Digital Imaging and Communications in Medicine (DICOM)

Supplement 228: Web Services and Protocol IOD for Volumetric Rendering

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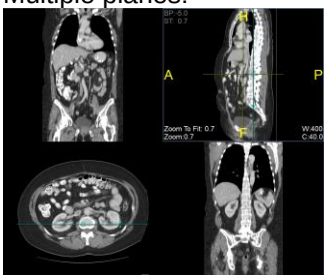
Closed Issues

1.	How should tradeoffs in quality vs. media size be addressed for lightweight devices? **Response:** Existing quality and scaling parameters.
2.	What is the desired level of “interactivity” for the basic user agent? **Response:** pan, zoom, rotate, animate, windowing, set rendering method
3.	Do we need to support Volume Rendering protocols that can be applied in hanging protocols for a zero footprint viewer? **Response:** Yes This is addressed in the Protocol IOD.
4.	Is there additional support required for Ultrasound? **Response:** No MPR should address most needs.
5.	How is vendor proprietary binary data supported? **Response:** Out of scope.
6.	Should the Origin Server return an error when the User Agent specifies Query Parameters that differ from those in Volumetric Rendering Protocol? **Response**: No The Query Parameters take precedence. See Section 8.3.5.3.3. Note: cp2292 has been submitted to address the fact that “Warning” header field (status code 299) as defined in RFC723 has been obsoleted in RFC9111.
7.	Should orientation Query Parameters override those in a Volumetric Presentation State? **Response**: Yes See explanation added to PS3.18 Section 8.3.5.3
8.	Should either the Volumetric Protocol UID, or the Volumetric Presentation State UID be required as the Target Resource in all requests? **Response**: No Instances and frames are also allowed as the Target Resource.
9.	Are the “volume” or the “input instances” the Target Resource? **Response**: Input instances. This is consistent with Volumetric Presentation States. “Volume Data” is an element of the rendering pipeline for Volumetric Presentation states and Volumetric Web Services.

10.	Should this service be extended to the URI Web Service PS18 9.x? **Response**: No The Retrieve Transaction of the Studies Web Service is sufficient. Addressing URI would add complexity.
11.	How can the returned media be as predictable as possible for the user agent when the Target Resource is 4D? **Response**: Returned media is based on the Target Resource and accept media type. See examples in this supplement.
12.	Is the proposed text in PS18 8.11 sufficient to address recognizable visual features that could be displayed by volumetric rendering? **Response:** Yes This was deemed sufficient by WG-06 and WG-14.
13.	How should a 4D animation (e.g., of a beating heart) be created? **Response**: See example B.x3. 4D animation is created when the user agent selects temporal input instances, and requests a Video media type.
14.	Should multiple blended volumes (e.g., merging CT and PET) be supported? **Response**: No This is out of scope for the basic user agent and addressed by Volumetric Presentation States in the Multiple Volume Rendering Volumetric Presentation State Storage IOD.
15.	Should viewport scaling be allowed as an overriding parameter for Volumetric Presentation States? **Response**: No
16.	Is it appropriate to apply an iccprofile to a color Volume Rendering? **Response**: Yes Color space for the rendered image is not defined by DICOM. ICC Profile parameters may be embedded in compatible media formats returned by the origin server, however due to variation in applications that support ICC profiles, there is no guarantee of a standardized color space for rendered images.
17.	Does multi-planar reformat (MPR) describe one view of a single reformatted plane or multiple synchronized views of multiple planes?

	Single plane:  Multiple planes:  **Response**: The de-facto definition MPR refers to a single plane. This plane can be reconstructed in one of several arbitrary planes. The MPR endpoint returns a single planar reformat. The client may create a display (or hanging protocol) consisting of multiple spatiality related planar reformats. See PS3.17 XXX.3.2.1, which states “Planar MPR views are often displayed together with other spatially related Planar MPR views”.
18.	Should this service be extensible? For example, could an origin server offer parameters to invoke a post processing application, such as automatic bone removal? **Response**: Yes To the extent that is already allowed in PS3.18 Section 8.3, which allows origin servers to define additional Query Parameters.
19.	Should there be an API to save a Volumetric Presentation State? **Response**: No The existing Store Transaction (a.k.a. STOW) is sufficient.
20.	Should 3D and MPR be in the same service, or distinct? This could be useful for conformance. **Response**: 3D and MPR has been separated into two services based on recommendation from WG-06.
21.	Should there be a patient instance based on the Volumetric Protocol, or is the Volumetric Presentation State sufficient? **Response**: No The Volumetric Presentation state is the patient instance.
22.	Are the constraints offered within the Volumetric Rendering Protocol, Volume Input Reference Query Parameter, and Volume Input Criteria Query Parameter adequate to enable rendering of study target resources?” **Response**: Yes No public comment was received on this item.

23.	Should all camera orientation Query Parameters be required in a request (i.e., “viewpointposition”, “viewpointlookat”, and “viewpointup”), or can one or more be omitted? **Response**: No If camera orientation Query Parameters are absent, the origin server may apply a default value.
24.	Should there be a resource that exposes the organized Volume Data as a bulkdata resource? **Response:** No This could be considered for a future work item if there is interest.
25.	Do User Agents need named oblique planes (e.g., LAO, RAO) to control anatomic orientation? **Response:** No. This supplement does not introduce oblique anatomic planes, as this would introduce a large number of projections, increasing complexity. User Agents have perpendicular planes defined in Section 8.3.5.3.5. User Agents could also use Viewpoint LookAt, Viewpoint position and Viewpoint Up Query Parameters to modify anatomic orientation.
26.	Are there other parameters or options that should be considered for selection of multi-phasic inputs and multi-volume rendering? Examples include: • Introduce a Volume Definition Object (similar to KOS)? • Add a service to identify instances that meet the Volume Input Requirements in section C.11.23.1 of PS3.3? • Let the origin server choose? • Some combination of solutions? **Response:** No This supplement introduces parameters: Volume Input Reference (Section 8.3.5.3.1) and Matching Attributes (Section 8.3.5.3.2), as well as the "Volume Definition" Module within the Volumetric Rendering Protocol IOD (Section C.X.X.3). The Volumetric Rendering Protocol IOD can be referenced as a query parameter (see Section 8.3.5.3.3).
27.	Are additional animation parameters needed? **Response:** No We considered the use case of rotating a 3D object to create a movie for ppt or multimedia report, however, the Presentation Animation Module may be too complex for some user agents. The following parameters should be adequate: Volumetric Curve Point Coordinates (8.3.5.3.11), Animation Step Size (8.3.5.3.12), and Animation Rate (8.3.5.3.13). Likewise, the Volumetric Rendering Protocol could be referenced by a user agent; it includes the entire Presentation Animation module.

28.	Should Segmentation and 3D print IODs be added to the scope of this supplement? **Response:** No This could be addressed in a future work item. Rendered MPR Volume and Rendered 3D Volume Resources limit the Target Resource to "either a Volumetric Presentation State Instance, or a collection of Image Instances or frames within Image Instances".
29.	Is using camera parameters instead of direction cosines for MPR orientation OK? **Response:** Yes No public comment was received on this item. In this supplement, camera orientation parameters (i.e., "viewpointposition", "viewpointlookat", or "viewpointup") apply to rendered 3D and MPR. Part 17 content has been added to explain the conversion MPR direction cosines to camera orientation parameters.
30.	Are zoom parameters beyond viewport scaling needed for 3D? **Response:** No No public comment was received on this item. Since the existing viewport scaling can be used for a 2D zoom after a volume is rendered, this supplement does not include Query Parameters corresponding to Render Field of View (0070,1606) or MPR View Width (0070,1508) and MPR View Height (0070,1512) attributes.
31.	Are conformance requirements proposed in Part 2 sufficient to document server behavior in a conformance statement? **Response:** Yes No public comment was received on this item
32.	Should the Volumetric Rendering Protocol be specified as a Resource Category within Non-Patient Instance Service? **Response:** No The Volumetric Rendering Protocol belongs to the family of Defined Procedure Protocols that is already a Resource Category in the NPI service.

33.	When the Volumetric Metadata parameter is included in a request, should the response include only the Rendered Volume Response Module, or the Rendered Volume Response Module and the rendered media? **Response:** Only the Rendered Volume Response Module WG-27 prefers to return a single part for each for the following reasons: 1. With HTTP/2 and later versions, a user agent can make a rendering request as usual, and the origin server could provide the Rendered Volume Response Module in a push notification. 2. The ability of user agents to display video within a multipart/related response varies, so it may be impossible for some user agents to support direct viewing. 3. The general trend in PS3.18 is to provide separate endpoints.

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Scope and Field of Application

This supplement introduces Volumetric Rendering web services and a Volumetric Rendering Protocol IOD to enable Volume Rendering (VR), Maximum Intensity Projection (MIP), and Multiplanar Planar Rendering (MPR) without having to specify the numerous and complex parameters required to do so.

Web services enable a user agent to initiate server-side 3D volumetric rendering by specifying Query Parameters and/or referencing a Volumetric Rendering Protocol, or a Volumetric Presentation State. The Resources introduced in the Supplement derive Query Parameters from Volumetric Presentation State attributes while maintaining alignment with current DICOMweb Studies Rendered Resources.

The Volumetric Rendering Protocol IOD is a Non-Patient Instance within the Defined Procedure Protocol IOD family. Its primary function is to facilitate the creation of predefined renderings, by establishing criteria and organizing image set inputs for rendering, and specifying Volumetric Rendering parameters, such as rendering algorithms, geometry, color, shading, and lighting.

Modifications to PS3.2

Modify PS3.2 Section N.1.3.2 Studies Service as follows:

N.1.3.2 Studies Service

Table N.1-9 lists details on the support of the Studies Service.

[Complete Table N.1-9 to indicate support for the Studies Web Service]

Table N.1-9. Study Service

Service	Transaction	Resource	User Agent	Origin Server
Studies Web Service	Retrieve Capabilities			
	Retrieve (WADO-RS)	Study		
		Study Metadata		
		Study Bulkdata		
		Study Pixel Data		
		Rendered Study		
		Rendered MPR Volume Study		
		Rendered 3D Volume Study		
		Study Thumbnail		
		Series		
		Series Metadata		
		Series Bulkdata		
		Series Pixel Data		
		Rendered Series		
		Rendered MPR Volume Series		
		Rendered 3D Volume Series		
		Series Thumbnail		
		Instance		
		Instance Metadata		
		Instance Bulkdata		
		Instance Pixel Data		
		Rendered Instance		
		Rendered MPR Volume Instance		
		Rendered 3D Volume Instance		
		Instance Thumbnail		
		Frames		
		Rendered Frames		
		Rendered MPR Volume Frames		
		Rendered 3D Volume Frames		
		Frame Thumbnail		
		Bulkdata		
	…			

[If your Origin Server supports any Rendered MPR Volume Resources or Rendered 3D Volume Resources, indicate supported SOP Classes in the "Process" column of Table N.1-1]

Add Volumetric Rendering Resources to PS3.2 Table N.5-72 as follows:

Table N.5-72. Resources Retrieve Transaction - User Agent

Resource	Comments
DICOM Instance Resources - See Resources path in Table 10.4.1-1 in PS3.18	
Study Instances	
Series Instances	
Individual Instance	
DICOM Metadata Resources - See Resources path in Table 10.4.1-2 in PS3.18	
Study Metadata	
Series Metadata	
Instance Metadata	
DICOM Bulkdata Resources - See Resources path in Table 10.4.1.5-1 in PS3.18	
Study Bulkdata	
Series Bulkdata	
Instance Bulkdata	
Bulkdata	
DICOM Pixel Data Resources - See Resources path in Table 10.4.1.6-1 in PS3.18	
Study Pixel Data	
Series Pixel Data	
Instance Pixel Data	
Frame Pixel data	
Rendered Resources - See Resources path in Table 10.4.1-3 in PS3.18	
rendered study	
rendered series	
rendered instance	
rendered frame	
rendered bulk	
Rendered MPR Volume Resources - See Resources path in Table 10.4.1.7-1 in PS3.18	
Rendered MPR Volume Study	
Rendered MPR Volume Series	
Rendered MPR Volume Instance	
Rendered MPR Volume Frames	
Rendered 3D Volume Resources - See Resources path in Table 10.4.1.8-1 in PS3.18	
Rendered 3D Volume Study	
Rendered 3D Volume Series	
Rendered 3D Volume Instance	
Rendered 3D Volume Frames	
Thumbnail Resources - See Resources path in Table 10.4.1-4 in PS3.18	
Study Thumbnail	
Series Thumbnail	
Instance Thumbnail	
Frame Thumbnail	

