Digital Imaging and Communications in Medicine (DICOM)

Supplement 167: X-Ray 3D Angiographic IOD Informative Annex

Prepared by:

DICOM Standards Committee, Working Group 2, Projection Radiography and Angiography

1300 N. 17th Street, Suite 900

Rosslyn, Virginia 22209 USA

VERSION: Final Text

January 13, 2015

Developed pursuant to DICOM Work Item Number 2005-09-C

Please send comments to Stephen Vastagh, NEMA (svastagh@medicalimaging.org)

Table of Contents

Scope and Field

This Supplement delivers explanatory information on the usage of DICOM attributes for X-Ray 3D Angiographic Image IOD.

The detailed purpose can be summarized as follows:

- Give more information beyond the definitions in PS 3.3 (detailed text vs. scenarios, examples, drawings, etc.);
- Identify scenarios where the X-Ray 3D Angiographic Image will be applied;
- Indicate restrictions on the applicable scenarios (defined terms recommended, values ranges, recommended presence of attributes);
- Encourage the usage of Type 3 attributes under particular scenarios;
- Assess the applicability for some conditional attributes under particular scenarios;
- Ensure that the introduction of private attributes is a “last resort only” situation.

Some of the concepts described in this Supplement are common to any X-Ray cone-beam reconstruction modality, although the application cases only apply to X-Ray 3D Angiographic SOP Class.

Changes to NEMA Standards Publication PS 3.17-2013

Digital Imaging and Communications in Medicine (DICOM)

Part 17: Explanatory Information

Add the following Annex to PS 3.17

Annex X X-Ray 3D Angiographic Image Encoding Examples (Informative)

X.1 GENERAL CONCEPTS OF X-RAY 3D ANGIOGRAPHY

This chapter describes the general concepts of the X-Ray 3D Angiography: the acquisition of the projection images, the 3D reconstruction, and the encoding of the X-Ray 3D Angiographic Image SOP instances. They provide better understanding of the different application cases in the rest of this Annex.

X.1.1 Process of creating an X-Ray 3D Angiography

Two main steps are involved in the process of creating an X-Ray 3D Angiographic Instance: The acquisition of 2D projections and the 3D reconstruction of the volume.

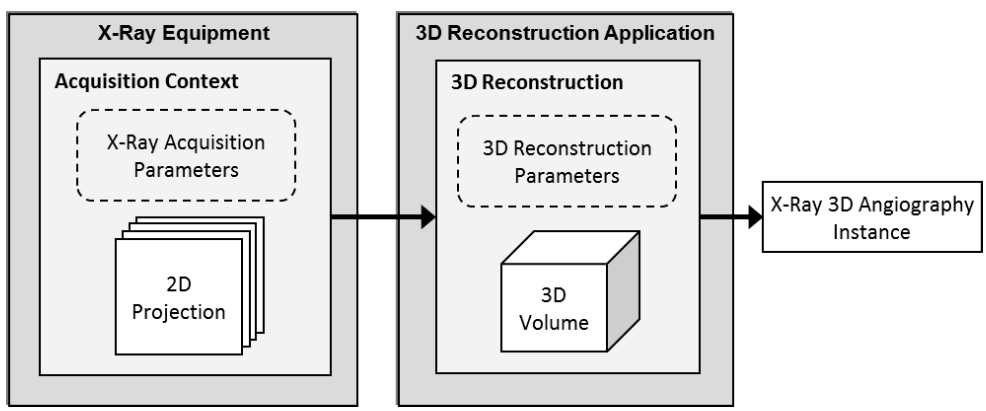


Figure X.1.1-1
Process flow of the X-Ray 3D Angiographic Volume Creation

X.1.1.1 Acquisition of 2D Projections

The X-Ray equipment acquires 2D projections at different angles. The Acquisition Context describes the technical parameters of a set of 2D projection acquisitions that are used to perform a 3D reconstruction. In the scope of the X-Ray 3D Angiographic SOP Class, all the projections of an Acquisition Context share common parameter values, such as:

- Detector settings, anti-scatter grid, field of view characteristics;
- Distances from the X-Ray source to the Isocenter and to the detector, table position and table angles;
- Focal spot, spectral filters;

- Contrast injection details;

If one value of such common parameters changes during the acquisition of the projections, then more than one Acquisition Context will be defined.

Typically the projections of an Acquisition Context are the result of a rotational acquisition where the X-Ray positioner follows a circular trajectory. However, it is possible to define an Acquisition Context as the set of multiple projections at different X-Ray incidences without a particular spatial trajectory.

An Acquisition Context is characterized by a period of time in which all the projections are acquired. Some other parameters are used to describe the Acquisition Context: start and end DateTime, average exposure techniques (mA, kVp, exposure duration…), positioner start, end and increment angles.

Additionally, other technical parameters that change at each projection can be documented in the X-Ray 3D Angiographic SOP Class on a per-projection basis:

- kVp, mA, exposure duration;
- Collimator shape and dimensions;
- X-Ray positioner angles;

X.1.1.2 3D Reconstruction

The 3D Reconstruction Application performing the 3D Reconstruction can be located in the same X-Ray equipment or in another workstation.

A 3D Reconstruction in the scope of the X-Ray 3D Angiographic SOP Class is the creation of one X-Ray 3D Angiographic volume from a set of projections from one or more Acquisition Context(s). Therefore, one 3D Reconstruction in this scope refers to the resulting volume, and not to the application logic to process the projections. This application logic is out of the scope of this SOP Class, the same encoding will result whether several 3D Reconstructions are performed in a single or in multiple application steps to create several volumes (e.g. low and high resolution volumes) from the same set of projections.

One 3D Reconstruction is characterized by some parameters like name, version, manufacturer, description and the type of algorithm used to process the projections.

The 3D Reconstruction can use one or more Acquisition Contexts to generate one single X-Ray 3D Angiographic Volume. Several 3D Reconstructions can be encoded in one single X-Ray 3D Angiographic Instance.

X.1.2 X-Ray 3D Angiographic Real World Entities Relationships

This section describes the relationships between the real world entities involved in X-Ray 3D Angiography.

The X-Ray equipment creates one or more acquisition contexts (i.e. one or more rotational acquisitions with different technical parameters). The projections can be kept internal to the equipment (i.e. not exported outside the equipment) or can be encoded as DICOM instances. In the scope of the X-Ray 3D Angiographic SOP Class, the projections can be encoded either as X-Ray Angiography SOP Class or Enhanced XA SOP Class.

If the projections are encoded as DICOM Instances, they can be referenced in the X-Ray 3D Angiographic image as Contributing Sources. Each Acquisition Context refers to all the DICOM instances involved in that context. If the projections are kept internal to the equipment, the X-Ray 3D Angiographic image can still describe the technical parameters of each acquisition context without referencing any DICOM instance.

The 3D Reconstruction Application creates one or more 3D Reconstructions, each 3D Reconstruction uses one or more Acquisition Contexts. One or more 3D Reconstructions can be encoded in one single X-Ray 3D Angiographic Instance.

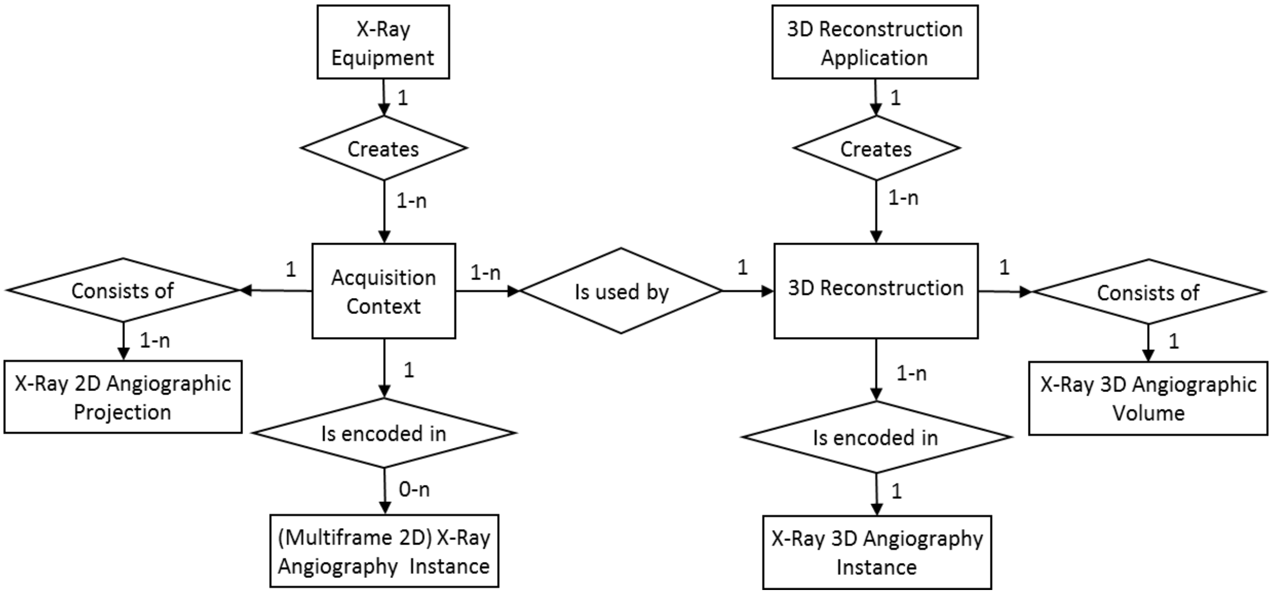


Figure X.1.2-1
Relationship between the creation of 2D and 3D Instances

X.1.3 X-Ray 3D Angiographic Pixel Data Characterization

Similarly to other 3D modalities like CT or MR, the X-Ray 3D Angiographic image is generated from original source data (i.e. original projections) which can be kept internal to the equipment. In this sense, the 3D dataset resulting from the reconstruction of the original projections is considered as original (i.e. the Value 1 of the attributes Image Type (0008,0008) and Frame Type (0008,9007) equals ORIGINAL).

Note that the original 2D projections can be stored as DICOM instances, and the X-Ray 3D Angiographic image can be created from a later reconstruction on a different equipment. In this case, since the source data is the same original set of projections, the 3D dataset is still considered as original.

