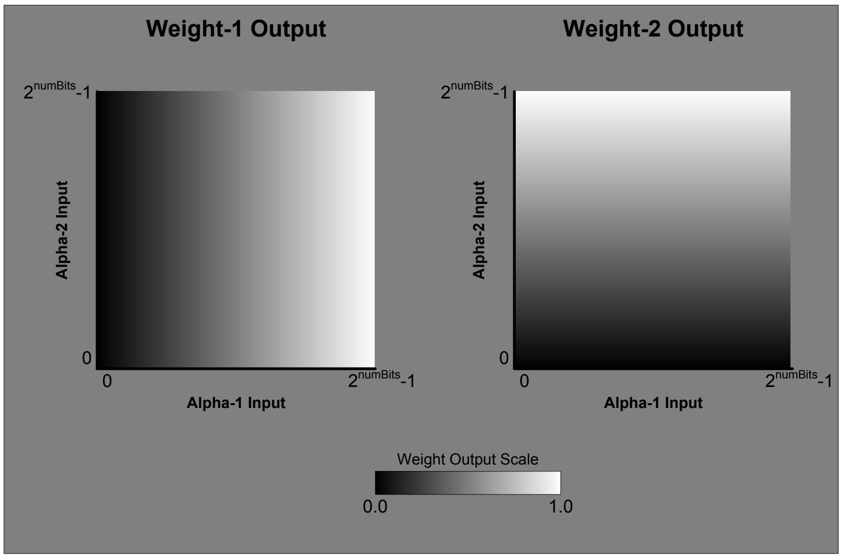


Figure Y.5-3
Weighting LUTs for Pass-Through Compositing

Y.5.4 Threshold Compositing

In this example, the Alpha values are specifed to be representative of the magnitude of the corresponding input data, and the weighting tables are designed such that the stronger of the two inputs are output at each point. If Alpha-2 is less than Alpha-1 then the output consists solely of RGB-1, while if Alpha-2 is greater than Alpha-1 then the output consists solely of RGB-2. This approach is common with ultrasound tissue intensity + flow velocity images, where each output pixel would be either a grayscale tissue value if the flow value is less than the tissue value or a colorized flow velocity value if the flow value is greater than the tissue value:

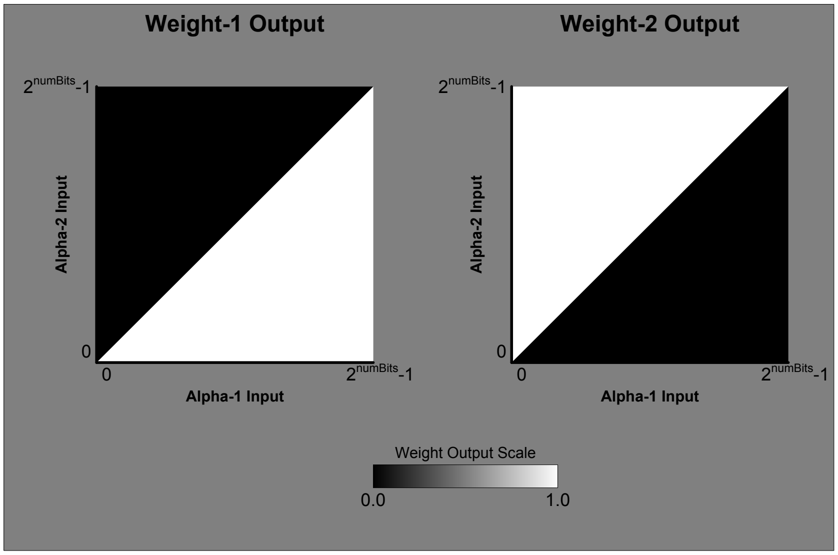


Figure Y.5-4:
Weighting LUTs for Threshold Composting

Y.6 Usage of the Classification and Compositing Components

With these components, blending operations such as the following are possible:

- One input to P-Values output:
  - Pixel Presentation (0008,9205) has a value of MONOCHROME

Figure Y.6-1: One Input To P-Values Output

- One input to PCS-Values output:
  - Pixel Presentation (0008,9205) has a value of TRUE_COLOR
  - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)