Add Volumetric Rendering Query Parameters to PS3.2 Table N.5-73 as follows:

28 **Table N.5-73. Query Parameters for Retrieve Transaction - User Agent**

Query Parameter	Supported Values	Comments
Accept	*[See examples in header parameters.]*	
Rendered Resource		
annotation	<<patient technique>>	
charset	<<UTF-8 ISO -8859-1 …>>	
quality		
viewport		
window		
iccprofile	<<no yes srgb adobergb rommrgb>>	
Rendered MPR Volume Resources or Rendered 3D Volume Resources		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
volumetricprotocol		
renderingmethod	**<<volume_rendered** **maximum_ip** **minimum_ip** **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
mprslab		
swivelrange		
volumetriccurvepoint		
animationstepsize		
animationrate		
renderedvolumetricmetadata		

Thumbnail Resource		
charset	<<UTF-8 ISO-8859-1 …>>	
viewport		

Add Volumetric Rendering Header Fields to PS3.2 Table N.5-74 as follows:

Editorial note: this incorporates media types introduced in Supplement 235

Table N.5-74. Header Fields for Retrieve Transaction - User Agent

Header Field	Supported Values	Comments
…		
Rendered Resource		
Accept	<<image/jpeg image/gif image/png image/jp2 image/jph image/jphc image/gif video/mpeg video/mp4 video/H265 text/html text/plain text/xml>>	See details in Section N.5.3.2.1.3.
Rendered MPR Volume Resources and Rendered 3D Volume Resources		

Accept	**<<image/jpeg** **image/gif** **image/png** **image/jp2** **image/jph** **image/jphc** **image/gif** **video/mpeg** **video/mp4** **video/H265** **multipart/related; type="application/dicom+xml"** **multipart/related; type="application/dicom+json">>**	**See details in Section N.5.3.2.1.3.**
Thumbnail Resource		
…		

Add Volumetric Rendering Header Fields to PS3.2 Table N.5-74 as follows:

Table N.5-75. Resources Retrieve Transaction - Origin Server

Resource	Comments
DICOM Instance Resources - See Resources path in Table 10.4.1-1 in PS3.18	
Study Instances	
Series Instances	
Individual Instance	
DICOM Metadata Resources - See Resources path in Table 10.4.1-2 in PS3.18	
Study Metadata	
Series Metadata	
Instance Metadata	
DICOM Bulkdata Resources - See Resources path in Table 10.4.1.5-1 in PS3.18	
Study Bulkdata	
Series Bulkdata	
Instance Bulkdata	
Bulkdata	
DICOM Pixel Data Resources - See Resources path in Table 10.4.1.6-1 in PS3.18	
Study Pixel Data	
Series Pixel Data	
Instance Pixel Data	
Frame Pixel data	

Rendered Resources - See Resources path in Table 10.4.1-3 in PS3.18	
rendered study	
rendered series	
rendered instance	
rendered frame	
rendered bulk	
Rendered MPR Volume Resources - See Resources path in Table 10.4.1.7-1 in PS3.18	
Rendered MPR Volume Study	
Rendered MPR Volume Series	
Rendered MPR Volume Instance	
Rendered MPR Volume Frames	
Rendered 3D Volume Resources - See Resources path in Table 10.4.1.8-1 in PS3.18	
Rendered 3D Volume Study	
Rendered 3D Volume Series	
Rendered 3D Volume Instance	
Rendered 3D Volume Frames	
Thumbnail Resources - See Resources path in Table 10.4.1-4 in PS3.18	
Study Thumbnail	
Series Thumbnail	
Instance Thumbnail	
Frame Thumbnail	

Add Volumetric Rendering Query Parameters to PS3.2 Table N.5-76 as follows:

Table N.5-76. Query Parameters for Retrieve Transaction - Origin Server

Query Parameter	Supported Values	Comments
Accept	[Supported Values are the same as for the Accept Header Field.]	
Rendered resource		
annotation	<<patient technique>> [Add additionally supported key word Values here.]	
charset	<<UTF-8 ISO-8859-1 …>>	
Quality		
Viewport		
Window		

iccprofile	<<no yes srgb adobergb rommrgb>>	
Rendered Volume resource		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
volumetricprotocol		***[Describe your product behavior when a User Agent provides both Query Parameters and a Volumetric Rendering Protocol. See Section 8.3.5.3.3 in PS3.18]***
renderingmethod	**<<volume_rendered** **maximum_ip** **minimum_ip** **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
mprslab		
swivelrange		
volumetriccurvepoint		
animationstepsize		
animationrate		
renderedvolumetricmetadata		
Thumbnail resource		
charset	<<UTF-8 ISO-8859-1 …>>	
Viewport		

Add Volumetric Rendering Protocol to PS3.2 Table N.5-140 as follows:

Table N.5-140. Non-Patient Instance Web Service Storage SOP Classes

SOP Class Nname	SOP Class UID	User Agent	Origin Server	Comments
Hanging Protocol Storage	1.2.840.10008.5.1.4.38.1			
Color Palette Storage	1.2.840.10008.5.1.4.39.1			
Generic Implant Template Storage	1.2.840.10008.5.1.4.43.1			
Implant Assembly Template Storage	1.2.840.10008.5.1.4.44.1			
Implant Template Group Storage	1.2.840.10008.5.1.4.45.1			
CT Defined Procedure Protocol Storage	1.2.840.10008.5.1.4.1.1.200.1			
Protocol Approval Storage	1.2.840.10008.5.1.4.1.1.200.3			
Volumetric Rendering Protocol Storage	**1.2.840.10008.5.1.4.xxuid.1**			

Modifications to PS3.3

Modify the following definitions in PS3.3.17 as follows:

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 Multi-Planar Reconstruction (Planar MPR)

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

Volume Data

Data represented by a set of parallel XY planes whose positions are relative to each other that are arranged in a cartesian voxel grid.

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.

Add Volumetric Rendering Protocol IOD to PS3.3 Table A.1-9 as follows:

63 **Table A.1-9. Composite Information Object Modules Overview - Protocols**

IODs Modules	CT Performed Procedure Protocol	XA Performed Procedure Protocol	CT Defined Procedure Protocol	XA Defined Procedure Protocol	Protocol Approval	Volumetric Rendering Protocol
Patient	M	M				
Clinical Trial Subject	U	U				
General Study	M	M				
Patient Study	U	U				
Clinical Trial Study	U	U				
General Series	M	M				
Clinical Trial Series	U	U				
Enhanced Series	M	M				
CT Protocol Series	M					
XA Protocol Series		M				
Frame of Reference	M	M				
General Equipment	M	M	M	M	M	**M**
Enhanced General Equipment	M	M	M	M	M	**M**
Protocol Context	M	M	M	M		**M**
Patient Protocol Context	U	U				
Clinical Trial Context			U	U		
Patient Specification			U	U		
Equipment Specification			M	M		
Instructions	U	U	U	U		**U**
Patient Positioning	U	U	U	U		
General Defined Acquisition			U	U		
Performed CT Acquisition	U					
Performed XA Acquisition		U				
General Defined Reconstruction			U	U		
Performed CT Reconstruction	U					
Performed XA Reconstruction		U				
Defined Storage			U	U		
Performed Storage	U	U				
Protocol Approval					M	
Volumetric Rendering Protocol						**M**
Volume Data Input Image Set Module						**U**
Volume Definition Module						**U**
Volume Render Geometry						**C**
Render Shading						**U**
Render Display						**C**

Multi-Planar Reconstruction Geometry						**C**
MPR Volumetric Presentation State Display						**C**
VOI LUT						**U**
Presentation Animation						**U**
SOP Common	M	M	M	M	M	**M**

Add new section for Volumetric Rendering Protocol IOD to PS3.3 Annex A Composite Information Object Definitions

A.XX Volumetric Rendering Protocol IOD

A.XX.1 Volumetric Rendering Protocol IOD Description

A Volumetric Rendering Protocol IOD is a non-patient instance belonging to the family of Defined Procedure Protocol IODs that specifies input image set selector constraints and a Rendered presentation of Volume Data. The Volumetric Transformations follow the Planar MPR Volumetric Transformations specified in PS3.4 Section FF.2.1.1, or the Volume Rendering Volumetric Transformations specified in PS3.4 Section FF.2.1.2.

It includes capabilities for specifying:

a. protocol context
b. volumetric source information
c. grouping of volumetric source information into Volume Data
d. multi-planar or volume rendered geometry
e. optional volume rendered shading models
f. an exemplary thumbnail

A.XX.2 Volumetric Rendering Protocol IOD Entity-Relationship Model

Volumetric Rendering Protocol IOD uses the E-R Model specified in Section 7.13.X.

A.XX.3 Volumetric Rendering Protocol IOD Module Table

Table A.XX.3-1 lists the Modules that make up the Volumetric Rendering Protocol IOD.

Table A.XX.3-1. Volumetric Rendering Protocol IOD Modules

IE	Module	Reference	Usage
Procedure Protocol	Protocol Context	C.34.2	M
	General Equipment Module	C.7.5.1	M
	Enhanced General Equipment Module	C.7.5.2	M
	Instructions Module	C.34.7	U
	Volumetric Rendering Protocol Module	C.XX.1	M
	Volume Data Input Image Set Module	C.XX.2	U

Volumetric Rendering Protocol	Volume Definition Module	C.XX.3	U - Optional if the value of Volume Type (00gg,eee1) is TEMPORAL_VOLUME or MULTIVOLUME May be present otherwise.
Presentation State	Volume Render Geometry	C.11.30	C - Required if Reformatting Operation Type (0072,0510) in the Volumetric Rendering Defined Protocol Module equals 3D RENDERING
	Render Shading	C.11.31	U - Optional if Reformatting Operation Type (0072,0510) in the Volumetric Rendering Defined Protocol Module equals 3D RENDERING
	Render Display	C.11.32	C - Required if Reformatting Operation Type (0072,0510) in the Volumetric Rendering Defined Protocol Module equals 3D RENDERING
	Multi-Planar Reconstruction Geometry	C.11.26	C - Required if Reformatting Operation Type (0072,0510) in the Volumetric Rendering Defined Protocol Module equals MPR
	MPR Volumetric Presentation State Display	C.11.27	C - Required if Reformatting Operation Type (0072,0510) in the Volumetric Rendering Defined Protocol Module equals MPR
	VOI LUT	C.11.2	U - Optional if Rendering Method (0070,120D) in the Volumetric Rendering Defined Protocol Module is not VOLUME_RENDERED
	Presentation Animation	C.11.29	U
	SOP Common	C.12.1	M

Add new section for Volumetric Rendering Protocol Modules to PS3.3 Annex C Information Module Definitions

C.XX Volumetric Rendering Protocol Modules

C.XX.1 Volumetric Rendering Protocol Module

Table C.XX-1.specifies the attributes of the Volumetric Rendering Defined Protocol Module

Table C.XX-1 Volumetric Rendering Protocol Module

Name	Tag	Type	Description

Reformatting Operation Type	(0072,0510)	1	Reformatting operation to be applied to the Image Set. Enumerated Values: MPR 3D_RENDERING
Rendering Method	(0070,120D)	1	Specifies the display algorithm to be applied to the Volume Data. Only one value shall be present. Enumerated Values: VOLUME_RENDERED A method where each XY pixel of the rendered view is determined by accumulating the set of non-transparent voxel samples along a ray. 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.
Icon Image Sequence	(0088,0200)	1	A image representing the type of output that would be generated by this Volumetric Rendering Protocol. Only a single Item is permitted in this Sequence.
>Include Table C.7-11b "Image Pixel Macro Attributes"			*See Section C.7.6.1.1.6*
Volume Organization Type	(00gg,eee1)	1	The Volume Data accepted as input to this Volumetric Rendering Protocol. See Section C.XX.1.1.1

C.XX.1.1 Volumetric Rendering Protocol Module Attribute Descriptions

C.XX.1.1.1 Volume Organization Type

Sequential acquisitions may result in multiple Volume Data Image Sets in which the same anatomical volume is imaged at multiple times in order to capture images of a non-cyclic, time varying event. For example, imaging of the uptake of a tracer or contrast in a specific organ over time.

The Volume Organization Type (00gg,eee1) characterizes the Volume Data input to Volumetric Rendering.