X.2 APPLICATION CASES

This chapter describes different scenarios and application cases where the 3D volume is reconstructed from rotational angiography. Each application case is structured in four sections:

1) **User Scenario**: Describes the user needs in a specific clinical context, and/or a particular system configuration and equipment type.

2) **Encoding Outline**: Describes the X-Ray 3D Angiographic Image SOP Class related to this scenario, and highlights key aspects.

3) **Encoding Details**: Provides detailed recommendations of the key attributes of the Image IOD(s) to address this particular scenario. The tables are similar to the IOD tables of the DICOM Part 3. Only attributes with a specific recommendation in this particular scenario have been included.

4) **Example**: Presents a typical example of the scenario, with realistic sample values, and gives details of the encoding of the key attributes of the Image IOD(s) to address this particular scenario. In the values of the attributes, the text in bold face indicates specific attribute values; the text in italic face gives an indication of the expected value content.

The first application case describes the most general reconstruction scenario, and can be considered as a baseline. The further application cases only describe the specificities of the new scenario vs. the baseline.

X.2.1 Case #1: One rotation, one 2D instance, one reconstruction, one X-Ray 3D instance

This application case is related to the most general reconstruction of a 3D volume directly from all the frames of a rotational 2D projection acquisition.

X.2.1.1 User Scenario

The image acquisition system performs a rotational acquisition around the patient and a volume is reconstructed from the acquired data (e.g. through “back-projection” algorithm). The reconstruction can either occur on the same system (e.g. Acquisition Modality) or a secondary processing system (e.g. Co-Workstation).

The reconstructed Volume needs to be encoded and kept saved for interchange with 3D rendering application or further equipment involved during an interventional procedure.

X.2.1.2 Encoding outline

This is the basic use case of X-Ray 3D Angiographic image encoding.

The rotational acquisition can be encoded either as a multiframe XA Image with limited frame-specific attributes or as an Enhanced XA Image, with frame-specific attributes encoded that support the algorithms to reconstruct a volume dataset.

The volume dataset is encoded as an X-Ray 3D Angiographic instance. The volume dataset typically spans the complete region of the projected matrix size (in number of rows and columns).

All the projections of the original XA instance or Enhanced XA instance are used to reconstruct the volume.

The X-Ray 3D Angiographic instance references the original XA instance or Enhanced XA instance and uses attributes to define the context on how the original 2D image frames are used to create the volume.

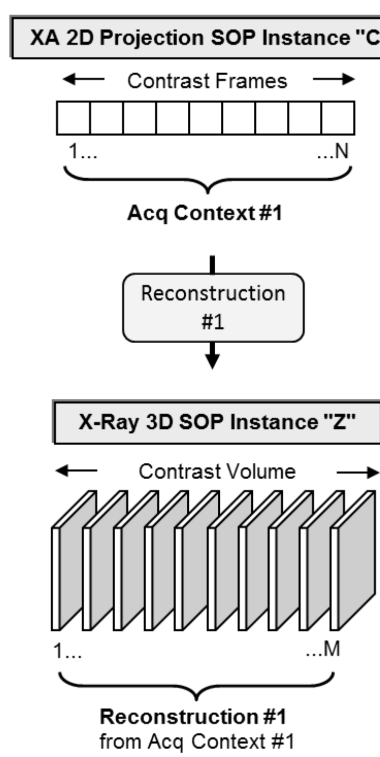


Figure X.2.1-1
Encoding of a 3D reconstruction from all the frames of a rotational acquisition

X.2.1.3 Encoding details

X.2.1.3.1 X-Ray 3D Angiographic Image IOD

X.2.1.3.1.1 General and Enhanced Series Modules Recommendations

These modules encode the Series relationship of the created volume.

Table X.2.1-1
GENERAL AND ENHANCED SERIES MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Series Instance UID	(0020,000E)	Use a different Series than the original projections.
Series Description	(0008,103E)	Free text to describe the volume content, different from the description of the series of the projection images.
Protocol Name	(0018,1030)	Free text to describe technical aspects of the reconstruction (focusing on imaging protocol rather than clinical protocol). May be relevant for grouping, sorting or finding of the X-Ray 3D volume.
Referenced Performed Procedure Step Sequence	(0008,1111)	Reference to the image acquisition procedure. May also reference a dedicated processing procedure step (e.g. UPS).

X.2.1.3.1.2 Frame of Reference Module Recommendations

This module encodes the identifier for the spatial relationship base of this volume. If the originating 2D images do not deliver a value, it has to be created for the reconstructed volume.

Table X.2.1-2
FRAME OF REFERENCE MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame of Reference UID	(0020,0052)	Volumes with identical FoR UID share the same spatial relationship. Copy the FoR UID if the originating image is encoded as an Enhanced XA Image.
Position Reference Indicator	(0020,1040)	If the system is capable to derive such information from the anatomy-related information in the projection X-Ray image data, otherwise no recommendation to set a value.

X.2.1.3.1.3 General and Enhanced General Equipment Modules Recommendations

This module encodes the equipment identification information of the system that reconstructed the volume data. Since the reconstruction is not necessarily performed by the same system that acquired the projections, the identification of the Equipment performing the reconstruction is recommended. Furthermore the Contributing Equipment Sequence (0018,A001) of the SOP Common Module is recommended to be used to preserve the identification of the system that created the projection image that was base for the reconstruction.

X.2.1.3.1.4 Image Pixel Module Recommendations

This module encodes the actual pixels of the volume slices. Each slice is encoded as one frame of the X-Ray 3D Angiographic instance. The order of the frames encoded in the pixel data is aligned with the Image Position (Patient) attribute. The order of frames is optimal for simple 2D viewing if the x-,y-,z-values steadily increase or decrease.

X.2.1.3.1.5 Enhanced Contrast/Bolus Module Recommendations

This module encodes the contrast media applied. The minimum information that needs to be provided is related to the contrast agent and the administration route. In the reconstructed image, the contrast information comes either from the acquisition system in case of direct reconstruction without source DICOM instances, or from the projection images in case of reconstruction from source DICOM instances.

Table X.2.1-3
ENHANCED CONTRAST/BOLUS MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Contrast/Bolus Agent Sequence	(0018,0012)	
>Include 'Code Sequence Macro' Table 8.8-1 Baseline CID 12.		See Section X.2.1.3.1.5.1
>Contrast/Bolus Administration Route Sequence	(0018,0014)	
>>Include 'Code Sequence Macro' Table 8.8-1 Baseline CID 11.		See Section X.2.1.3.1.5.1

X.2.1.3.1.5.1 Differences between XA and Enhanced XA

If the source instance is encoded as an Enhanced XA instance, the Enhanced Contrast/Bolus Module is specified in that IOD, then those values are copied from the source instance.

If the source instance is encoded as an XA Image, only the Contrast/Bolus Module is specified in that IOD. Although acquisition devices are encouraged to provide details of the contrast, most of the relevant attributes are type 3, so it is possible that if contrast was applied, the only indication will be the presence of Contrast/Bolus Agent (0018,0010) since that attribute is type 2. In that case, if the application is unable to get more specific information from the operator, it may populate the contrast details with the generic (C-B0300, SRT, "Contrast agent") code for contrast agent and the (R-41198, SRT, "Unknown") code for the administration route.

X.2.1.3.1.6 Multi-frame Dimensions Module Recommendations

This module encodes a (default) presentation order of the image frames.

Table X.2.1-4
MULTI-FRAME DIMENSIONS MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Dimension Organization Sequence	(0020,9221)	This will be an initial single dimension and therefore a single Dimension UID is sufficient.
Dimension Organization Type	(0020,9311)	The value will be "3D".
Dimension Index Sequence	(0020,9222)	Specifies a Dimension Index that refers to the Image Position (Patient) as dimension for frame order during 2D presentation of an X-Ray 3D volume.

X.2.1.3.1.7 Patient Orientation Module Recommendations

This module encodes the orientation of the Patient for later use with same or other equipment. The related coded terms can be derived from the Patient Position (0018,5100) according to the following table, where:

- PO denotes the Patient Orientation Code Sequence (0054,0410);
- POM denotes the Patient Orientation Modifier Code Sequence (0054,0412);
- PGR denotes the Patient Gantry Relationship Code Sequence (0054,0414).

Table X.2.1-5
PATIENT POSITION TO ORIENTATION CONVERSION RECOMMENDATIONS

Patient Position	Patient Orientation Coding
HFS	PO: (F-10450, SRT, “recumbent”) POM: (F-10340, SRT, “supine”) PGR: (F-10470, SRT, “headfirst”)
HFP	PO: (F-10450, SRT, “recumbent”) POM: (F-10310, SRT, “prone”) PGR: (F-10470, SRT, “headfirst”)
FFS	PO: (F-10450, SRT, “recumbent”) POM: (F-10340, SRT, “supine”) PGR: (F-10480, SRT, “feet-first”)
FFP	PO: (F-10450, SRT, “recumbent”) POM: (F-10310, SRT, “prone”) PGR: (F-10480, SRT, “feet-first”)
HFDR	PO: (F-10450, SRT, “recumbent”) POM: (F-10317, SRT, “right lateral decubitus”) PGR: (F-10470, SRT, “headfirst”)
HFDL	PO: (F-10450, SRT, “recumbent”) POM: (F-10319, SRT, “left lateral decubitus”) PGR: (F-10470, SRT, “headfirst”)
FFDR	PO: (F-10450, SRT, “recumbent”) POM: (F-10317, SRT, “right lateral decubitus”) PGR: (F-10480, SRT, “feet-first”)
FFDL	PO: (F-10450, SRT, “recumbent”) POM: (F-10319, SRT, “left lateral decubitus”) PGR: (F-10480, SRT, “feet-first”)

X.2.1.3.1.8 X-Ray 3D Image Module Recommendations

This module encodes the specific content of the reconstructed volume.

Table X.2.1-6
X-RAY 3D IMAGE MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Image Type	(0008,0008)	Use “ORIGINAL” value 1 (Pixel Data Characteristics) to indicate a reconstruction from original projections. Use “VOLUME” in value 3 (Image Flavor) to indicate regularly sampled.
Icon Image Sequence	(0088,0200)	Include if the reconstruction application may be able to generate a rendered representative icon image.