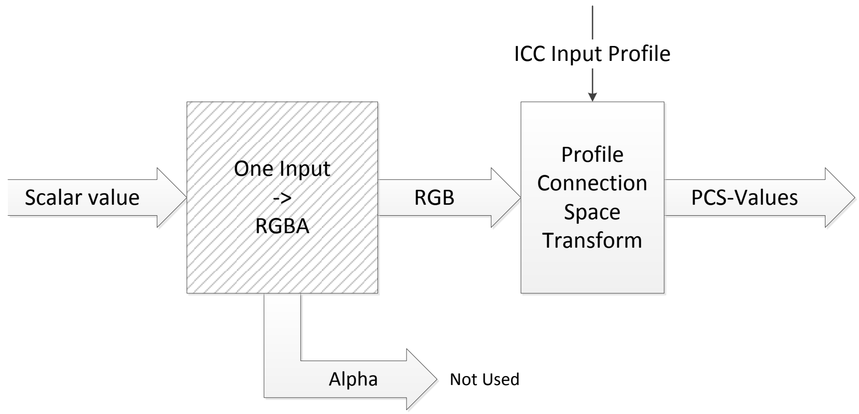


Figure Y.6-2: One Input to PCS-Values Output

- Two inputs to PCS-Values output:
  - Pixel Presentation (0008,9205) has a value of TRUE_COLOR
  - Presentation State Classification Component Sequence (0070,1801) has two items:
    - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)
    - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)
  - Presentation State Compositor Component Sequence (0070,1805) has one item:
    - RGB Compositor component

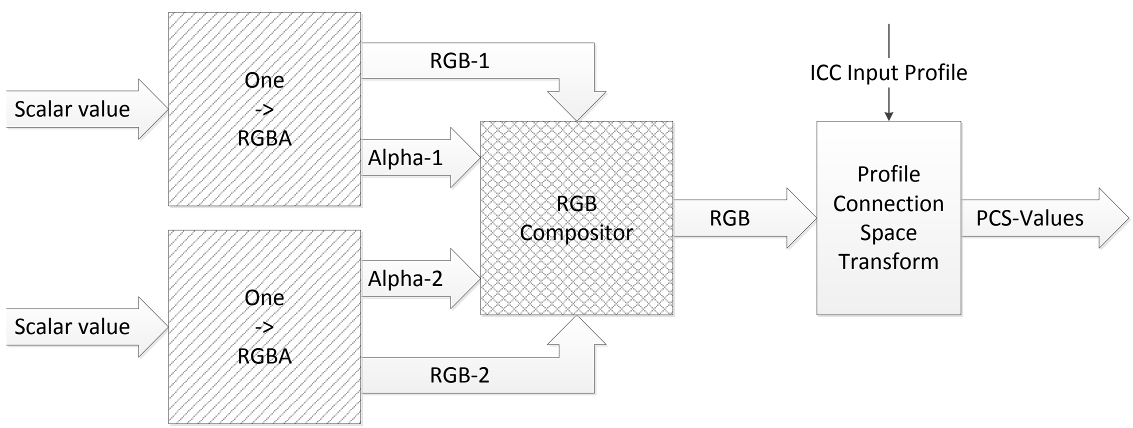


Figure Y.6-3: Two Inputs to PCS-Values Output

- Three inputs to PCS-Values output:
  - Pixel Presentation (0008,9205) has a value of TRUE_COLOR
  - Presentation State Classification Component Sequence (0070,1801) has three items:
    - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)
    - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)

  - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)
- Presentation State Compositor Component Sequence (0070,1805) has two items:
  - RGB Compositor component that combines the outputs of the first two classification components into one RGB
  - RGB Compositor component that combines the outputs of the previous RGB Compositor and the third classification component into one RGB. This RGB Compositor internally sets the missing Alpha to (1 – Alpha-3) since there is no Alpha output from the previous RGB Compositor