Enumerated Values:

VOLUME

a single Volume Data set at a single point in time

TEMPORAL_VOLUME

multiple temporally related Volume Data sets that are spatially co-located. Examples include:

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

MULTIVOLUME

multiple Volume Data sets that are spatially separated. See Figure C.7.6.16-4 for an example.

C.XX.2 Volume Data Input Image Set Module

Table C.XX-2 specifies the attributes of the Volume Data Input Image Set Module.

Table C.XX-2 Volume Data Input Image Set Module

Name	Tag	Type	Description
Volume Data Input Image Set Specification Sequence	(00gg,eee2)	1	Constraints on attributes, values, and/or value ranges for the set of Image Instances or frames that will make up the input data for volumetric rendering. See Sections C.11.23.1 and C.XX.2.1 One or more items are permitted in this Sequence.
>Include Table 10.25-1 "Attribute Value Constraint Macro Attributes"			The same Attribute shall not appear in more than one Item in the Sequence with the same values for Selector Sequence Pointer (0072,0052) and Selector Sequence Pointer Items (0074,1057).

C.XX.2.1 Volume Data Input Image Set Module Attribute Descriptions

C.XX.2.1.1 Volume Data Input Image Set Selector Sequence

The Volume Data Input Image Set Selector Sequence (00gg,eee2) identifies one or more acceptable image sets intended for one or more Volume Data sets. An Image Set may be an entire Study, Series or multi-frame instance, or a subset thereof, and is identified by procedure, anatomy, modality or other attribute values.

Note

1. The following Attributes from image IODs are examples of some possible values for Selector Attribute (0072,0026) of Volume Data Input Image Set Selector Sequence (00gg,eee2). This is not a complete list:
   - Image Type (0008,0008) or Frame Type (0008,9007)
   - Anatomic Region Sequence (0008,2218)
   - Acquisition Contrast (0008,9209)
   - Acquisition Time (0008,0032)

- Contrast/Bolus Agent (0018,0010)
- Body Part Examined (0018,0015)
- Scanning Sequence (0018,0020)
- Echo Time (0018,0081)
- Echo Number(s) (0018,0086)
- Protocol Name (0018,1030)
- Trigger Time (0018,1060)
- Image Trigger Delay (0018,1067)
- Trigger Window (0018,1094)
- Echo Pulse Sequence (0018,9008)
- Phase Contrast (0018,9014)
- Effective Echo Time (0018,9082)
- Laterality (0020,0060)
- Image Laterality (0020,0062)
- Dimension Index Value (0020,9157)

2. The Selector Attribute Macro allows selection of Private Creator Attributes

C.XX.3 Volume Definition Module

Table C.XY-1 specifies the attributes of the Volumetric Definition Module

Table C.XX-3 Volume Definition Module

Name	Tag	Type	Description
Volume Data Organization Sequence	(00gg,eee3)	1	Constraints on the characteristics of Volume Data. See Section C.XX.3.1.1. One or more Items shall be included in this Sequence.
>Include Table 10.25-1 "Attribute Value Constraint Macro Attributes"			The same Attribute shall not appear in more than one Item in the Sequence with the same values for Selector Sequence Pointer (0072,0052) and Selector Sequence Pointer Items (0074,1057).
Volume Data Sorting Sequence	(00gg,eee4)	3	Sequence that defines sorting criteria to be applied to the result Volume Data Organization Sequence (00gg,eee3). Defines the order in which the display algorithm and presentation parameters are applied. See Section C.XX.3.1.2. One or more Items shall be included in this Sequence.
>Include Table 10-20a "Extended Selector Attribute Macro Attributes"			
>Sorting Direction	(0072,0604)	1	Sorting direction to be applied to the value(s) in the image set of the Attribute identified by the Extended Selector Attribute Macro Enumerated Values: INCREASING DECREASING

C.XX.3.1 Volume Definition Module Attribute Descriptions

C.XX.3.1.1 Volume Data Organization Sequence

The Items in the Volume Data Organization Sequence (00gg,eee3) define the grouping of Image Instances, or frames within Image Instances, identified in the Volume Definition Module, into collections of one or more sets of Volume Data.

C.XX.3.1.2 Volume Data Sorting Sequence

The Items in the Volume Data Sorting Sequence (00gg,eee4) define the order in which the display algorithm and presentation parameters are applied to Volume Data resulting from the Volume Data Organization Sequence (00gg,eee3). The sorting criteria may include the value of a numeric, date, or time Attribute that is expected to be present in each of the image objects in the Volume Data. A sorting direction shall be associated with each sorting criterion. If a textual Attribute is used for sorting, then the INCREASING sorting direction indicates alphabetical order, and DECREASING indicates reverse alphabetical order.

If a Code Sequence Attribute is used for sorting, then Code Meaning (0008,0104) shall be sorted alphabetically. If a string numeric Attribute is used for sorting (VR of IS or DS), then sorting shall be on the numeric value, and padding shall be ignored. When sorting by date or time Attribute, then sorting shall be on the temporal value, not the alphabetic string.

If there are multiple Items in the Volume Data Sorting Sequence (00gg,eee4), then the sorting operations shall be applied in Item order. The least rapidly varying Attribute for the sorting operation shall be the first Item in the Sequence.

Add new Protocol Directory Record Type to Section F.3.2.2

Table F.3-3. Directory Information Module Attributes

Attribute Name	Tag	Type	Attribute Description
>Directory Record Type	(0004,1430)	1	Defines a specialized type of Directory Record by reference to its position in the Media Storage Directory Information Model (see Section F.4). Enumerated Values: **PATIENT** … **DEF PERF PROT** **PRIVATE** Privately defined record hierarchy position. Type shall be defined by Private Record UID (0004,1432).

Add new Protocol Directory Record Type to Section F.4 and update Figure.

Editorial note: this needs to be synchronized with cp1715.

Table F.4-1. Relationship Between Directory Records

Directory Record Type	Section	Directory Record Types that may be included in the next lower-level directory Entity
(Root Directory Entity)		PATIENT, HANGING PROTOCOL, … **DEF PROC PROT,** PRIVATE
DEF PROC PROT	**F.5.4x**	**PRIVATE**

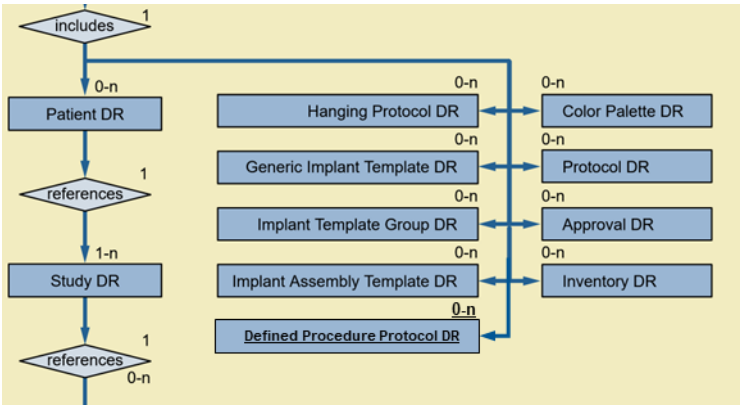


Figure F.4-1. Basic Directory IOD Information Model

Add new Protocol Directory Record Definition to Section F.5

F.5.4x Protocol Directory Record Definition

The Directory Record is based on the specification of Section F.3. It is identified by a Directory Record Type of Value "DEF PROC PROT". Table F.5-4x lists the set of keys with their associated Types for such a Directory Record Type. The description of these keys may be found in the Modules related to the Procedure Protocol IE of Protocol IODs. This Directory Record shall be used to reference a Protocol SOP Instance. This type of Directory Record may reference a Lower-Level Directory Entity that includes one or more Directory Records as defined in Table F.4-1.

Table F.5-4x. Protocol Keys

Attribute Name	Tag	Type	Attribute Description
Specific Character Set	(0008,0005)	1C	Required if an extended or replacement character set is used in one of the keys.
Protocol Name	(0018,1030)	1	
Instance Creation Date	(0008,0012)	1	
Instance Creation Time	(0008,0013)	2	
Any other Attribute of the Procedure Protocol IE Modules		3	

Modifications to PS3.4

Add Volumetric Rendering Protocol SOP Class to GG.3

GG.3 SOP Classes

The application-level services addressed by the Non-Patient Object Storage Service Class definition are specified in the SOP Classes specified in Table GG.3-1.

Table GG.3-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)
Hanging Protocol Storage	1.2.840.10008.5.1.4.38.1	Hanging Protocol IOD
Color Palette Storage	1.2.840.10008.5.1.4.39.1	Color Palette IOD
Generic Implant Template Storage	1.2.840.10008.5.1.4.43.1	Generic Implant Template IOD
Implant Assembly Template Storage	1.2.840.10008.5.1.4.44.1	Implant Assembly Template IOD
Implant Template Group Storage	1.2.840.10008.5.1.4.45.1	Implant Template Group IOD
CT Defined Procedure Protocol Storage	1.2.840.10008.5.1.4.1.1.200.1	CT Defined Procedure Protocol IOD
Protocol Approval Storage	1.2.840.10008.5.1.4.1.1.200.3	Protocol Approval IOD
XA Defined Procedure Protocol Storage	1.2.840.10008.5.1.4.1.1.200.7	XA Defined Procedure Protocol IOD
Inventory Storage	1.2.840.10008.5.1.4.1.1.201.1	Inventory IOD
Volumetric Rendering Protocol Storage	**1.2.840.10008.5.1.4.xxuid.1**	**Volumetric Rendering Protocol IOD**

Add new section for Volumetric Rendering Protocol to PS3.4 GG Non-Patient Object Storage:

GG.6.X Volumetric Rendering Protocol SOP Class

GG.6.X.1 Instance Creator

An implementation that conforms to the Volumetric Rendering Protocol Storage SOP Class as an SCU and is a SOP Instance creator shall state in its Conformance Statement:

- the Image Storage SOP Classes that are supported by the SCU and referenced in the Volumetric Rendering Protocol Storage SOP Class.

GG.6.X.2 Display Application

The following behavior shall be documented in the Conformance Statement of any implementation claiming conformance to a Volumetric Rendering Protocol Storage SOP Class as an SCP and interprets the contents of instances of the SOP Class to affect 3D rendering:

- the Image Storage SOP Classes that are supported by the SCP and referenced in the Volumetric Rendering Protocol Storage SOP Class.

Modifications to PS3.6

Update PS3.6 Table 6-1 Registry of DICOM Data Elements as follows:

Table 6-1. Registry of DICOM Data Elements

Tag	Name	Keyword	VR	VM	
…					
(00gg,eee1)	**Volume Type**	**VolumeType**	**CS**	**1**	
(00gg,eee2)	**Volume Data Input Image Set Specification Sequence**	**VolumeImageInputSetSelectorSequence**	**SQ**	**1**	
(00gg,eee3)	**Volume Organization Index Sequence**	**VolumeOrganizationIndexSequence**	**SQ**	**1**	
(00gg,eee4)	**Volume Data Sorting Sequence**	**MultivolumeVolumeRelationshipOrderSequence**	**SQ**	**1**	

Update PS3.6 Table A-1 UID Values as follows:

Table A-1. UID Values

UID Value	UID NAME	UID Type	Part
…			
1.2.840.10008.5.1.4.xxuid.1	**Volumetric Rendering Protocol Storage**	**SOP Class**	**PS3.4**

Modifications to PS3.15

Modify Section C.2 as follows:

C.2 Creator RSA Digital Signature Profile

The creator of a DICOM SOP Instance may generate signatures using the Creator RSA Digital Signature Profile. The Digital Signature produced by this Profile serves as a lifetime data integrity check that can be used to verify that the pixel data in the SOP instance has not been altered since its initial creation. An implementation that supports the Creator RSA Digital Signature Profile may include a Creator RSA Digital Signature with every SOP Instance that it creates; however, the implementation is not required to do so.

The signature shall use one of the RIPEMD-160, MD5, SHA-1 or SHA-2 family (SHA256, SHA384, SHA512) of hashing functions to generate a MAC, which is then encrypted using a private RSA key. All validators of digital signatures shall be capable of using a MAC generated by any of the hashing functions specified (RIPEMD-160, MD5, SHA-1 or SHA256, SHA384, SHA512).