X.2.1.3.1.9 X-Ray 3D Angiographic Image Contributing Sources Module Recommendations

This module encodes the source SOP instances used to create the X-Ray 3D Angiographic instance.

Table X.2.1-7
X-RAY 3D ANGIOGRAPHIC IMAGE CONTRIBUTING SOURCES MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Contributing Sources Sequence	(0018,9506)	One item since there is only one originating image that contributed to the creation of the X-Ray 3D Angiographic image.

X.2.1.3.1.10 X-Ray 3D Angiographic Acquisition Module Recommendations

This module encodes the important technical and physical parameters of the source SOP instances used to create the X-Ray 3D Angiographic Image instance.

The contents of the Enhanced XA Image IOD and XA Image IOD are significantly different. Therefore the contents of the X-Ray 3D Acquisition Sequence will vary depending on availability of encoded data in the source instance.

The content of the X-Ray 3D General Positioner Movement Macro provides a general overview on the Positioner data. In case a system does not support the Isocenter Reference System, it may still be of advantage to provide the patient-based Positioner Primary and Secondary Angles in the Per Projection Acquisition Sequence (0018,9538).

The contents of the Per Projection Acquisition Sequence (0018,9538) need to be carefully aligned with the list of frame numbers in the Referenced Frame Numbers (0008,1160) attribute in the Source Image Sequence (0008,2112).

Table X.2.1-8
X-RAY 3D ANGIOGRAPHIC IMAGE ACQUISITION MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
X-Ray 3D Acquisition Sequence	(0018,9507)	One item since there is only one acquisition context that contributed to the reconstruction of the X-Ray 3D Angiographic image pixel data contents.

X.2.1.3.1.11 Pixel Measures Macro Recommendations

This module encodes the detailed size of the volume element (Pixel Spacing for row/column dimension of each slice, and Slice Thickness for the distance between slices). It depends on the reconstruction algorithm and is not necessarily identical to the related sizes in the projection images.

For a single volume this macro is encoded “shared” as all the slices will have the same Pixel Spacing and Slice Thickness.

X.2.1.3.1.12 Frame Content Macro Recommendations

This module encodes the timing information of the frames, as well as dimension and stack index values.

In the reconstruction from rotational projections the figure C.7.6.16-2 of PS3.3 C.7.6.16.2.2.1 should be interpreted carefully. All the frames forming one X-Ray 3D Angiographic volume have been reconstructed simultaneously, therefore all of them have a same time reference and the same acquisition duration.

The projections have been acquired over a period of time, all of them contributing to each 3D frame. Therefore, it’s recommended to encode the 3D frame acquisition duration as the elapsed time from the first to the last projection frame time that contributed to that volume.

Table X.2.1-9
FRAME CONTENT MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame Content Sequence	(0020,9111)	Provides details for each frame. The Date and Time attributes are identical for all frames and are set to the date/time of the first projection frame due to the nature of the volume creation. The Stack information can be used to group frames into sub-volumes, if needed.
>Frame Reference DateTime	(0018,9151)	Use the date and time of the first 2D frame used for the reconstruction of this 3D frame. Same value for all the frames of the same reconstruction.
>Frame Acquisition DateTime	(0018,9074)	Use the same value as the Frame Reference DateTime (0018,9151).
>Frame Acquisition Duration	(0018,9220)	Use the duration of the rotational acquisition. Same value for all the frames of the same reconstruction.
>Dimension Index Values	(0020,9157)	From 1 to M or M to 1 depending whether the frames are to be displayed in the storage order or reverse, M being the number of frames of the reconstructed volume.
>Stack ID	(0020,9056)	Use the value “1” for all the frames, since they belong to the same reconstructed volume.
>In-Stack Position Number	(0020,9057)	From 1 to M, where M is the number of frames of the reconstructed volume.

X.2.1.3.1.13 Derivation Image Macro Recommendations

The volume is directly reconstructed from the original set of projections and therefore not “derived” in this sense. Thus this macro is not applicable in this scenario as the contents of the Contributing Sources Sequence (0018,9506) and the X-Ray 3D Acquisition Sequence (0018,9507) are sufficient to describe the relationship to the originating image.

X.2.1.3.1.14 Frame Anatomy Macro Recommendations

This macro encodes the anatomical context. It can be important to parameterize the presentation of the volumes. For a single volume this macro is encoded “shared”. Typically the anatomy of the volume is only available if the information is already provided within the originating projection image, either by detection algorithm or by user input.

X.2.1.3.1.15 X-Ray 3D Frame Type Macro Recommendations

This macro encodes the general characteristics of the volume slices like color information for presentation, volumetric properties for geometrical manipulations etc. In case of a single volume, this macro is encoded “shared” as each slice of the volume has identical characteristics. If multiple volumes are encoded in a single instance, this macro may be encoded “per frame”.

X.2.1.4 Example

X.2.1.4.1 Reconstruction using all frames of an Enhanced XA Image

This basic example is the reconstruction of a volume by a back-projection from all frames of a rotational acquisition which have been encoded as an Enhanced XA Instance. The rotational acquisition takes 5 seconds to acquire all the projections.

Note: the example would be very similar if the rotational acquisition was encoded as an XA Image.

The dimension organization is based on the spatial position of the 3D frames. The frames are to be displayed in the same order as stored.

The UIDs of this example correspond to the diagram shown in Figure X.2.1-1.

Image Type	(0008,0008)	=	**ORIGINAL\PRIMARY\VOLUME\NONE**
SOP Instance UID	(0008,0018)	=	*UID „Z“*
Modality	(0008,0060)	=	**XA**
Pixel Presentation	(0008,9205)	=	**MONOCHROME**
Volumetric Properties	(0008,9206)	=	**VOLUME**
Volume Based Calculation Technique	(0008,9207)	=	**NONE**
…..			
Contributing Sources Sequence	(0018,9506)		
Item 1			*Contributing sources (only one in this example)*
>Contributing SOP Instances Reference Sequence	(0020,9529)		
Item 1			
>>Referenced Series Sequence	(0008,1115)		
Item 1			
>>>Referenced Instance Sequence	(0008,114a)		
Item 1			
>>>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>>>Referenced SOP Instance UID	(0008,1155)	=	*UID „C“*
>>>Series Instance UID	(0020,000e)	=	*UID „B“*
>>Study Instance UID	(0020,000d)	=	*UID „A“*
>… *(other attributes from the contributing image sources)*			
…..			
X-Ray 3D Acquisition Sequence	(0018,9507)		
Item 1			*Acquisition context #1*
>Source Image Sequence	(0008,2112)		
Item 1			*one source image for this acquisition context*
>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	=	*UID „C“*
>… *(other attributes of this acquisition context)*			
>Per Projection Acquisition Sequence	(0018,9538)		
Item 1			*data of projection #1 of this acquisition context*
>> … *(other attributes)*			
Item 2			*data of projection #2 of this acquisition context*
>> … *(other attributes)*			
….			
…..			
X-Ray 3D Reconstruction Sequence	(0018,9530)		
Item 1			*Reconstruction #1*
>Acquisition Index	(0020,9518)	=	**1**
> … *(other attributes related to this reconstruction)*			
…..			
Frame of Reference UID	(0020,0052)	=	*UID „D“*
Dimension Organization Sequence	(0020,9221)		
Item 1			*One dimension*
>Dimension Organization UID	(0020,9164)	=	*UID „E“*
Dimension Index Sequence	(0020,9222)		
Item 1			
>Dimension Organization UID	(0020,9164)	=	*UID „E“*
>Dimension Index Pointer	(0020,9165)	=	**(0020,0032)**
>Functional Group Pointer	(0020,9167)	=	**(0020,9113)**
Dimension Organization Type	(0020,9311)	=	**3D**
…..			

Attribute	Tag	Value
Shared Functional Group Sequence	(5200,9229)	
Item 1		*Common to all frames of the X-Ray 3D*
…		
>Pixel Measures Sequence	(0028,9110)	
Item 1		
>>Slice Thickness	(0018,0050)	
>>Pixel Spacing	(0028,0030)	
>Plane Orientation Sequence	(0028,9116)	
Item 1		
>>Image Orientation (Patient)	(0020,0037)	
>Frame Anatomy Sequence	(0020,9071)	
Item 1		
>>Frame Laterality	(0020,9072)	
>>Anatomic Region Sequence	(0008,2218)	
>Frame VOI LUT Sequence	(0028,9132)	
Item 1		
>>Window Center	(0028,1050)	
>>Window Width	(0028,1051)	
>X-Ray 3D Frame Type Sequence	(0018,9504)	
Item 1		
>>Frame Type	(0008,9007)	= **ORIGINAL\PRIMARY\VOLUME\NONE**
>>Pixel Presentation	(0008,9205)	= **MONOCHROME**
>>Volumetric Properties	(0008,9206)	= **VOLUME**
>>Volume Based Calculation Technique	(0008,9207)	= **NONE**
>>Reconstruction Index	(0020,9536)	= **1** (all frames share the same reconstruction data)
…		
…..		
Per-Frame Functional Groups Sequence	(5200,9230)	
…		
Item i		*Frame "i" of the X-Ray 3D*
>Frame Content Sequence	(0020,9111)	
Item 1		
>>Frame Reference DateTime	(0018,9151)	= *DateTime of the 1st frame of source*
>>Frame Acquisition DateTime	(0018,9074)	= *DateTime of the 1st frame of source*
>>Frame Acquisition Duration	(0018,9220)	= **5000.0**
>>Dimension Index Values	(0020,9157)	= **i** *(consecutive numbers from 1 to M)*
>>Stack ID	(0020,9056)	= **1** (all frames belong to the same stack)
>>In-Stack Position Number	(0020,9057)	= **i** *(consecutive numbers from 1 to M)*
>Plane Position Sequence	(0020,9113)	
Item 1		
>>Image Position (Patient)	(0020,0032)	
…		

Figure X.2.1-2
Attributes of 3D Reconstruction using all frames

X.2.2 Case #2: Reconstruction from a sub-set of projection frames

This application case is related to a reconstruction from a sub-set of projection frames.

X.2.2.1 User Scenario

The image acquisition system performs one rotational acquisition. Not all of the acquired frames, but every N^{th} frame is used to reconstruct the volume, e.g. to speed-up the reconstruction.