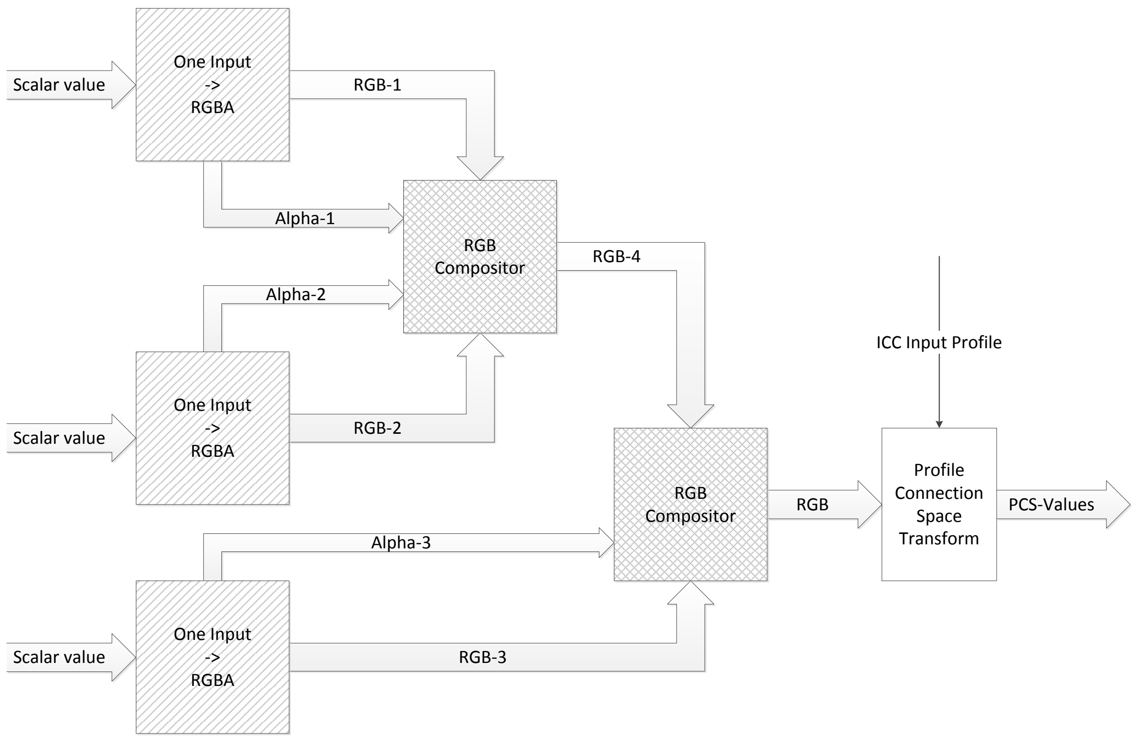


Figure Y.6-4: Three Inputs to PCS-Values Output

- The Volumetric Presentation State Display Module provides functionality equivalent to the Enhanced Blending and Display Pipeline defined in PS 3.3 C.7.6.23:

For P-Value output:

- Pixel Presentation (0008,9205) has a value of MONOCHROME
- Presentation LUT Shape (2050,0020) is present

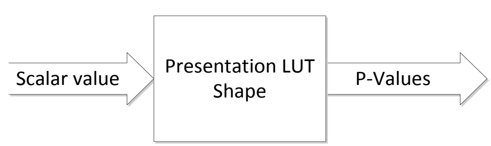


Figure Y.6-5: VPS Display Pipeline Equivalent to the Enhanced Blending and Display Pipeline for P-Values

For PCS-Value output:

- Pixel Presentation (0008,9205) has a value of TRUE_COLOR
- Presentation State Classification Component Sequence (0070,1801) has two items:
  - One Input -> RGBA component (Component Type (0070,1802) = ONE_TO_RGBA)
  - Two Input -> RGBA component (Component Type (0070,1802) = TWO_TO_RGBA)
- Presentation State Compositing Component Sequence (0070,1805) has one item:
  - RGB Compositor component

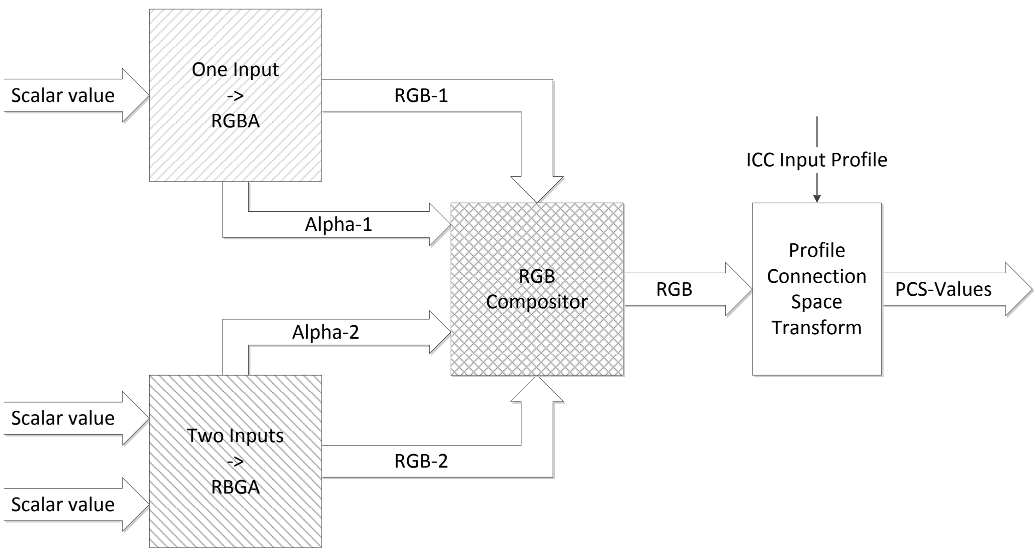


Figure Y.6-6: VPS Display Pipeline Equivalent to the Enhanced Blending and Display Pipeline for PCS-Values