As a minimum, an implementation shall include the following Attributes in generating the Creator RSA Digital Signature:

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 **and the Enhanced General Equipment Module** that are present

…

x. any Attributes of the Protocol Context Module that are present

x. any Attributes of the Instructions Module that are present

x. any Attributes of the Volumetric Rendering Protocol Module that are present

x. any Attributes of the Volume Data Input Image Set Module that are present

x. any Attributes of the Volume Definition Module that are present

x. any Attributes of the Volume Render Geometry Module that are present

x. any Attributes of the Render Shading Module that are present

x. any Attributes of the Render Display Module that are present

x. any Attributes of the Multi-Planar Reconstruction Geometry Module that are present

x. any Attributes of the MPR Volumetric Presentation State Display Module that are present

x. any Attributes of the VOI LUT Module that are present

x. any Attributes of the Presentation Animation Module that are present

Modifications to PS3.18

Add the following Section after Section 8.3.5.2:

8.3.5.3 Query Parameters for Rendered MPR Volume Resources and Rendered 3D Volume Resources

Query parameters defined in this section control the creation of new 3D or MPR images based on Volume Data identified by the Target Resource.

The following rules pertain to all parameters defined in this section:

1. All parameters are optional for the user agent.
2. All parameters are optional for the origin server.
3. These parameters only apply to resources that are images.

The set of transformations specified by the parameters in this section shall be applied to the images as if the parameters were a Volumetric Presentation State, that is, in the order specified by the applicable image rendering pipeline specified in Section FF.2 of PS3.4.

Table 8.3.5-2 shows the Query Parameters that may be used when requesting a Rendered Volume Representation.

Table 8.3.5-2. Retrieve Rendered Volume Query Parameters

Key	Values	Target Resource Category	Section
volumeinputreference	uid or frame	Image (single or multi-frame)	8.3.5.3.1
match	; See attribute matching rules in Section 8.3.4.1	Image (single or multi-frame)	8.3.5.3.2
volumetricprotocol	uid	Image (single or multi-frame)	8.3.5.3.3
renderingmethod	"volume_rendered", "maximum_ip" , "minimum_ip" or "average_ip"	Image (single or multi-frame)	8.3.5.3.4
orientation	"a", "p", "r", "l", "h" or "f"	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.5
viewpointposition	px , py , pz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.6
viewpointlookat	lx , ly , lz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.7
viewpointup	ux , uy , uz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.8
mprslab	st	Image (single or multi-frame)	8.3.5.3.9
swivelrange	sr	Image (single or multi-frame)	8.3.5.3.10
volumetriccurvepoint	px , py , pz	Image (single or multi-frame)	8.3.5.3.11
animationstepsize	ss	Image (single or multi-frame)	8.3.5.3.12
animationrate	rt	Image (single or multi-frame)	8.3.5.3.13
renderedvolumetricmetadata	"yes"	Image (single or multi-frame)	8.3.5.3.14

Rendered MPR Volume Resources and Rendered 3D Volume Resources have two mutually exclusive options to determine the initial orientation of the resampled Volume Data:

1. The “orientation” parameter establishes the standard anatomic position of the patient as viewed by the camera, and
2. camera orientation parameters (“viewpointposition”, “viewpointlookat”, or “viewpointup”) establish the camera position and direction as it views the patient.

When incorporating animation parameters, the initial frame is established by orientation parameters. The parameters “swivelrange”, "volumetriccurvepoint" and “animationstepsize” dictate subsequent frames. When animating multiple sets of temporally related, spatially co-located Volume Data (such as a multiphase acquisition), the initial frame's displayed phase is determined by the origin server.

There is no parameter to control the type of projection used during rendering. The origin server shall use Orthographic projection for Rendered 3D Volume Resources. See Section C.11.30.1 in PS3.3.

There is no parameter to explicitly control Render Field of View, MPR View Height or MPR View Width (see Sections C.11.30 and C.11.26 in PS3.3). The “viewport” parameter can be used to scale the returned media. See Section 8.3.5.1.3.

8.3.5.3.1 Volume Input Reference

The “volumeinputreference” parameter identifies the Instance, or Frame within an Instance, from which the origin server shall extract characteristics and identify additional Instances or Frames in the Target Resource with the same values for those characteristics. The user agent uses this parameter to identify a desired subset when the Target Resource is a superset of the intended Volume Data. The origin server

shall identify a subset that conforms to the Volume Input Requirements for Rendered MPR Volume Resources and Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

The syntax of this parameter for a multi-frame image is:

```
%s" volumeinputreference =" uid "," frame
```

Otherwise it is:

```
%s" volumeinputreference =" uid
```

Where

`uid`	Is the Unique Identifier of the Volume Input Reference SOP Instance when the Target Resource is a series or study.
`frame`	Is the frame number within an Image Instance when the Volume Input Reference is an Enhanced IOD Image Instance.

Note

`uid` corresponds to Referenced SOP Instance UID (0008,1155) and `frame` corresponds to Referenced Frame Number (0008,1160) See Section 10.3 in PS3.3.

The origin server shall create Volume Data from instances or frames having characteristics identical to the Volume Input Reference based on implementation-specific logic.

The origin server shall return a 400 (Bad Request), and may include an appropriate Status Report, if any of the following are true:

- the Target Resource is a Presentation State,
- valid Volume Data is not found based on the Volume Input Reference,
- the UID is not found in the Target Resource,
- the frame is not found in the Target Resource,
- a Match Attribute/Value pair is present in another parameter in the request.

8.3.5.3.2 Match

The “match” parameter specifies common DICOM Attribute/Value pair characteristics of the Volume Data.

When the user agent identifies a Target Resource that is a superset of the intended Volume Data, it may identify Attribute/Value pairs that specify matching criteria to identify specific Instances or Frames in the Target Resource to resample as Volume Data. The resulting subset shall conform to the Volume Input Requirements for Rendered MPR Volume Resources and Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

See Section 8.3.4.1 for the syntax of this parameter.

The user agent may include the following Attributes in the parameter:

- Instance IE Attributes
- Private Data Element Tags and their corresponding Private Creator Element Tags

The origin server shall reconstruct Volume Data meeting the Volume Input Criteria.

The origin server shall return a 400 (Bad Request), and may include an appropriate Status Report, if any of the following are true:

- the Target Resource is a Volumetric Presentation State,
- valid Volume Data is not found based on the Attribute/Value pair,

- the “volumeinputreference” parameter is also present.

8.3.5.3.3 Volumetric Protocol

The "volumetricprotocol" parameter allows a user agent to reference a Volumetric Rendering Protocol instance from which the origin server will extract volumetric rendering parameter values to be applied to the Volume Data.

The syntax of this parameter is:

```
%s"volumetricprotocol =" uid
```

Where

`uid`	Is the Unique Identifier of a Volumetric Rendering Protocol SOP Instance. See PS3.3 Section 7.13.x.

The origin server shall retrieve the instance corresponding to the specified UID, extract Volumetric Rendering parameters from that instance and apply them to the Volume Data.

Query Parameters can be included in the request to modify the rendering prescribed by the protocol. These may either:

- provide new parameter/value pairs not specified in the protocol, or
- provide updated values for parameters in the protocol.

The application of additional Query Parameters is determined by the origin server. If any of the Query Parameters are not applied, the origin server shall include the following in the Warning header field:

```
Warning: 299 <service>: The volumetric rendering was created with modifications.
```

This can result in the selective application of parameters, and unexpected rendering results for the user agent. The user agent may request the Rendered Volume Response Module to obtain the parameters applied to produce the rendering. User agents may also choose to send subsequent requests with different parameters to attain a result without warnings.

The origin server shall return a 400 (Bad Request), and may include an appropriate Status Report, if any of the following are true:

- the parameter UID value is not a Volumetric Protocol SOP Instance,
- the parameter UID is not found,
- the Target Resource is a Volumetric Presentation State,
- the Target Resource does not meet the Volume Input Requirements in PS3.3 Section C.11.23.1, or
- the Target Resource is not compatible with the Volume Organization Type (00gg,eee1) specified in the Volumetric Protocol.

8.3.5.3.4 Rendering Method

The "renderingmethod" parameter specifies the display algorithm to be applied to the Volume Data.

The syntax of this parameter is:

```
%s"renderingmethod=" 1#( %s"volume_rendered" / %s"maximum_ip" / %s"minimum_ip" /
%s"average_ip" )
```

Where

`volume_rendered`	A method where each XY pixel of the rendered view is determined by accumulating the set of non-transparent voxel samples along a ray.
`maximum_ip`	A method that projects the interpolated sample with maximum intensity that falls 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 falls in the path of each ray traced from the viewpoint to the plane of projection.
`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.

Notes

1. These values correspond to the differently capitalized values of Rendering Method (0070,120D). See Sections C.11.23 and C.11.30 in PS3.3.
2. There is no parameter to control the type of projection used during rendering. Rendered 3D Volume Resources use Orthographic projection. See Figure C.11.30-1 in PS3.3.

If "renderingmethod" is not present, the origin server may apply a default rendering method, based on the resource, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.5 Orientation

The "orientation" parameter specifies the patient's orientation as seen by the camera for the current 3D or MPR Volumetric Presentation View.

The syntax of this parameter is:

```
%s"orientation =" 1#( %s"a" / %s"p" / %s"r" / %s"l" / %s"h" / %s"f" )
```

Where

`a`	Anterior: The camera is viewing the patient from their anterior in the coronal plane, and viewpoint up is oriented to the patient's superior.
`p`	Posterior: The camera is viewing the patient from their posterior in the coronal plane, and viewpoint up is oriented to the patient's superior.
`r`	Right: The camera is viewing the patient from their right in the sagittal plane, and viewpoint up is oriented to the patient's superior.
`l`	Left: The camera is viewing the patient from their left in the sagittal plane, and viewpoint up is oriented to the patient's superior.
`h`	Head: The camera is viewing the patient from above in the axial plane, and viewpoint up is oriented to the patient's anterior.
`f`	Foot: The camera is viewing the patient from below in the axial plane, and viewpoint up is oriented to the patient's anterior..

Note

These values correspond to the differently capitalized values of the Patient Orientation (0020,0020) and Image Orientation (Patient) (0020,0037). See Section C.7.6.1.1.1 in PS3.3 and Section A in PS3.17.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

Note

This is intended to allow the user to adjust orientation after viewing the initial orientation defined in the Volumetric Presentation State.

If both the “orientation” parameter and any of the camera orientation parameters (i.e., “viewpointposition”, “viewpointlookat”, or “viewpointup”) are present, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.6 Viewpoint Position

The "viewpointposition" parameter specifies the position of the camera in the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointposition =" px "," py "," pz
```

Where

`px, py and pz` Position of the viewpoint in volume space. A point (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint Position (0070,1603) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

Any or all of the camera orientation parameters may be included. If any of the camera orientation Query Parameters are absent, the origin server may apply a default value (e.g.,

- set “viewpointposition” to the patient’s anterior,
- set “viewpointlookat” to the center of volume,
- set “viewpointup” to the patient’s superior),

or return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.7 Viewpoint LookAt

The "viewpointlookat" parameter specifies the point that the camera is looking at within the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointlookat =" lx "," ly "," lz
```

Where

`lx, ly and lz` Viewpoint LookAt point (i.e., the point that the camera is looking at). A point (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint LookAt Point (0070,1604) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

8.3.5.3.8 Viewpoint Up

The "viewpointup" parameter specifies the vertical orientation of the camera within the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointup =" ux "," uy "," uz
```

Where

`ux, uy and uz`	Viewpoint up direction (i.e., the direction that the top of the camera is pointing to). A vector (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint Up Direction (0070,1605) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

8.3.5.3.9 MPR Slab Thickness

The "mprslab" parameter specifies the thickness of the MPR plane. This parameter results in an orthographic rendering with a defined thickness using the method defined by "renderingmethod". See PS3.3 Section C.11.26.1.1 for more information.

The syntax of this parameter for a Rendered MPR Volume is:

```
%s"mprslab =" st
```

Where

`st`	Thickness of the Multi-Planar Reconstruction slab as a value greater than zero, in mm.

Notes

1. This corresponds to the MPR Slab Thickness (0070,1503) attribute. See Section C.11.26 in PS3.3.
2. The slab thickness of the returned media might not match the requested thickness due to the voxel size of the Target Resource.

If "renderingmethod" is not present, the origin server may apply a default rendering method, based on the resource and/or slab thickness, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.10 Swivel Range

The "swivelrange" parameter specifies the angular range over which a rendered volume rotates around the swivel axis, which is defined as the axis parallel to the “viewpointup“ intersecting the “viewpointlookat”. The rendered volume rotates back and forth.

The syntax of this parameter is:

```
%s"swivelrange =" sr
```

Where

`sr` Range in which a volume rotates back-and-forth around the swivel axis, in degrees.

Note

This corresponds to the differently capitalized SWIVEL value of Presentation Animation Style (0070,1A01) and Swivel Range (0070,1A06). See Section C.11.29 in PS3.3 and Section FF.2.4.2 in PS3.4.

The origin server shall create an animation with a number of frames equal to Swivel Range divided by the "animationstepsize".

If the “swivelrange” parameter is present and the “animationrate” parameter is not present, the origin server shall determine the animation rate.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.11 Volumetric Curve Point Coordinates

The "volumetriccurvepoint" parameter specifies coordinates of points on the animation 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. At least two points are required for an animation. See Section C.11.29.1 in PS3.3.

The syntax of this parameter is:

```
%s" volumetriccurvepoint =" px "," py "," pz
```

Where

`px, py and pz` Position of a point on the animation curve. A point (x,y,z) in the VPS-RCS, in mm.

Note

This corresponds to the Volumetric Curve Points (0070,150D) attribute. See Section C.11.29 in PS3.3.

The origin server shall create an animation with a number of frames equal to the total distance of the Volumetric Curve divided by the "animationstepsize".

If the "volumetriccurvepoint" parameters are present and the “animationrate” parameter is not present, the origin server shall determine the animation rate.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.12 Animation Step Size

The "animationstepsize" parameter specifies distance between animation steps, or frames, in a Volumetric Rendering animation.

For a swivel animation, the distance between steps is in degrees. For a Volumetric Curve, the distance between steps is in mm along the animation curve.

The syntax of this parameter is:

477 `%s" animationstepsize =" ss`

478 Where

`ss` The animation step size, an integer greater than zero.

479 Note

480 This corresponds to the Number of Animation Step Size (0070,1A05) attribute. See Section C.11.29 in
481 PS3.3.

482 The origin server shall create an animation, with a number of frames equal to either:
483 • the “swivelrange” divided by the "animationstepsize", or
484 • the total distance of the Volumetric Curve divided by the "animationstepsize".

485 If " animationstepsize " is not present, and either “swivelrange”, or “volumetriccurvepoint” are present, the
486 origin server may apply a default animation step size, or alternatively, return 400 (Bad Request) and may
487 include an appropriate Status Report.

488 If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad
489 Request) and may include an appropriate Status Report.

490 **8.3.5.3.13 Animation Rate**

491 The “animationrate” parameter specifies the rate at which an animated 3D or MPR Volumetric
492 Presentation is displayed.

493 The syntax of this parameter is:

494 `%s" animationrate =" rt`

495 Where

`rt` Rate in steps per second, an integer greater than zero.

496 Notes

497 1. This corresponds to Recommended Animation Rate (0070,1A03) in Section C.11.29 in PS3.3 and
498 Section FF.2.4.2 in PS3.4.
499 2. Playback of the returned media on a client may or may not achieve the requested animation rate.

500 If " animationrate" is not present, and other animation parameters are present (e.g., “swivelrange”,
501 “animationstepsize”, or “volumetriccurvepoint”), the origin server may apply a default animation rate, or
502 alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

503 If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad
504 Request) and may include an appropriate Status Report.

505 **8.3.5.3.14 Rendered Volumetric Metadata**

506 The "renderedvolumetricmetadata" parameter specifies that, in addition to the requested 2D
507 representation of the rendered volume, the response payload includes a Rendered Volume Response
508 Module of the parameters applied by the origin server to generate the volumetric rendering.
509
510 The syntax of this parameter is:

511 `%s"renderedvolumetricmetadata =" "yes"`

512 Where

`yes`	Indicates that only the Rendered Volume Response Module shall be present in the response payload.

The defined value is "yes". The origin server shall return a response payload containing a Rendered Volume Response Module as specified in Annex X.

If this parameter is not present, no Response Module is requested and the 2D representation of the rendered volume shall be returned.

The Rendered Volume Response Module provides the complete set of rendering parameters, including those specified as query parameters by the user agent, as well as those determined by the origin server. This is intended to ensure reproducible rendering results on the origin server, given identical Target Resource and header fields.

The content of the Rendered Volume Response Module shall be idempotent. This means that the original query parameters, excluding the renderedvolumetricmetadata parameter, and a subsequent request containing the full set of parameters from the Response Module shall return the same 2D representation of the rendered volume.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

Update PS3.18 Section 8.11 as follows:

8.11 Security and Privacy

It is very likely that DICOM objects contain Protected Health Information. Privacy regulations in the United States (HIPAA), Europe (GDPR), and elsewhere, require that Individually Identifiable Information be kept private. It is the responsibility of those implementing and deploying the DICOM Standard to ensure that applicable regulations for security and privacy are satisfied.

See, for example, [ONC Privacy Security Guide].

Some types of images, such as rendered volumes, or the source slices from which they are created, may include recognizable visual features.

The DICOM PS3.10 File Format has security considerations that will apply whenever DICOM PS3.10 File format is used. See Section 7.5 in PS3.10.

Modify Table 10.1-1. Resources and Descriptions as follows:

Table 10.1-1. Resources and Descriptions

Resource	Description
Studies Service	The Base URI of the Studies Service.
All Studies	The All Studies resource references the entire collection of Studies contained in the Studies Service.
Study	The Study resource references a single Study.
Study Metadata	The Study Metadata resource references the Metadata of a Study.
Study Bulkdata	The Study Bulkdata resource references the Bulkdata of a Study.
Study Pixel Data	The Study Pixel Data resource references the Pixel Data of a Study.

Resource	Description
Rendered Study	The Rendered Study resource references a Study to be rendered **as a different representation of DICOM instances**.
Rendered MPR Volume Study	**The Rendered MPR Volume Study resource references a Study to be rendered as a multiplanar reformat.**
Rendered 3D Volume Study	**The Rendered 3D Volume Study resource references a Study to be rendered as a volume rendering.**
Study Thumbnail	The Study Thumbnail resource references a thumbnail image of a Study.
Study's Series	The Study's Series resource references the collection of all Series contained in a Study.
Study's Instances	The Study's Instances resource references the collection of all Instances in a single Study.
All Series	The All Series resource references the collection of all Series in all Studies contained in the Studies Service.
Series	The Series resource references a single Series.
Series Metadata	The Series Metadata resource contains the Metadata of a Series in a Study.
Series Bulkdata	The Series Bulkdata resource references the Bulkdata of a Series.
Series Pixel Data	The Series Pixel Data resource references the Pixel Data of a Series.
Rendered Series	The Rendered Series resource references a Series to be rendered **as a different representation of DICOM instances**.
Rendered MPR Volume Series	**The Rendered MPR Volume Series resource references a Series to be rendered as a multiplanar reformat.**
Rendered 3D Volume Series	**The Rendered 3D Volume Series resource references a Series to be rendered as a volume rendering.**
Series Thumbnail	The Series Thumbnail resource references a thumbnail image of a Series.
Series' Instances	The Series' Instances resource references the collection of all Instances in a single Series.
All Instances	The All Instances resource references the collection of all Instances in all Series in all Studies contained in the Studies Service.
Instance	The Instance resource references a single Instance.
Instance Metadata	The Instance Metadata resource contains the Metadata of an Instance.
Instance Bulkdata	The Instance Bulkdata resource references the Bulkdata of a Instance.
Instance Pixel Data	The Instance Pixel Data resource references the Pixel Data of a Instance.
Rendered Instance	The Rendered Instance resource references an Instance to be rendered **as a different representation**.
Rendered MPR Volume Instance	**The Rendered MPR Volume Instance resource references an Instance to be rendered as a multiplanar reformat.**
Rendered 3D Volume Instance	**The Rendered 3D Volume Instance resource references an Instance to be rendered as a volume rendering.**
Instance Thumbnail	The Instance Thumbnail resource references a thumbnail image of an Instance.
Frames	The Frames resource references an ordered collection of frames in a single multi-frame Instance.

Resource	Description
Rendered Frames	The Rendered Frames resource references an ordered collection of frames of a single multi-frame Instance, to be rendered **as a different representation**.
Rendered MPR Volume Frames	**The Rendered MPR Volume Frames resource references collection of frames to be rendered as a multiplanar reformat.**
Rendered 3D Volume Frames	**The Rendered 3D Volume Frames resource references collection of frames to be rendered as a volume rendering.**
Frame Thumbnail	The Frame Thumbnail resource references a thumbnail image for frames within an Instance.
Bulkdata	The Bulkdata resource contains a Bulkdata Value.

Update PS3.18 Table 10.3-2 Resources by Transaction as follows:

In Table 10.3-2, the Target Resources permitted for each transaction are marked with M if support is mandatory for the origin server and O if it is optional. A blank cell indicates that the resource is not allowed in the transaction.

Table 10.3-2. Resources by Transaction

Resource	Retrieve	Store	Search
Studies Service			
All Studies		M	M
Study	M	M	
Study Metadata	M		
Study Bulkdata	O		
Study Pixel Data	O		
Rendered Study	M		
Rendered MPR Volume Study	**O**		
Rendered 3D Volume Study	**O**		
Study Thumbnail	O		
Study's Series			M
Study's Instances			M
All Series			M
Series	M		
Series Metadata	M		
Series Bulkdata	O		
Series Pixel Data	O		

Series' Instances			M
Rendered Series	M		
Rendered MPR Volume Series	**O**		
Rendered 3D Volume Series	**O**		
Series Thumbnail	O		
All Instances			M
Instance	M		
Instance Metadata	M		
Instance Bulkdata	O		
Instance Pixel Data	O		
Rendered Instance	M		
Rendered MPR Volume Instance	**O**		
Rendered 3D Volume Instance	**O**		
Instance Thumbnail	O		
Frames	M		
Rendered Frames	M		
Rendered MPR Volume Frames	**O**		
Rendered 3D Volume Frames	**O**		
Frame Thumbnail	O		
Bulkdata	M	M	

Add the following Sections after Section 10.4.1.1.6:

10.4.1.1.7 Rendered MPR Volume Resources

Rendered MPR Volume Resources (defined in Table 10.4.1.7-1) are used to retrieve representations of a DICOM Resource after performing multiplanar reformatting. Reformatting represents a cross-section of a volume of slice data as an Euclidean plane in accordance with the principles established for Planar MPR Volumetric Presentation States (see PS3.4, Section FF.2.1.1). Rendered images are returned as Acceptable Media Types in the response payload.

Note

These resources ensure uniform client requests and reasonably consistent rendering outcomes. Due to inherent differences in algorithm implementations, an identical match of rendering results between different implementations is not assured.

The Target Resource shall be either:

- a Planar MPR Volumetric Presentation State Instance, or
- a collection of Image Instances or frames within Image Instances that conform to the Volume Input Requirements for Rendered MPR Volume Resources (see PS3.3, Section C.11.23.1)
- a collection of Image Instances or frames within Image Instances, refined using one of the Query Parameters defined in Section 8.3.5.3, to meet Volume Input Requirements for Rendered MPR Volume Resources (see PS3.3, Section C.11.23.1).

Table 10.4.1.7-1. Retrieve Transaction Rendered MPR Volume Resources

Resource	URI Template
Rendered MPR Volume Study	/studies/{study}/renderedmpr
Rendered MPR Volume Series	/studies/{study}/series/{series}/renderedmpr
Rendered MPR Volume Instance	/studies/{study}/series/{series}/instances/{instance}/renderedmpr
Rendered MPR Volume Frames	/studies/{study}/series/{series}/instances/{instance}/frames/{frames}/renderedmpr

Note

The URI template for a Rendered MPR Volume Instance may apply to a multiframe image instance being rendered or to a Volume Rendering Volumetric Presentation State instance.

10.4.1.1.8 Rendered 3D Volume Resources

Rendered 3D Volume Resources (defined in Table 10.4.1.8-1) are used to retrieve representations of a DICOM Resource rendered after performing 3D rendering, in accordance with the principles established for Volume Rendering Volumetric Presentation States (see PS3.4, Section FF.2.1.2), by applying thresholding, ray-casting, volume rendering, or other methods to display a volume of slice data as a three dimensional projection. Rendered images are returned as Acceptable Media Types in the response payload.

Note

These resources ensure uniform client requests and reasonably consistent rendering outcomes. Due to inherent differences in algorithm implementations, an identical match of rendering results between different implementations is not assured.

The Target Resource shall be either:

- a Planar MPR Volumetric Presentation State Instance, or
- a collection of Image Instances or frames within Image Instances that conform to the Volume Input Requirements for Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1)
- a collection of Image Instances or frames within Image Instances, refined using one of the Query Parameters defined in Section 8.3.5.3, to meet Volume Input Requirements for Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

Table 10.4.1.8-1. Retrieve Transaction Rendered 3D Volume Resources

Resource	URI Template
Rendered 3D Volume Study	/studies/{study}/series/rendered3d
Rendered 3D Volume Series	/studies/{study}/series/{series}/rendered3d
Rendered 3D Volume Instance	/studies/{study}/series/{series}/instances/{instance}/rendered3d

Resource	URI Template
Rendered 3D Volume Frames	/studies/{study}/series/{series}/instances/{instance}/frames/{frames}/rendered3d

Note

The URI template for a Rendered 3D Volume Instance may apply to a multiframe image instance being rendered or to a Planar MPR Volumetric Presentation State instance.

Modify Table 10.4.1-5. Query Parameters by Resource as follows:

10.4.1.2 Query Parameters

Table 10.4.1-5. Query Parameters by Resource

Key	Resources	Usage		Section
		User Agent	Origin Server	
accept	All Resources	O	M	Section 8.3.3.1
charset	Metadata Resources	O	M	Section 8.3.3.2
annotation	Rendered Resources	O	M	Section 8.3.5.1.1
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
quality	Rendered Resources	O	M	Section 8.3.5.1.2
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
viewport	Rendered Resources	O	M	Section 8.3.5.1.3
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
	Thumbnail Resources	O	O	
window	Rendered Resources	O	M	Section 8.3.5.1.4
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
iccprofile	Rendered Resources	O	O	Section 8.3.5.1.5
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
volumeinputreference	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.1**
	Rendered 3D Volume Resources	**O**	**O**	
match	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.2**
	Rendered 3D Volume Resources	**O**	**O**	

volumetricprotocol	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.3**
	Rendered 3D Volume Resources	**O**	**O**	
renderingmethod	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.4**
	Rendered 3D Volume Resources	**O**	**O**	
orientation	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.5**
	Rendered 3D Volume Resources	**O**	**O**	
viewpointposition	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.6**
	Rendered 3D Volume Resources	**O**	**O**	
viewpointlookat	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.7**
	Rendered 3D Volume Resources	**O**	**O**	
viewpointup	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.8**
	Rendered 3D Volume Resources	**O**	**O**	
mprslab	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.9**
swivelrange	**Rendered 3D Volume Resources**	**O**	**O**	**Section 8.3.5.3.10**
volumetriccurvepoint	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.11**
animationstepsize	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.12**
	Rendered 3D Volume Resources	**O**	**O**	
animationrate	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.13**
	Rendered 3D Volume Resources	**O**	**O**	
renderedvolumetricmetadata	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.14**
	Rendered 3D Volume Resources	**O**	**O**	

Add the following Section after 10.4.3.3.6 Pixel Data Resource Payload:

10.4.3.3.7 Rendered Volume Resource Payload

The payload for a Rendered 3D Volume Resource (see Section 10.4.1.1.7) or a Rendered MPR Volume Resource (see Section 10.4.1.1.8) shall contain:

- a 2D representation of the rendered volume according to the parameters of the display algorithm,

and may also contain;

- a Rendered Volume Resources Response Module (see Annex X) corresponding to the request.

If both are returned, the payload shall be a multipart payload, otherwise the payload shall be single part. See Section B.x2 for an example.

Add the following Sections after Section B.25:

B.x1 Render a Series as a 3D Volume

This example illustrates a request to render a series of legacy instances as a 3D volume, returned as a jpeg. Since no other parameters are specified, they are determined by the origin server.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
/series/1.2.250.1.59.40211.789001276.14556172.67789
/rendered3D?renderingmethod=volume_rendered
HTTP/1.1
Host: www.hospital-stmarco
Accept: image/jpeg

HTTP/1.1 200 OK
Content-Length: 79323
Content-Type: image/jpeg
<BINARY JPEG DATA>
```