X.2.2.2 Encoding outline

Only selected frames of the original XA instance or Enhanced XA instance are used to reconstruct the volume.

The X-Ray 3D instance references the original XA instance or Enhanced XA instance and uses attributes to define the context on how and which of the original image frames are used to create the volume.

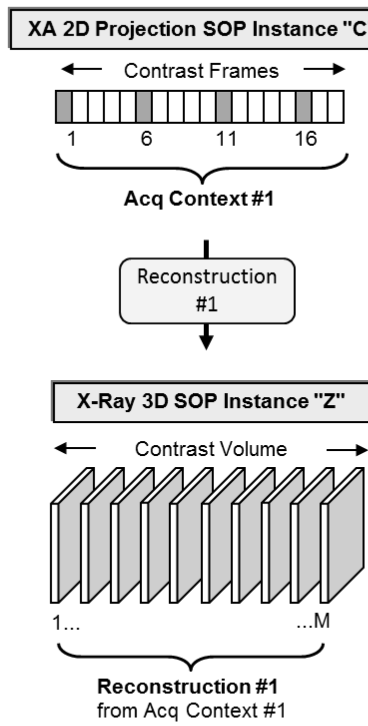


Figure X.2.2-1
Encoding of one 3D reconstruction from a sub-set of projection frames

X.2.2.3 Encoding details

X.2.2.3.1 X-Ray 3D Angiographic Image IOD

X.2.2.3.1.1 X-Ray 3D Angiographic Acquisition Module Recommendations

This module encodes the important technical and physical parameters of the source SOP instances and the frames used to create the X-Ray 3D Angiographic instance.

Table X.2.2-1
X-RAY 3D ANGIOGRAPHIC IMAGE ACQUISITION MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
X-Ray 3D Acquisition Sequence	(0018,9507)	One item since there is only one acquisition context that contributed to the reconstruction of the X-Ray 3D Angiographic image pixel data contents.
>Source Image Sequence	(0008,2112)	
>>Referenced Frame Number	(0008,1160)	Only include the frame numbers used for the reconstruction.

>Per Projection Acquisition Sequence	(0018,9538)	The content of the X-Ray 3D General Positioner Movement Macro only provides an overview of the Positioner data. When not all frames of the originating projection image are used, it is recommended to provide the patient-based Positioner Primary and Secondary Angles in the Per Projection Acquisition Sequence (0018,9538). The contents of the Per Projection Acquisition Sequence (0018,9538) need to be carefully aligned with the list of frame numbers in the Referenced Frame Numbers (0008,1160) attribute in the Source Image Sequence (0008,2112).

X.2.2.3.1.2 Frame Content Macro Recommendations

This module encodes the timing information of the frames, as well as dimension and stack index values.

Table X.2.2-2
FRAME CONTENT MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame Content Sequence	(0020,9111)	Provides details for each frame.
>Frame Acquisition Duration	(0018,9220)	Use the elapsed time from the first to the last projection frame time used for this reconstruction.

X.2.2.4 Example

This specific example is the reconstruction of a volume by a back-projection from every 5th frame of a rotational acquisition and encoded as an Enhanced XA Image.

Note: the example would be very similar if the rotational acquisition was encoded as an XA Image.

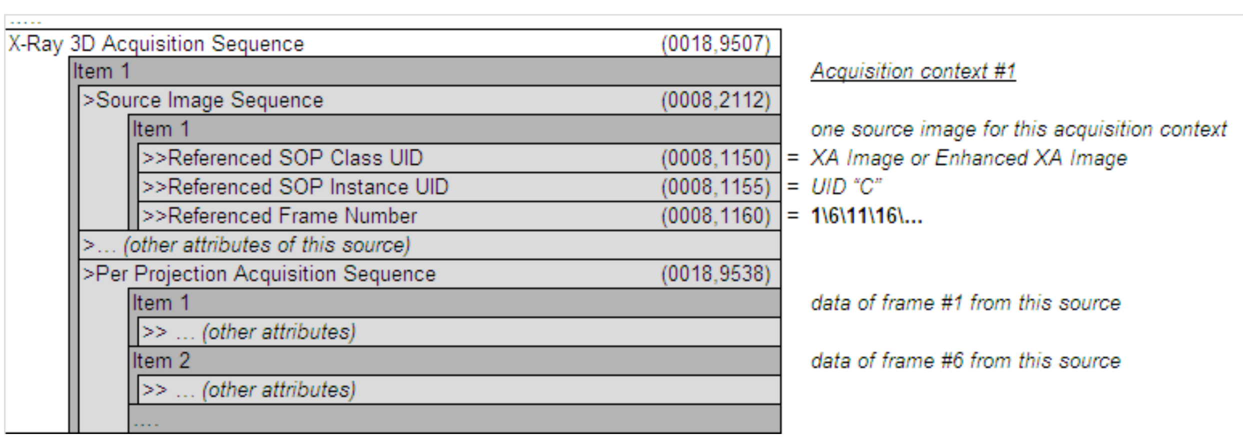


Figure X.2.2-2
Attributes of 3D Reconstruction using every 5th frame

X.2.3 Case #3: Reconstruction from a sub-region of all image frames

This application case is related to a regular reconstruction of the full field of view of a rotational acquisition followed by a specific reconstruction of a sub-region that contains an object of interest (e.g. interventional device implanted, stent, coils etc…).

X.2.3.1 User Scenario

The image acquisition system performs one rotational acquisition after the intervention, on the region of the patient where an implant has been placed.

Two 3D volumes are reconstructed; one of the full field of view of the projection images, another of a sub-region of each of the acquired frames, e.g. to extract the object of interest into a smaller volume dataset. The second volume is likely performed at higher resolution and likely applies different 3D reconstruction techniques, for instance to highlight the material of the implant. The purpose is to overlap the two volumes and enhance the visibility of the object of interest over the full field volume.

X.2.3.2 Encoding outline

The rotational acquisition can either be encoded as XA Image or as Enhanced XA Image.

Each reconstruction is encoded in a different X-Ray 3D Angiographic instance.

Not all parts of each frame of the original XA instance or Enhanced XA instance are used to reconstruct the second volume.

The X-Ray 3D instance references the original XA instance or Enhanced XA instance and uses attributes to define the context on how and which part of the original image frames are used to create the Volume.

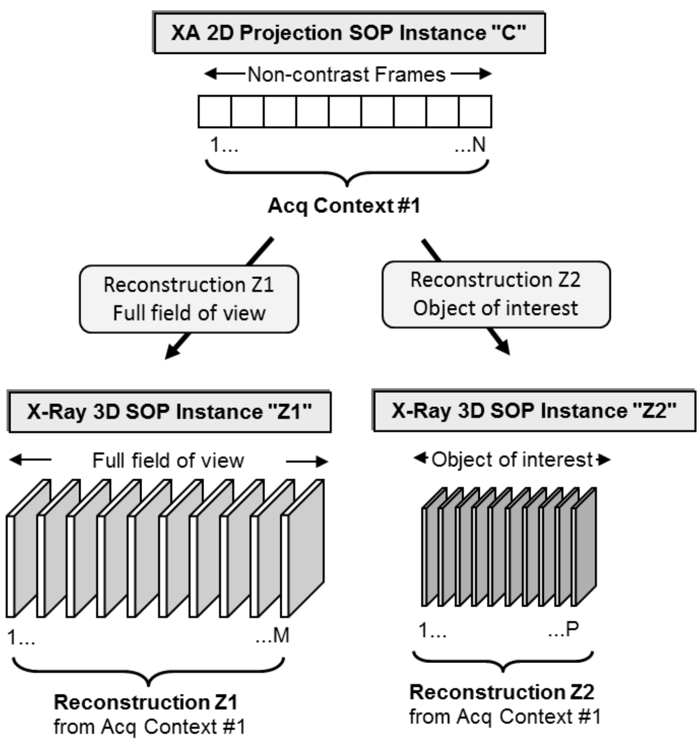


Figure X.2.3-1
Encoding of two 3D reconstructions of different regions of the anatomy

X.2.3.3 Encoding details

X.2.3.3.1 X-Ray 3D Angiographic Image IOD

X.2.3.3.1.1 Frame of Reference Module Recommendations

Since the two volumes are reconstructed from the same projections, the reconstruction application will use the same patient coordinate system on both volumes so that the spatial location of the object of interest in both volumes will be the same. Therefore the two X-Ray 3D Instances will have the same Frame Of Reference (FOR) UID. If the originating 2D Instances do not deliver a value of FOR UID, a new FOR UID has to be created for the reconstructed volumes.

Table X.2.3-1
FRAME OF REFERENCE MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame of Reference UID	(0020,0052)	Use the same value for the full field of view volume and the sub-region volume.

X.2.3.3.1.2 Pixel Measures Macro Recommendations

The detailed size of the volume element (Pixel Spacing for x/y dimension and Slice Thickness for z dimension) may be different between the full field of view reconstruction and the sub-region reconstruction.

Table X.2.3-2
PIXEL MEASURES MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Pixel Measures Sequence	(0028,9110)	The pixel sizes and/or slice thickness are not necessarily equal in the two reconstructed volumes. Within each individual volume this sequence is encoded as “shared”.

X.2.3.3.1.3 Plane Position (Patient) Macro Recommendations

The plane position of the first slice in the first volume may have a different value than in the second volume, as the sub-region volume can be smaller and shifted with respect to the full field of view volume.

X.2.1.3.1.4 Plane Orientation (Patient) Macro Recommendations

The plane orientation could be different in the second volume depending on the application needs, e.g. to align the slices with the object of interest.

X.2.3.3.1.5 Frame Content Macro Recommendations

This module encodes the timing information of the frames, as well as dimension and stack index values.

Table X.2.3-3
FRAME CONTENT MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame Content Sequence	(0020,9111)	Provides details for each frame.
>Frame Acquisition Duration	(0018,9220)	Use the duration of the rotational acquisition in the two reconstructed volumes.

X.2.3.3.1.6 Frame Anatomy Macro Recommendations

The volume directly reconstructed from a sub-region of each of the original projection X-Ray frames does not necessarily reflect the same anatomy or laterality as the full field of view volume. Therefore the Frame Anatomy macro may point to a different anatomic context than the one documented for the originating frames.