B.x2 Render a Multi-frame Instance as a 3D Volume Rendering

This example illustrates a request for a Rendered Volume Response Module representing the rendering of a multi-frame instance as a 3D volume, returned as an mp4 video animating the initial anterior view swiveled 180 degrees left to right at 20fps. Since animation step size is not specified, the server determines one and includes it in the Rendered Volume Response Module.

Notes

The request encodes the orientation as “Anterior”. The Rendered Volume Response Module encodes camera orientation as described in Section 8.3.5.3.7.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
/series/1.2.250.1.59.40211.789001276.14556172.67789
/instances/1.2.250.1.59.40211.2678810.87991027.899772.2
/rendered3D?renderingmethod=volume_rendered
&orientation=a
&swivelrange=180
&animationrate=20
&renderedvolumetricmetadata=yes
HTTP/1.1
Host: www.hospital-stmarco
Accept: application/dicom+json

HTTP/1.1 200 OK
Content-Length: 369
Content-Type: application/dicom+json
{
    "00720510": {
        "vr": "CS",
        "Value": ["3D_RENDERING"]
    },
    "0070120D": {
```

```
            "vr": "CS",
            "Value": ["VOLUME_RENDERED"]
        },
        "00801603": {
            "vr": "FD",
            "Value": [100,101,200]
        },
        "00801604": {
            "vr": "FD",
            "Value": [100,100,200]
        },
        "00801605": {
            "vr": "FD",
            "Value": [0,0,1]
        },
        "00701A06": {
            "vr": "FD",
            "Value": [180]
        },
        "00701A05": {
            "vr": "FD",
            "Value": [1.8]
        },
        "00701A03": {
            "vr": "FD",
            "Value": [20]
    }
```

B.x3 Render a Study as an MPR

This example illustrates a request to render a study as an MPR, returned as a 30fps mp4 video animating an Oblique orientation (specified using viewpoint parameters). The request also specifies a window width of 400 and center of 40 and the rendering method. The user agent specifies that the rendered instances should consist of the multi-phase cardiac acquisition frames for the R-R interval between 140 and 260 milliseconds.

Note

See PS3.4 Section C2.2.2 for Attribute Matching.

The origin server will need to identify the relevant instances in the study (based on the presence of Cardiac R-R Interval Specified (0018,9070) with matching values). Since an animation step size was not specified, and a temporal range is specified (for the cardiac R-R interval), the origin server understands that a temporal animation of multiple series each containing a single phase is requested.

Since MPR slab thickness is not specified, the server renders the MPR slab at a nominal thickness.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910/renderedmpr?
CardiacRRIntervalSpecified=140-260
&renderingmethod=average_ip
&viewpointposition=532,38,126
&viewpointlookat=-532,-76,-154
&viewpointup=0,0,0
&animationrate=30
&window=400,40,linear
HTTP/1.1
Host: www.hospital-stmarco
Accept: video/mp4

HTTP/1.1 200 OK
Content-Length: 3145728
```

```
Content-Type: video/mp4
<BINARY MPEG-4 DATA>
```

B.x4 Render One Phase of a Multi-phase Series as an MIP

This example illustrates a request for a static MPR rendering of one phase of a multi-phase series. A volume input reference is provided to identify the desired phase. Coronal orientation is specified using camera orientation parameters. The MPR MIP is 20mm thick, and windowed at a width of 700 and center of 100. A scaled jpeg is returned.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
/series/1.2.250.1.59.40211.789001276.14556172.67789/renderedmpr?
volumeinputreference=1.2.250.1.59.40211.2678810.87991027.899772.2
&renderingmethod=maximum_ip
&mprslab=20
&viewpointposition=100,101,200
&viewpointlookat=100,100,200
&viewpointup=0,0,1
&viewport=512,512,128,128,256,256
&window=700,100,linear
HTTP/1.1
Host: www.hospital-stmarco
Accept: image/jpeg

HTTP/1.1 200 OK
Content-Length: 79323
Content-Type: image/jpeg
<BINARY JPEG DATA>
```

B.x5 Search for Volumetric Protocols

This example illustrates a Non-Patient Instance Search request to retrieve Volumetric Protocols containing “CT” in the Protocol Name.

```
GET /radiology/defined-procedure-protocols?
SOPClassUID=1.2.840.10008.5.1.4.xxuid.1
&ProtocolName=*CT*
&includefield=ProtocolName
HTTP/1.1
Host: www.hospital-stmarco
Accept: application/dicom+json

HTTP/1.1 200 OK
Content-Length: 2155
Content-Type: application/dicom+json; charset=utf-8
[
  {
    "00080016": {
      "vr": "UI",
      "Value": [
        "1.2.840.10008.5.1.4.xxuid.1"
      ]
    },
    "00080018": {
      "vr": "UI",
      "Value": [
        "1.2.250.1.59.40211.3984751.65329182.421683.7"
      ]
    },
    "00181030": {
```

```
        "vr": "LO",
        "Value": [
          "CT Thick Slab MIP"
        ]
          ...
      },
      {
       "00080016": {
        "vr": "UI",
        "Value": [
          "1.2.840.10008.5.1.4.xxuid.1"
        ]
       },
       "00080018": {
        "vr": "UI",
        "Value": [
          "1.2.250.1.59.40211.1938473.11563245.456832.9"
        ]
       },
       "00181030": {
        "vr": "LO",
        "Value": [
          "CT Default Volume Rendered"
        ]
          ...
```

Update PS3.18 Table H-1. Resources and Methods as follows:

Table H-1. Resources and Methods

Service	Resource	Transactions	Reference
Studies (see Section 10.1.1)			
	studies	Search for Studies Store Instances	Section 10.6 Section 10.5
	{StudyInstance}	Retrieve Study Store Study Instances	Section 10.4 Section 10.5
	metadata	Retrieve Study Metadata	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Study**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Study**	**Section 10.4**
	series	Search for Study Series	Section 10.6
	{SeriesInstance}	Retrieve Series	Section 10.4
	metadata	Retrieve Series Metadata	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Series**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Series**	**Section 10.4**
	instances	Search for Study Series Instances	Section 10.4
	{SOPInstance}	Retrieve Instance	Section 10.4
	metadata	Retrieve Instance Metadata	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Instance**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Instance**	**Section 10.4**
	frames	N/A	N/A
	{framelist}	Retrieve Frames	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Frames**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Frames**	**Section 10.4**
	instances	Search for Study Instances	Section 10.6
	series	Search for Series	Section 10.6

Service	Resource	Transactions	Reference
	{SeriesInstance}	N/A	N/A
	{instances}	Search for Instances	Section 10.6
	instances	Search for Instances	Section 10.6
	{BulkDataReference}	Retrieve Bulkdata	Section 10.4
Worklist (see Section 11.1.1)			
	workitems	Search for Workitem Create Workitem	Section 11.9 Section 11.4
	{Workitem}	Retrieve Workitem Update Workitem	Section 11.4 Section 11.6
	state	Change Workitem State	Section 11.7
	cancelrequest	Request Workitem Cancellation	Section 11.8
	subscribers	N/A	N/A
	{AETitle}	Subscribe Unsubscribe	Section 11.10 Section 11.11
	1.2.840.10008.5.1.4.34.5	N/A	N/A
	subscribers	N/A	N/A
	{AETitle}	Subscribe Unsubscribe	Section 11.10 Section 11.11
	suspend	Unsubscribe	Section 11.11
	1.2.840.10008.5.1.4.34.5.1	N/A	N/A
	subscribers	N/A	N/A
	{AETitle}	Subscribe Unsubscribe	Section 11.10 Section 11.11
	suspend	Suspend Worklist Subscription	Section 11.11
Non-Patient Instance (see Section 12.1.1)			
	color-palettes	N/A	N/A
	{uid}	Retrieve Store Search	Section 12.4 Section 12.5 Section 12.6
	defined-procedure-protocol	N/A	N/A
	{uid}	Retrieve Store Search	Section 12.4 Section 12.5 Section 12.6
	hanging-protocol	N/A	N/A
	{uid}	Retrieve Store Search	Section 12.4 Section 12.5 Section 12.6
	implant-templates	N/A	N/A
	{uid}	Retrieve Store Search	Section 12.4 Section 12.5 Section 12.6
	inventories	N/A	N/A
	{uid}	Retrieve Store Search	Section 12.4 Section 12.5 Section 12.6

Add the following Section after Annex I:

X Rendered Volume Response Module

The Rendered Volume Response Module provides the user agent with a representation of the parameters applied by the origin server to generate the volumetric rendering.

This information may be used by the user agent to:

- inform the operator (e.g., populate the user interface with parameters to aid in the interpretation of rendered content)
- serve as the basis for subsequent requests (e.g., to iteratively modify parameters to obtain a desired rendering outcome)
- compose a Non-Patient Instance to store the Volumetric Rendering Protocol
- provide insight into the choices made by the origin server to select defaults and/or address errors when producing the rendering

X.1 Response Message Body

Table X.1-1 defines the Attributes that are returned in a Rendered MPR Volume Resource or a Rendered 3D Volume Resource response message body.

Notes

1. These represent Query Parameters that may be specified by the user agent in Rendered MPR Volume Resources or Rendered 3D Volume Resources. See Section 8.3.5.3.
2. Anatomic orientation parameters (see Section 8.3.5.3.5) are converted to camera orientation parameters to facilitate fine grain adjustments in a subsequent request.

Table X.1-1. Rendered Volume Response Module Attributes

Attribute Name	Tag	Type	Attribute Description
Reformatting Operation Type	(0072,0510)	1	Reformatting operation to be applied to the Image Set.
Rendering Method	(0070,120D)	1	Specifies the display algorithm to be applied to the Volume Data.
Viewpoint Position	(0070,1603)	1	Position of the viewpoint in volume space.
Viewpoint LookAt Point	(0070,1604)	1	Point the viewpoint is looking at.
Viewpoint Up Direction	(0070,1605)	1	Vertical orientation of the view.
MPR Slab Thickness	(0070,1503)	1C	Required if Reformatting Operation Type (0072,0510) has a value of MPR and there is a specified thickness.
VOI LUT Function	(0028,1056)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Window Width	(0028,1051)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Window Center	(0028,1051)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Swivel Range	(0070,1A06)	1C	Required for SWIVEL animations.
Animation Step Size	(0070,1A05)	1C	Required for SWIVEL or CROSSCURVE animations.
Recommended Animation Rate	(0070,1A03)	1C	Required for video media types.

Modifications to PS3.17

Reword the heading for Section XXX as follows:

XXX. Volumetric Rendering ~~Presentation States~~ (Informative)

Add the following Section after Section XXX.6:

XXX.a Scope of Volumetric Rendering Web Service

Rendered Volume Resources enable a user agent to request a server-side 3D volumetric rendering. The user agent communicates the desired rendering by providing Query Parameters, and/or by referencing a Volumetric Rendering Protocol, or a Volumetric Presentation State within the RESTful request. The origin server then resamples the Target Resource of DICOM instances into Volume Data, applies the provided parameters, and returns the representation in the requested Media Type.

Volumetric Rendering Query Parameters provide basic functions that can be used independently to render a volume of Input Instances upon a GET request. Advanced functions are enabled by referencing a Presentation State, or a Volumetric Rendering Protocol containing rendering, presentation, graphic annotation, animation, cropping and segmentation parameters defined prior to a GET request. Basic and advanced functions are summarized in Table XXX.a-1

Table XXX.a-1. Basic and Advanced Web Services Functionality

Basic Functions Provided in Volumetric Rendering Web Services	Advanced Functions Available by Referencing a Volumetric Presentation State or a Volumetric Rendering Protocol
• Pan • Zoom • Windowing • Set Quality • Rotate • Animate • Set Render Method	• Display Color • Shading and Lighting • Crop • Compositing (e.g., fusion and blending) • Annotate • Perspective render projection • Render endoluminal view (e.g., fly through)

XXX.a.1 Volumetric Rendering Web Service Examples

XXX.a.1.1 MPR Rendering of a CT

A CT study is being reviewed on a web-based lightweight viewer. The viewer includes a hanging protocol that displays an MPR image. To obtain the MPR image, the viewer submits a RESTful service request specifying a rendering mode, slab thickness, spacing, and media type. The origin server renders the referenced CT images based on the requested parameters and returns the result in the requested media type. The images are presented by the viewer.

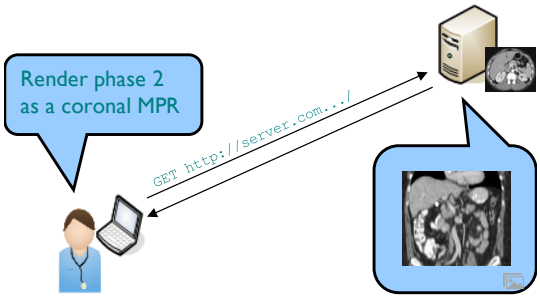


Figure XXX.a-1 MPR Rendering of a CT

XXX.a.1.1.1 Volumetric Rendering Web Service Pipeline

The user agent identifies input instances with geometric consistency, which are then assembled into volume data by the origin server. Algorithm and display parameters are applied to the volume data in order to achieve the requested presentation, and lastly, the representation is encoded into one or more images of the requested media type and returned in a response payload to the user agent.

Figure XXX.a-2 shows the rendering pipeline for a simple volume and how different parts of the request URL correspond to various rendering details. Details of each step are described in the subsections that follow.

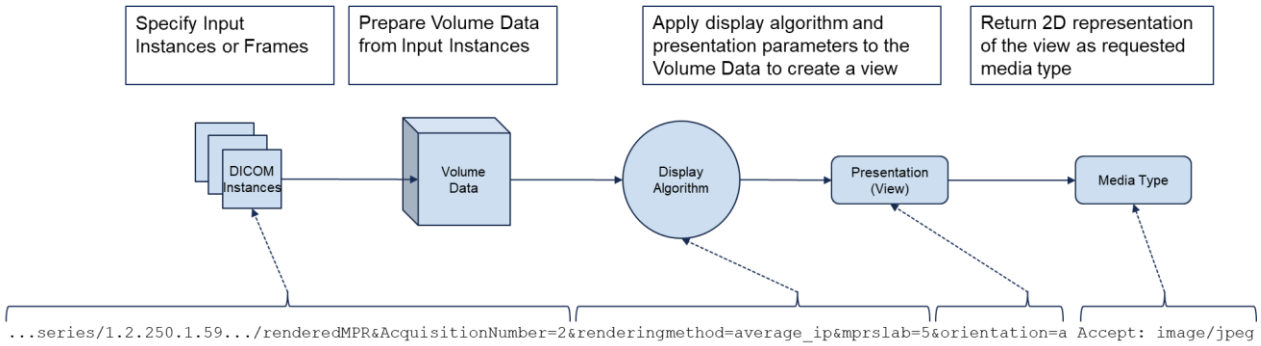


Figure XXX.a-2 Volumetric Rendering Web Service Rendering Pipeline for MPR Rendering of a CT

XXX.a.1.1.2 Specify Input Instances or Frames

Volumetric rendering applications require 2D slice data input. For the origin server to render the data as a volume, the input slices require a degree of consistency, such as a common patient frame of reference, pixel attributes (rows, columns, bit depth) and spatial alignment. Slices may possess Z-axis overlap and/or gaps. DICOM defines the requirements for collections of frames that make up Volumetric Source Information in the Presentation Input Type Volume Input Requirements in PS3.3, Section C.11.23.1.

In this example, three CT acquisitions through the liver are obtained, each corresponding to a contrast phase (arterial, portal-venous and venous). All images are in a single series of Legacy CT Image objects. The scanner used to acquire the images increments Acquisition Number (0020,0012) for each contrast phase in the series:

1 = arterial
2 = portal-venous
3 = venous

The user agent identifies the desired phase by requesting the Acquisition Number value “2”, corresponding to the portal-venous contrast phase. The origin server identifies the subset of instances within the Target Resource having the requested Acquisition Number, determines that they meet the Presentation Input Type Volume Input Requirements, and proceeds to prepare the Volume Data.

XXX.a.1.1.3 Prepare Volume Data from Input Instances

Volumetric Source Information is used to prepare Volume Data. Simple Volume Data consists of a contiguous set of frames at a single point in time. A simple volume is also referred to as 3D, in which each of the three dimensions represent a spatial axis (x, y and z).

In this example, the origin server assembles the pixel data from the identified instances into a simple volume as depicted in Figure XXX.a-3.

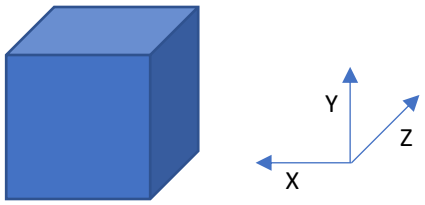


Figure XXX.a-3 Simple Volume Data

XXX.a.1.1.4 Apply Display Algorithm

The Volume Data is presented using a display algorithm, such as Volume Rendering (VR), Maximum Intensity Projection (MIP), and Multiplanar Planar Rendering (MPR).

In this example, the user agent requests a 5 millimeter thick, average intensity projection MPR. The origin server applies an “average_ip” algorithm, a method that projects the mean intensity of all interpolated samples in the path of each ray traced from the viewpoint to the plane of projection.

XXX.a.1.1.5 Apply Presentation Parameters

Presentation parameters define either:

- a fixed view
- an initial view and animation with optional parameters