X.2.3.4 Example

In this example, the slices of the two volumes are reconstructed in the axial plane of the patient; the row direction is aligned in the positive x-direction of the patient (right-left) and the column direction is aligned in the positive y-direction of the patient (anterior-posterior).

The full field of view reconstruction in encoded with the Instance UID “Z1” and consists of a 512 cube volume of 0.2 mm of voxel size. The sub-region reconstruction in encoded with the Instance UID “Z2” and consists of a 256 cube volume of the voxel size of 0.1 mm.

Both volumes share the same Frame of Reference UID.

SOP Instance UID	(0008,0018)	= *UID “Z1”*	
Rows	(0028,0010)	= **512**	
Columns	(0028,0011)	= **512**	
……			
Frame of Reference UID	(0020,0052)	= *UID “D”*	
……			
Shared Functional Group Sequence	(5200,9229)		
Item 1			*Common to all frames of the X-Ray 3D*
…			
>Pixel Measures Sequence	(0028,9110)		
Item 1			
>>Slice Thickness	(0018,0050)	= **0.2**	
>>Pixel Spacing	(0028,0030)	= **0.2**	
>Plane Orientation Sequence	(0028,9116)		
Item 1			
>>Image Orientation (Patient)	(0020,0037)	= **1\0\0\0\1\0**	
>Frame Anatomy Sequence	(0020,9071)		
Item 1			
>>Frame Laterality	(0020,9072)		*provide value*
>>Anatomic Region Sequence	(0008,2218)		*provide anatomic region*
…			
……			
Per-Frame Functional Groups Sequence	(5200,9230)		*"M" frames*
…			
Item i			*Frame I of the X-Ray 3D*
>Plane Position Sequence	(0020,9113)		
Item 1			
>>Image Position (Patient)	(0020,0032)		
…			

Figure X.2.3-2
Attributes of 3D Reconstruction of the full field of view of the projection frames

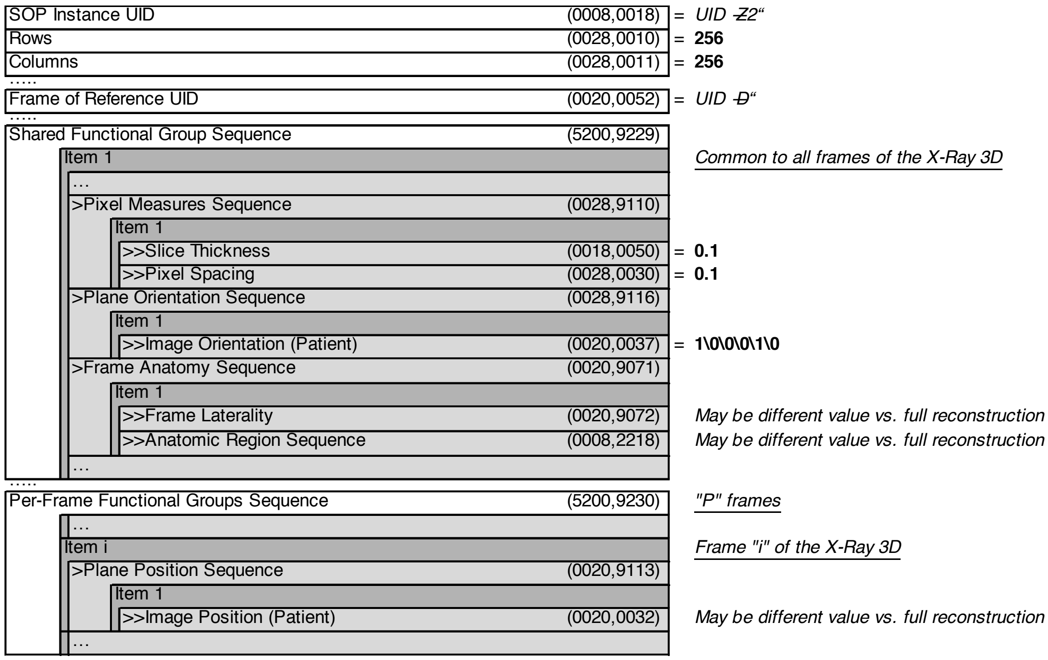


Figure X.2.3-3
Attributes of 3D Reconstruction using a sub-region of all frames

X.2.4 Case #4: Multiple rotations, one or more 2D instances, one reconstruction, one X-Ray 3D instance

This application case is related to a high resolution reconstruction from several rotations around the same anatomy.

X.2.4.1 User Scenario

The image acquisition system performs multiple 2D rotational acquisitions around the patient with movements in the same or opposite directions in the patient’s transversal plane. A single volume is reconstructed from the acquired data (e.g. through “back-projection” algorithm). The reconstruction can either occur on the same system (e.g. Acquisition Modality) or a secondary processing system (e.g. Co-Workstation).

The reconstructed Volume needs to be encoded and saved for further use.

X.2.4.2 Encoding outline

The rotational acquisitions can be encoded either as a single instance (e.g. “C”) containing several rotations or as several instances (e.g. “C1”, “C2”…) containing one rotation per instance. The rotational acquisitions can either be encoded as XA Image(s) with limited frame-specific attributes or as Enhanced XA Image(s), with frame-specific attributes encoded that inform the algorithms to reconstruct a volume dataset.

The reconstructed volume dataset is encoded as a single X-Ray 3D Angiographic instance. The reconstructed region covers typically the full field of view of the projected matrix size.

All frames of the original XA Images or Enhanced XA Images are used to reconstruct the volume.

The X-Ray 3D instance references the original acquisition instances and records attributes of the projections describing the acquisition context.

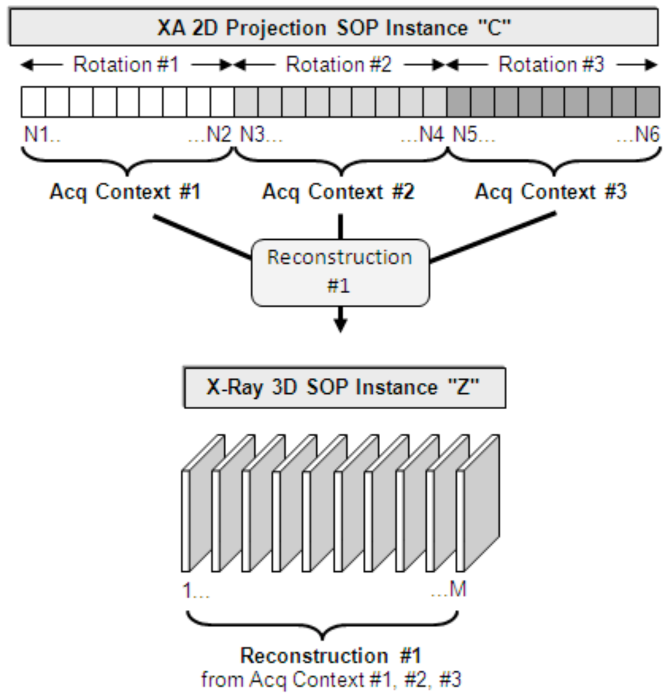


Figure X.2.4-1
Encoding of one 3D reconstruction from three rotational acquisitions in one instance

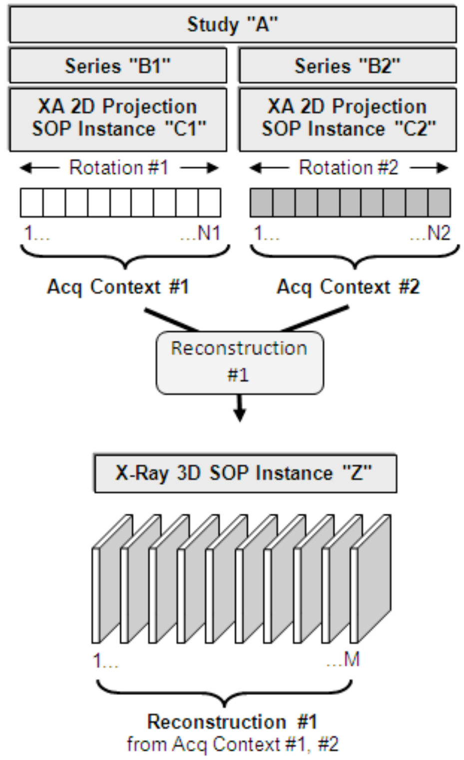


Figure X.2.4-2
Encoding of one 3D reconstruction from two rotational acquisitions in two instances

X.2.4.3 Encoding details

X.2.4.3.1 2D X-Ray Angiographic Image IOD

This scenario is based on the encoding of the different rotations in one or more 2D instance(s), which can be encoded either as X-Ray Angiography or Enhanced XA Images.

X.2.4.3.1.1 Frame of Reference Module Recommendations

In the case of multiple source 2D Instances, the acquisition equipment assumes that the patient has not moved between the different rotations. This module encodes the same FOR UID in all the rotations, identifying a common spatial relationship between them, thus allowing the 3D reconstruction to use the projections of all the rotations to perform a single volume reconstruction.

If the source 2D Instances do not provide a value of FOR UID, it has to be created for the reconstructed volume.

Table X.2.4-1
FRAME OF REFERENCE MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame of Reference UID	(0020,0052)	All XA Images or Enhanced XA Images created from the rotational acquisitions share the same spatial relationship.
Position Reference Indicator	(0020,1040)	No recommendation to set a value, unless a system is capable to derive such information from the anatomy or has a mandatory user interface to enter such information.

Note: The case where all the source 2D Instances have the same FOR UID is the “lucky” case. If no FOR UID value is provided in the 2D Instances, or if the FOR UIDs are different, there should be an additional 2D registration step before performing the 3D reconstruction.

X.2.4.3.2 X-Ray 3D Angiographic Image IOD

X.2.4.3.2.1 X-Ray 3D Angiographic Image Contributing Sources Module Recommendations

This module encodes the source SOP instance(s) used to create the X-Ray 3D Angiographic instance.