In this example, the user agent requested an anterior view. Since an image media type, not a video media type, is requested in the Accept header field, and there is only one volume, the origin server creates a view of a fixed coronal orientation at a default location within the volume.

XXX.a.1.1.6 Return 2D Representation

In the last step of the pipeline, the rendered view is encoded using an Acceptable Media Type and returned in the response payload.

In this example, the user agent requests “image/jpeg” in the Accept header field. In response, the origin server returns a representation of the MPR as a single frame jpeg image.

XXX.a.1.2 MIP Rendering of an MRI

A temporal MRI study (consisting of 5 Dynamic Contrast Enhanced phases of the breast) is being reviewed on a web-based lightweight viewer. The viewer includes a hanging protocol that displays a 3D MIP. To obtain the 3D MIP, the viewer submits a RESTful service request specifying the Instances to be rendered, rendering mode, orientation, animation and media type. The origin server renders the referenced MR images based on the requested parameters and returns the result in the requested media type. The images are presented by the viewer.

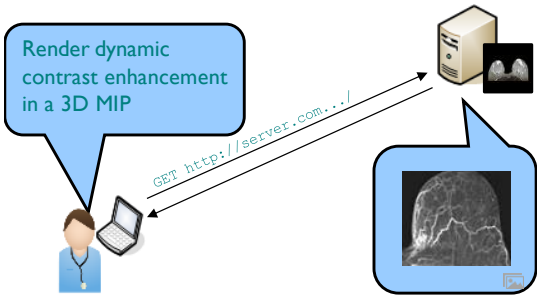


Figure XXX.a-4 MIP Rendering of an MR

XXX.a.1.2.1 Volumetric Rendering Web Service Pipeline

Figure XXX.a-2 shows the rendering pipeline for temporal volumes and how different parts of the request URL correspond to various rendering details. Details of each step are described in the subsections that follow. For brevity, only 2 volumes are shown.

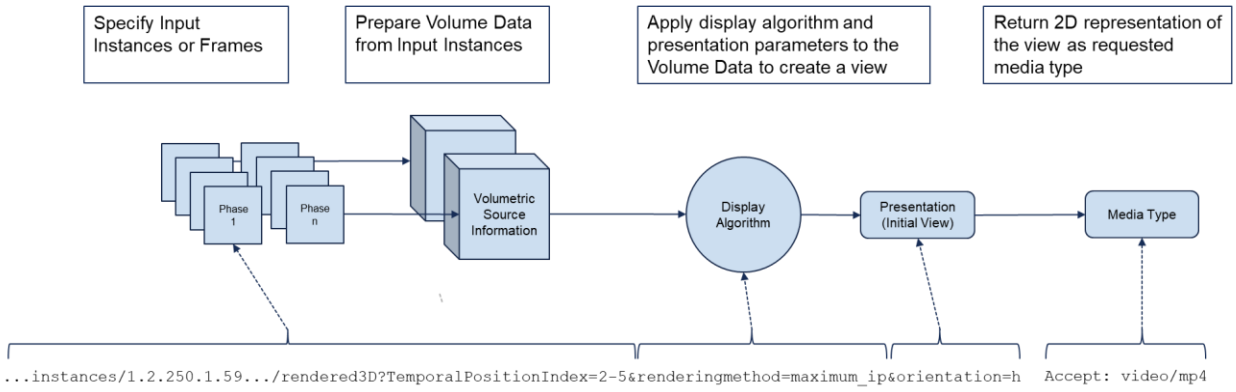


Figure XXX.a-5 Volumetric Rendering Web Service Rendering Pipeline for MIP Rendering of an MR

XXX.a.1.2.2 Specify Input Instances or Frames

In this example, the first phase is non-contrast, phases 2-5 are contrast enhanced. All phases are encoded in a single Enhanced MR object. Phases are identified by the Temporal Position Index (0020,0100).

The user agent identifies the desired phases by requesting the Temporal Position Index values “2-5” corresponding to the contrast enhanced phases. The origin server identifies the frames within the Target Resource having the requested Temporal Position Index, determines that they meet the Presentation Input Type Volume Input Requirements, and proceeds to prepare the Volume Data.

XXX.a.1.2.3 Prepare Volume Data from Input Instances

Multi-volume data consists of two or more simple volumes that are related and rendered simultaneously. Each time point is represented as a simple volume that meets the Volume Input Requirements.

In this example, the origin server assembles the pixel data of the matching frames into four simple volumes, one for each timepoint, as depicted in Figure XXX.a-3.

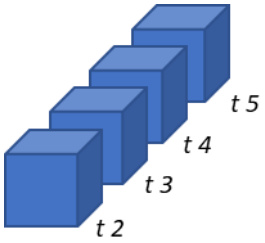


Figure XXX.a-6 Multi Volume Data

XXX.a.1.2.4 Apply Display Algorithm

In this example, the user agent requests a 3D MIP. The origin server applies a “maximum_ip” algorithm, a method that projects each volume with the maximum intensity of the samples that falls in the path of each ray traced from the viewpoint to the plane of projection.

XXX.a.1.2.5 Apply Presentation Parameters

In this example, the user agent requested a top-down view. As a video was requested, and no animation parameters were provided to specify the rotation of the 3D volumes, the origin server chooses not to apply any spatial animation. Instead, it applies a temporal animation, displaying each volume sequentially at a frame rate of 1fps.

XXX.a.1.2.6 Returned Images

In this example, the user agent requests video in the Accept header field. In response, the origin server returns a representation of the temporal MIP as an mpeg video.

XXX.b Scope of Volumetric Rendering Protocol IOD

The Volumetric Rendering Protocol IOD is a non-patient instance belonging to the family of Defined Procedure Protocol IODs that specifies criteria for, and organizes image set inputs into Volume Data, and specifies the Volumetric Transformations to be applied. This section provides examples of the Volumetric Rendering Protocol and Volume Data Input Image Set Modules. For examples or Procedure Protocol IE Modules refer to Section AAAA. For examples of Presentation State IE Modules, refer to Section XXX.3.

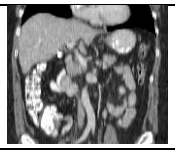
XXX.b.1 Volumetric Rendering Protocol Examples

XXX.b.1.1 MPR Rendering of a CT

This example depicts a Volumetric Rendering Protocol based on the example in Section XXX.a.1.1 “MPR Rendering of a CT”. In this example, the protocol specifies MPR rendering of a CT Series.

The Volumetric Rendering Protocol is defined to identify contrast-enhanced input instances based on Protocol Name (0018,1030), and presence of Contrast/Bolus Agent (0018,0010). The resulting volume is rendered as a temporal MIP coronal slab.

Table XXX.b-1. CT MPR Encoding Example

Name	Value
Volumetric Rendering Protocol Module	
Reformatting Operation Type	MPR
Rendering Method	AVERAGE_IP
Icon Image Sequence	
Volume Organization Type	VOLUME
Volume Data Input Image Set Module	
Volume Data Input Image Set Specification Sequence	
%item1	
>Selector Attribute Name	SOP Class UID
>Selector Attribute VR	UI
>Selector Attribute	(0008,0016)
>Selector Value Number	1

>Constraint Type	EQUAL
>Constraint Violation Significance	FAILURE
>Constraint Value Sequence	
>%item1	
>>Selector UI Value	1.2.840.10008.5.1.4.1.1.2
>%enditem	
%enditem	
%item2	
>Selector Attribute Name	Protocol Name
>Selector Attribute VR	LO
>Selector Attribute	(0018,1030)
>Selector Value Number	1
>Constraint Type	EQUAL
>Constraint Violation Significance	WARNING
>Constraint Value Sequence	
>%item1	
>>Selector LO Value	"3-phase liver"
>%enditem	
%item3	
>Selector Attribute Name	Contrast/Bolus Agent
>Selector Attribute VR	LO
>Selector Attribute	(0018,0010)
>Selector Value Number	1
>Constraint Type	UNCONSTRAINED
>Constraint Violation Significance	WARNING
%enditem	

Notes

1. This example establishes a Constraint Violation Significance of FAILURE if the SOP Class UID of the input instances is anything other than CT Image Storage. Alternatively, a Constraint Type of MEMBER_OF could have been included to establish a list of allowable values for (legacy) CT Image Storage and Enhanced CT Image Storage SOP Class types. The decision rests with the author.
2. It also requires a Protocol Name of "3-phase liver", based on site-specific protocols. This requirement could also include a list of values (MEMBER_OF).
3. This protocol restricts inputs to be contrast-enhanced. The protocol's effectiveness relies on contrast-enhanced images. However, this constraint is not significant enough to warrant a FAILURE, thus, a WARNING Constraint Violation Significance is encoded to prompt a notification to the operator when non-contrast images are detected.

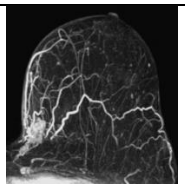
XXX.b.1.2 MIP Rendering of an MRI

This example depicts a Volumetric Rendering Protocol based on the example in Section XXX.a.1.1 “MIP Rendering of an MRI”. In this example, the protocol specifies a temporal MIP rendering of each phase within the Enhanced MR Instance.

The Volumetric Rendering Protocol is defined to identify DCE input frames based on Image Type (0008,0008) and Temporal Position Index (0020,0100). Frames are grouped into Volume Data based on

961 the Temporal Position Index (0020,0100). Each resulting volume (i.e., phase) is rendered as a temporal
962 3D MIP, starting with phase 2, the earliest contrast-enhanced phase.

963 **Table XXX.d-2. MR Temporal Volume Encoding Example**

Name	Value
Volumetric Rendering Protocol Module	
Reformatting Operation Type	3D_RENDERING
Rendering Method	MAXIMUM_IP
Icon Image Sequences	
Volume Organization Type	TEMPORAL_VOLUME
Volume Data Input Image Set Module	
Volume Data Input Image Set Specification Sequence	
%item1	
>Selector Attribute Name	SOP Class UID
>Selector Attribute VR	UI
>Selector Attribute	(0008,0016)
>Selector Value Number	1
>Constraint Type	EQUAL
>Constraint Violation Significance	FAILURE
>Constraint Value Sequence	
>%item1	
>>Selector UI Value	1.2.840.10008.5.1.4.1.1.4.1
>%enditem	
%enditem	
%item2	
>Selector Attribute Name	Image Type
>Selector Attribute VR	CS
>Selector Attribute	(0008,0008)
>Selector Value Number	3
>Constraint Type	EQUAL
>Constraint Violation Significance	FAILURE
>Constraint Value Sequence	
>%item1	
>>Selector CS Value	DYNAMIC
>%enditem	
%enditem	
Volume Definition Module	
Volume Data Organization Sequence	
%item1	

>Selector Attribute Name	Temporal Position Index
>Selector Attribute VR	UL
>Selector Attribute	(0020,0100)
>Selector Value Number	1
>Constraint Type	GREATER_OR_EQUAL
>Constraint Violation Significance	FAILURE
>Constraint Value Sequence	
>%item1	
>>Selector IS Value	2
>%enditem	
%enditem	
Volume Data Sorting Sequence	
%item1	
>Selector Attribute Name	Temporal Position Index
>Selector Attribute VR	UL
>Selector Attribute	(0020,0100)
>Selector Value Number	1
>Sorting Direction	INCREASING
%enditem	

Notes

1. When this protocol is referenced as a value for the Volumetric Protocol parameter in a Rendered MPR Volume request, additional parameters may be included to define animation behavior, such as presenting a static or rotating view visualizing contrast enhancement over time.
2. Because the first phase of this acquisition is non-contrast, intended as a subtraction mask, the Temporal Position Index is set to 2 or higher (GREATER_OR_EQUAL). This results in a FAILURE for static inputs, e.g., when the Temporal Position Index is absent, or equals 1.
3. The Volume Data Sorting Sequence is included to determine the order for displaying the Temporal Volumes, beginning at 1 (representing the earliest timepoint) and proceeding in ascending order to the latest timepoint.

XXX.c Converting MPR Orientation to Viewpoint Attributes in Volumetric Rendering Web Services

The Rendered 3D and Rendered MPR camera orientation parameters for Volumetric Rendering web services, such as the Volume Rendering Volumetric Presentation State IOD, specify orientation from the perspective of a camera in the Volumetric Presentation State Reference Coordinate System (VPS-RCS) with three parameters consisting of:

- “viewpointposition”, a point,
- "viewpointlookat", a point, and
- “viewpointup”, a vector.

Conversely, the Planar MPR Volumetric Presentation State IOD specifies the MPR slab orientation as a direction cosine (x,y,z), in the MPR View Width Direction (0070,1507) and MPR View Height Direction (0070,1511) attributes.

MPR slab orientation attributes can be converted to camera attributes as follows:

$\texttt{viewpointlookat} = T_{xyz} + X_{xyz} * W / 2 + Y_{xyz} * H / 2$

`viewpointposition` = $V_{xyz} + Z_{xyz}$

`viewpointup` = Y_{xyz}

Where:

T_{xyz} = coordinates of the MPR Top Left Hand Corner (0070,1505) in mm
X_{xyz} = values from the direction cosine of the MPR View Width Direction (0070,1507)
Y_{xyz} = values from the direction cosine of the MPR View Height Direction (0070,1511)
Z_{xyz} = the vector cross products of X_{xyz} and Y_{xyz}
W = MPR View Width (0070,1508) in mm
H = MPR View Height (0070,1512) in mm
V_{xyz} = coordinates of the `viewpointlookat` point

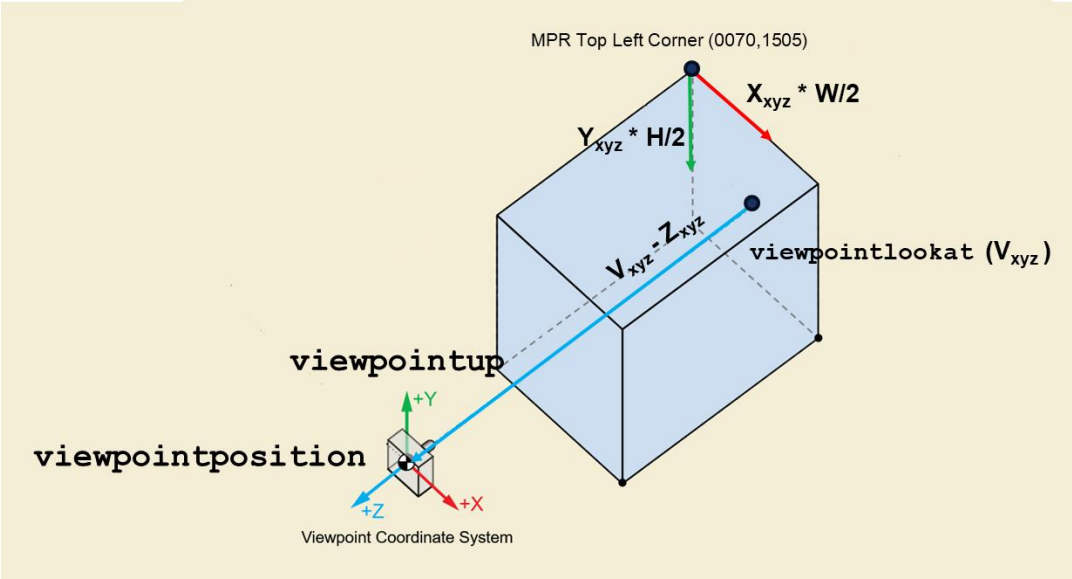


Figure XXX.c-1 Converting MPR Orientation to Viewpoint Attributes