Table X.2.4-2
X-RAY 3D ANGIOGRAPHIC IMAGE CONTRIBUTING SOURCES MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Contributing Sources Sequence	(0018,9506)	One item for each of the originating instances that was used for the reconstruction of the X-Ray3D Angiographic image.

X.2.4.3.2.2 X-Ray 3D Angiographic Acquisition Module Recommendations

There are multiple acquisition contexts, one per rotation of the equipment. This module encodes the frame numbers of the source SOP instance that belong to each acquisition context, as well as the important technical and physical parameters of the source SOP instances used to create the X-Ray 3D Angiographic instance.

Table X.2.4-3
X-RAY 3D ANGIOGRAPHIC IMAGE ACQUISITION MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
X-Ray 3D Acquisition Sequence	(0018,9507)	One item for each acquisition context (i.e. each rotation) that contributed to the reconstruction of the X-Ray 3D Angiographic image pixel data contents.
…		
>Source Image Sequence	(0008,2112)	One item for each acquisition context.
>>Referenced SOP Class UID	(0008,1150)	
>>Referenced SOP Instance UID	(0008,1155)	The source SOP instance where this rotation belongs.
>>Referenced Frame Number	(0008,1160)	The frame numbers of the projections corresponding to this rotation.
…		
>Per Projection Acquisition Sequence	(0018,9538)	The content of this sequence needs to be carefully aligned with the list of frame numbers in the Referenced Frame Numbers (0008,1160) attribute in the Source Image Sequence (0008,2112).

X.2.4.3.2.3 Frame Content Macro Recommendations

This module encodes the timing information of the frames, as well as dimension and stack index values.

Table X.2.4-4
FRAME CONTENT MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame Content Sequence	(0020,9111)	Provides details for each frame.

>Frame Acquisition Duration	(0018,9220)	Use the elapsed time from the first projection frame time of the first rotation to the last projection frame time of the last rotation used for this reconstruction.

X.2.4.4 Example

This example is the reconstruction of a volume by a back-projection from all frames of a rotational acquisition with two rotations encoded as two XA Images.

Attribute	Tag		Value / Comment
SOP Instance UID	(0008,0018)	=	*UID "Z"*
…..			
Contributing Sources Sequence	(0018,9506)		*Two contributing sources in this example*
Item 1			
>Contributing SOP Instances Reference Sequence	(0020,9529)		
Item 1			
>>Referenced Series Sequence	(0008,1115)		
Item 1			
>>>Referenced Instance Sequence	(0008,114a)		
Item 1			
>>>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>>>Referenced SOP Instance UID	(0008,1155)	=	*UID "C1"*
>>>Series Instance UID	(0020,000e)	=	*UID "B1"*
>>Study Instance UID	(0020,000d)	=	*UID "A"*
>Acquisition Datetime	(0008,002A)	=	Date and time of the Instance "C1"
>Acquisition Protocol Name	(0018,9423)	=	Protocol 1
>… (other attributes from this contributing image source)			
Item 2			
>Contributing SOP Instances Reference Sequence	(0020,9529)		
Item 1			
>>Referenced Series Sequence	(0008,1115)		
Item 1			
>>>Referenced Instance Sequence	(0008,114a)		
Item 1			
>>>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>>>Referenced SOP Instance UID	(0008,1155)	=	*UID "C2"*
>>>Series Instance UID	(0020,000e)	=	*UID "B2"*
>>Study Instance UID	(0020,000d)	=	*UID "A"*
>Acquisition Datetime	(0008,002A)	=	Date and time of the Instance "C2"
>Acquisition Protocol Name	(0018,9423)	=	Protocol 2
>… (other attributes from this contributing image source)			
…..			
X-Ray 3D Acquisition Sequence	(0018,9507)		
Item 1			*Acquisition context #1*
>Source Image Sequence	(0008,2112)		
Item 1			*one source image for this acquisition context*
>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	=	*UID "C1"*
>… (other attributes of this source: kVp, mA, FOV, filter...)			
Item 2			*Acquisition context #2*
>Source Image Sequence	(0008,2112)		
Item 1			*one source image for this acquisition context*
>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	=	*UID "C2"*
>… (other attributes of this source: kVp, mA, FOV, filter...)			
…..			
X-Ray 3D Reconstruction Sequence	(0018,9530)		
Item 1			*Reconstruction #1*
>Acquisition Index	(0020,9518)	=	**1\2**
> … (other attributes related to this reconstruction)			
…..			
Shared Functional Group Sequence	(5200,9229)		
Item 1			*Common to all frames of the X-Ray 3D*
…			
>X-Ray 3D Frame Type Sequence	(0018,9504)		
Item 1			
>>Reconstruction Index	(0020,9536)	=	**1** (all frames share the same reconstruction data)
>>…			
…			

Figure X.2.4-3
Attributes of 3D Reconstruction using multiple rotation images

X.2.5 Case #5: One rotation, one 2D instance, multiple reconstructions, one X-Ray 3D instance

This application case is related to a rotational acquisition of several cardiac cycles with related ECG signal information.

X.2.5.1 User Scenario

The image acquisition system performs one 2D rotational acquisition of the heart in a cardiac procedure. The gantry is continuously rotating at a constant speed. The ECG is recorded during the rotation, and the cardiac trigger delay time is known for each frame of the rotational acquisition allowing it to be assigned to a given cardiac phase.

Several 3D volumes are reconstructed, one for each cardiac phase.

X.2.5.2 Encoding outline

The rotational acquisition can either be encoded as XA Image or as Enhanced XA Image. The XA instance (let’s call it “C”) is encoded in the Series “B” of the Study “A”.

Each reconstruction is related to one cardiac phase corresponding to a sub-set of frames of the rotational acquisition. Therefore, each cardiac phase represents one acquisition context.

Each reconstruction leads to one volume, all volumes are encoded in one single X-Ray 3D Angiographic instance (“Z”). Each volume is for a different cardiac phase. All volumes share the same stack id.

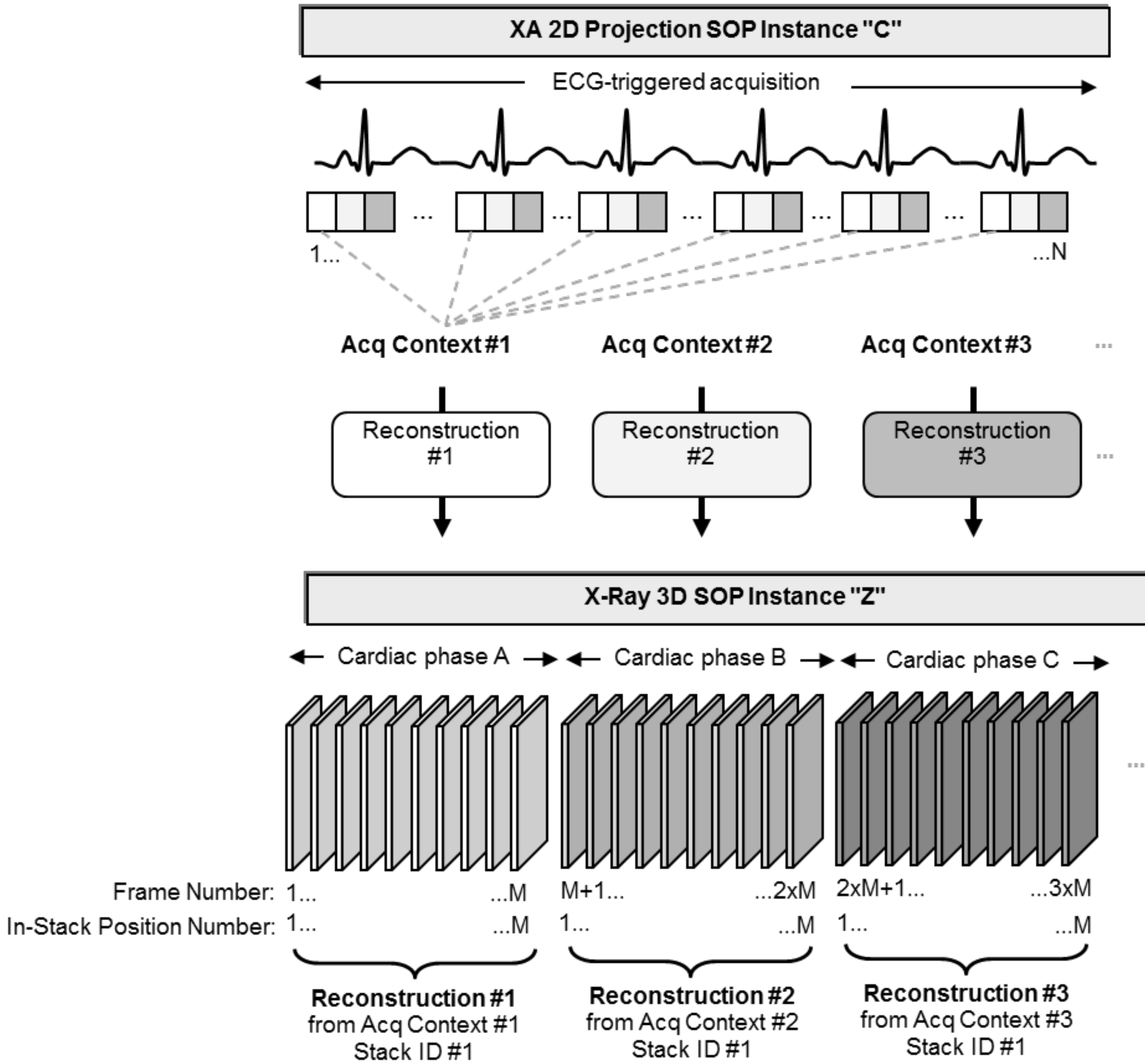


Figure X.2.5-1
Encoding of various 3D reconstructions at different cardiac phases

Note 1: This figure shows only the first three cardiac phases. An implementation may chose how many phases it will reconstruct.

Note 2: Projection frames are assigned to a phase based on their cardiac trigger delay time. The rotation speed and acquisition pulse rate will not necessarily align uniformly with the cardiac cycle (especially if the heartbeat is irregular). Thus different phases may end up with different number of projections assigned to them. The reconstructed volumes will have the same space.

X.2.5.3 Encoding details

X.2.5.3.1 2D X-Ray Angiographic Image IOD

This scenario is based on the encoding of a single rotational acquisition in one 2D instance, together with the information of the ECG and/or the cardiac trigger delay times of each frame of the rotational image.

X.2.5.3.2 X-Ray 3D Angiographic Image IOD

X.2.5.3.2.1 Image Pixel Module Recommendations

This module encodes the description of the pixels of the slices of the volumes, each slice being one frame of the X-Ray 3D Angiographic instance. The pixel data encodes all the frames of the first cardiac phase followed by all the frames of the second cardiac phase and so on. Whithin one cardiac phase, the order of the frames is aligned with the Image Position (Patient) attribute.

X.2.5.3.2.2 Multi-frame Dimension Module Recommendations

This module encodes the dimensions for the presentation order of the image frames.

Table X.2.5-1
MULTI-FRAME DIMENSIONS MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Dimension Organization Sequence	(0020,9221)	There will be a single Dimension UID.
Dimension Organization Type	(0020,9311)	The value will be “3D”.
Dimension Index Sequence	(0020,9222)	Two items are defined: the first one related to the cardiac phase, the second one related to the spatial position of the slices. All frames of the same reconstructed volume have the same cardiac phase.
>Dimension Index Pointer	(0020,9165)	In the first item, the attribute Nominal Percentage of Cardiac Phase (0020,9241) is used. In the second item, the attribute Image Position (Patient) (0020,0032) is used.
>Functional Group Pointer	(0020,9167)	Contains the tags (0018,9118) Cardiac Synchronization Sequence and (0020,9113) Plane Position Sequence respectively in the first and second item.
>Dimension Organization UID	(0020,9164)	Same value for both items.

X.2.5.3.2.3 X-Ray 3D Angiographic Acquisition Module Recommendations

There are multiple acquisition contexts, one per cardiac phase. This module encodes the frame numbers of the source SOP instance that belong to each acquisition context and have the same cardiac phase.

Table X.2.5-2
X-RAY 3D ANGIOGRAPHIC IMAGE ACQUISITION MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
X-Ray 3D Acquisition Sequence	(0018,9507)	One item for each acquisition context (i.e. each cardiac phase).
>Source Image Sequence	(0008,2112)	
>>Referenced Frame Number	(0008,1160)	The frame numbers of the source SOP instance that belong to this acquisition context (i.e. that have the same cardiac phase). Note: The number of projection frames may be different for each acquisition context. See Note 2 of Section X.2.5.2.

X.2.5.3.2.4 X-Ray 3D Reconstruction Module Recommendations

This module encodes the identification of the reconstructions performed to create the X-Ray 3D Angiographic Instance.

Table X.2.5-3
X-RAY 3D RECONSTRUCTION MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
X-Ray 3D Reconstruction Sequence	(0018,9530)	One item for each single reconstruction, i.e. for each cardiac phase.
>Acquisition Index	(0020,9518)	Number of the acquisition context for this reconstruction. As there is one reconstruction for each cardiac phase, the acquisition index is equal to the reconstruction index.
>Reconstruction Description	(0018,9531)	Free text description of the purpose of the reconstruction. It's recommended to identify the cardiac phase.

X.2.5.3.2.5 Frame Content Macro Recommendations

This module encodes the timing information of the frames, as well as dimension and stack index values. All frames forming a volume of one cardiac phase have the same time reference, and a single dimension index value for the first dimension. All volumes for all cardiac phases share the same stack id because they span the same space.

Table X.2.5-4
FRAME CONTENT MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame Content Sequence	(0020,9111)	
>Frame Reference DateTime	(0018,9151)	Use the date and time of the first 2D frame used for the reconstruction of this 3D frame. In practice it will be the time of the first projection of this cardiac phase.
>Frame Acquisition DateTime	(0018,9074)	Use the same value as the Frame Reference DateTime (0018,9151).
>Frame Acquisition Duration	(0018,9220)	Use the elapsed time from the first to the last projection frame time used for the reconstruction of this 3D frame.
>Cardiac Cycle Position	(0018,9236)	Use the most representative position in the cardiac cycle.
>Dimension Index Values	(0020,9157)	The first value of this attribute contains the same index for all the frames of the same volume (i.e. same cardiac phase). The second value indexes the spatial position of each frame in the volume.
>Stack ID	(0020,9056)	Same ID for all the frames of all cardiac phases.
>In-Stack Position Number	(0020,9057)	From 1 to M for each cardiac phase, where M is the number of frames in each reconstructed phase. The spatially corresponding frames in different cardiac phases share the same In-Stack Position Number.

X.2.5.3.2.6 Cardiac Synchronization Macro Recommendations

This module encodes a value representing the cardiac phase of the 3D frames (i.e. the time of the frame relative to the R-peak).

Table X.2.5-5
CARDIAC SYNCHRONIZATION MACRO RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Cardiac Synchronization Sequence	(0018,9118)	
>Nominal Percentage of Cardiac Phase	(0020,9241)	All the frames belonging to the same reconstruction will have the same value. This attribute is used as a dimension index.
>Nominal Cardiac Trigger Delay Time	(0020,9153)	Use the average time in ms from the time of the previous R-peak to the value of the Frame Reference DateTime (0018,9151).

X.2.5.3.2.7 X-Ray 3D Frame Type Macro Recommendations

This macro encodes the context of the volume slices. In this scenario of multi-volume encoding, it is encoded “per frame”, since the slices belong to different volumes depending on the cardiac phase.

X.2.5.4 Example

In this example the gantry performs one single rotation around the heart at 20 degrees per second, covering an arc of 200 degrees during 10 seconds. Approximately 10 cardiac cycles are acquired. The frame rate is 8 frames per second, resulting in 8 projections acquired at each cardiac cycle corresponding to 8 different cardiac phases.

Overall there will be 80 projections; 10 projections for each of the 8 cardiac phases. Each cardiac phase represents one acquisition context. The information of the cardiac trigger delay time is encoded for each projection. The projections are encoded as an XA Image with the Instance UID “C”.

The reconstruction application creates 8 volumes, each volume is reconstructed by a back-projection from the 10 frames having the same cardiac trigger delay time, i.e. the frames acquired at the same cardiac phase. Each volume contains 256 frames. The 8 reconstructed volumes are encoded in one single X-Ray 3D Angiographic instance of Instance UID “Z”.

Attribute	Tag		Value
SOP Instance UID	(0008,0018)	=	*UID “Z“*
…..			
X-Ray 3D Acquisition Sequence	(0018,9507)		
Item 1			*Acquisition context #1*
>Source Image Sequence	(0008,2112)		
Item 1			
>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	=	*UID “C“*
>>Referenced Frame Number	(0008,1160)	=	**1\9\17\25…**
>… (other attributes of this source)			
Item 2			*Acquisition context #2*
>Source Image Sequence	(0008,2112)		
Item 1			
>>Referenced SOP Class UID	(0008,1150)	=	*XA Image or Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	=	*UID “C“*
>>Referenced Frame Number	(0008,1160)	=	**2\10\18\26…**
>… (other attributes of this source)			
……			
…..			
X-Ray 3D Reconstruction Sequence	(0018,9530)		
Item 1			*Reconstruction #1*
>Acquisition Index	(0020,9518)	=	**1**
>Reconstruction Description	(0020,9518)	=	**Cardiac phase A**
> … (other attributes related to this reconstruction)			
Item 2			*Reconstruction #2*
>Acquisition Index	(0020,9518)	=	**2**
>Reconstruction Description	(0020,9518)	=	**Cardiac phase B**
> … (other attributes related to this reconstruction)			
……			
…..			
Dimension Organization Sequence	(0020,9221)		
Item 1			*One dimension*
>Dimension Organization UID	(0020,9164)	=	*UID “E“*
Dimension Index Sequence	(0020,9222)		
Item 1			
>Dimension Organization UID	(0020,9164)	=	*UID “E“*
>Dimension Index Pointer	(0020,9165)	=	**(0020,9241)**
>Functional Group Pointer	(0020,9167)	=	**(0018,9118)**
Item 1			
>Dimension Organization UID	(0020,9164)	=	*UID “E“*
>Dimension Index Pointer	(0020,9165)	=	**(0020,0032)**
>Functional Group Pointer	(0020,9167)	=	**(0020,9113)**
Dimension Organization Type	(0020,9311)	=	**3D**
…..			

Figure X.2.5-2
Common Attributes of 3D Reconstruction of Three Cardiac Phases

Attribute	Tag	Value
…..		
Per-Frame Functional Groups Sequence	(5200,9230)	
Item 1		*Frame "1" of the X-Ray 3D*
>X-Ray 3D Frame Type Sequence	(0018,9504)	
Item 1		
>>Reconstruction Index	(0020,9536)	= **1**
>Frame Content Sequence	(0020,9111)	
Item 1		
>>Frame Reference DateTime	(0018,9151)	= *1st frame of source of cardiac phase A*
>>Frame Acquisition DateTime	(0018,9074)	= *1st frame of source of cardiac phase A*
>>Cardiac Cycle Position	(0018,9236)	= **END_SYSTOLE**
>>Dimension Index Values	(0020,9157)	= **1\1**
>>Stack ID	(0020,9056)	= **1**
>>In-Stack Position Number	(0020,9057)	= **1**
>Cardiac Synchronization Sequence	(0018,9118)	
Item 1		
>>Nominal Percentage of Cardiac Phase	(0020,9241)	= **0.0**
>>Nominal Cardiac Trigger Delay Time	(0020,9153)	= **0.0**
…		
Item 2		*Frame "2" of the X-Ray 3D*
>X-Ray 3D Frame Type Sequence	(0018,9504)	
Item 1		
>>Reconstruction Index	(0020,9536)	= **1**
>Frame Content Sequence	(0020,9111)	
Item 1		
>>Frame Reference DateTime	(0018,9151)	= *1st frame of source of cardiac phase A*
>>Frame Acquisition DateTime	(0018,9074)	= *1st frame of source of cardiac phase A*
>>Cardiac Cycle Position	(0018,9236)	= **END_SYSTOLE**
>>Dimension Index Values	(0020,9157)	= **1\2**
>>Stack ID	(0020,9056)	= **1**
>>In-Stack Position Number	(0020,9057)	= **2**
>Cardiac Synchronization Sequence	(0018,9118)	
Item 1		
>>Nominal Percentage of Cardiac Phase	(0020,9241)	= **0.0**
>>Nominal Cardiac Trigger Delay Time	(0020,9153)	= **0.0**
…		
Item 257		*Frame "257" of the X-Ray 3D*
>X-Ray 3D Frame Type Sequence	(0018,9504)	
Item 1		
>>Reconstruction Index	(0020,9536)	= **2**
>Frame Content Sequence	(0020,9111)	
Item 1		
>>Frame Reference DateTime	(0018,9151)	= *1st frame of source of cardiac phase B*
>>Frame Acquisition DateTime	(0018,9074)	= *1st frame of source of cardiac phase B*
>>Cardiac Cycle Position	(0018,9236)	= **UNDETERMINED**
>>Dimension Index Values	(0020,9157)	= **2\1**
>>Stack ID	(0020,9056)	= **1**
>>In-Stack Position Number	(0020,9057)	= **1**
>Cardiac Synchronization Sequence	(0018,9118)	
Item 1		
>>Nominal Percentage of Cardiac Phase	(0020,9241)	= **12.5**
>>Nominal Cardiac Trigger Delay Time	(0020,9153)	= **0.125**
…		

Figure X.2.5-3
Per-Frame Attributes of 3D Reconstruction of Three Cardiac Phases

X.2.6 Case #6: Two rotations, two 2D instances, two reconstructions, two X-Ray 3D instances

This application case is related to two rotational acquisitions on the same anatomical region before and after the intervention, with table movement between the two acquisitions. The two reconstructed volumes are created and automatically registered on the same patient coordinate system.

X.2.6.1 User Scenario

The image acquisition system performs two different 2D rotational acquisitions at two different times of the interventional procedure: the first acquisition before the intervention (e.g. before placement of a stent) and the second one after the intervention.

Between the two acquisitions the table position has changed with respect to the Isocenter. The rotational acquisitions are performed with the same spatial trajectory of the X-Ray Detector relative to the Isocenter; therefore the second acquisition contains a slightly different region of the patient.

Two 3D volumes are reconstructed, one for each rotational acquisition. After the intervention, the two 3D volumes are displayed together on the same patient coordinate system. The user can visually assess the placement of the stent over the anatomy pre-intervention. The patient position on the table does not change during the procedure.

X.2.6.2 Encoding outline

The rotational acquisitions can either be encoded as XA Image or as Enhanced XA Image. The two XA instances (let's call them "C1" and "C2") are encoded in two different Series ("B1" and "B2") of the same Study ("A").

The volume datasets are encoded as two X-Ray 3D Angiographic instances ("Z1" and "Z2"). The volumes are typically a full set (in number of rows, columns and slices) of the projected matrix size (in number of rows and columns).

Each reconstructed volume contains one acquisition context consisting of all the frames of the corresponding source 2D XA Image. To display the two volumes together, they share the same Frame of Reference UID.

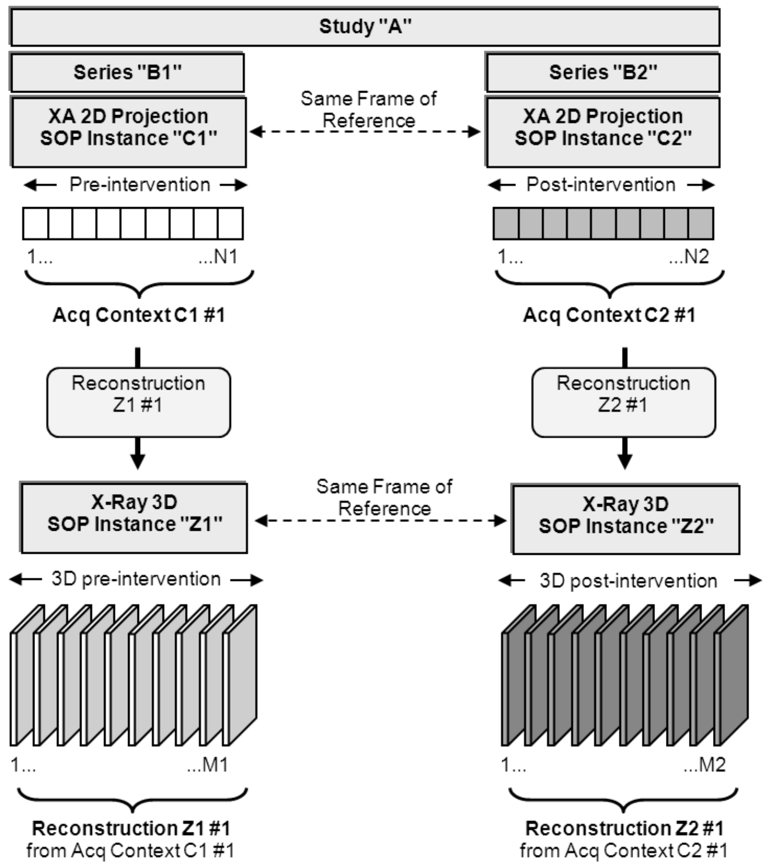


Figure X.2.6-1
Encoding of two 3D reconstructions at different steps of the intervention

X.2.6.3 Encoding details

X.2.6.3.1 X-Ray 3D Angiographic Image IOD

X.2.6.3.1.1 Frame of Reference Module Recommendations

Since the purpose of this scenario is to overlap the two volumes without additional spatial registration, the spatial location of the anatomy of interest in both volumes needs to be the same. To keep the two volumes spatially registered, the reconstruction application will use the table position of both rotations to correct the table movement with respect to the Isocenter, thus creating both volumes with the same spatial origin and axis, i.e. same patient coordinate system.

Therefore, it is recommended to encode both instances with the same FOR UID, equal to the Frame of Reference UID of the XA projection images. If the originating XA images do not contain a Frame of Reference UID, the reconstruction application will create the FOR UID equal for the two reconstructed volumes.

Table X.2.6-1
FRAME OF REFERENCE MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Frame of Reference UID	(0020,0052)	Use the same FOR UID value for both volumes.
Position Reference Indicator	(0020,1040)	Use a value either provided by the operator of the acquisition modality or the reconstruction console, if supplied.

X.2.6.3.1.2 Patient Orientation Module Recommendations

This module encodes the patient orientation with respect to the table. It is supposed to contain the same values in both 3D volumes, since the patient does not move between the two rotational acquisitions.

X.2.6.3.1.3 Pixel Measures Macro Recommendations

The detailed size of the volume element (Pixel Spacing for row/column dimension of each slice and Slice Thickness for the distance of slices) depends on the reconstruction algorithm and is not necessarily identical to the related sizes in the source (projection) image(s).

Table X.2.6-2
PIXEL MEASURES MACRO RECOMMENDATIONS

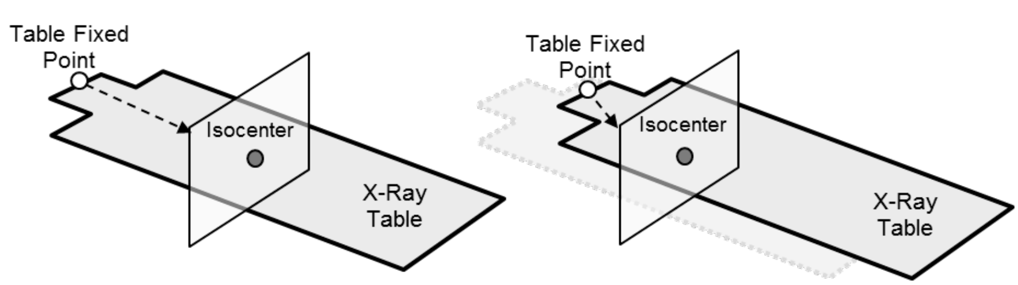
Attribute Name	Tag	Recommendation
Pixel Measures Sequence	(0028,9110)	Provide it as a shared macro, i.e. each slice of a volume has the same Pixel Spacing and Slice Thickness.
>Pixel Spacing	(0028,0030)	May be different between the two volumes.
>Slice Thickness	(0018,0050)	May be different between the two volumes.

X.2.6.3.1.4 Plane Position (Patient) Macro Recommendations

This macro encodes the position of the 3D slices relative to the patient.

It is assumed that the patient does not move on the table between the two rotational acquisitions, but the table moves with respect to the Isocenter. Although the spatial trajectory of the X-Ray Detector relative to the Isocenter of the two rotational acquisitions is the same, the two volumes contain a different region of the patient.

To allow spatial registration between the two volumes, the position of the slices of the two volumes need to be defined with respect to the same point of the patient. As the patient does not move on the table, the reconstruction application will define the patient origin as a fixed point on the table, so that the 3D slices of the two volumes are all related to the same fixed point on the table (i.e. same point of the patient) by the attribute Image Position (Patient) (0020,0032).



3D pre-intervention 3D post-intervention

Figure X.2.6-2
One frame of two 3D reconstructions at two different table positions

The volume is positioned in the spatial coordinates identified by the frame of reference, which is common to the two volumes. Therefore, the position of the slices of both volumes is defined with respect to the same patient origin.

X.2.6.3.1.5 Plane Orientation (Patient) Macro Recommendations

The slices can be oriented in any relation w.r.t. the patient coordinate system. The plane orientation is expected to be the same for the two volumes; however it could be different without compromising the registration.

X.2.6.4 Example

In this example, two rotational images are acquired; the first one before the intervention and the second one after the intervention. They are encoded with the Instance UIDs “C1” and “C2” respectively.

In both rotational acquisitions, the patient position with respect to the table is head-first prone, and the table is not rotated nor tilted with respect to the Isocenter. The patient coordinates and the Isocenter coordinates are then aligned on x, y and z.

The patient origin is defined by the application as a fixed point on the table.

During the first rotational acquisition, the table position with respect to the Isocenter in the lateral direction [x] is +20mm, in the vertical direction [y] is +40mm, and in the longitudinal direction [z] is +60mm.

During the second rotational acquisition, the table position with respect to the Isocenter in the lateral direction [x] is -10mm, in the vertical direction [y] is +80mm, and in the longitudinal direction [z] is +110mm.

The second acquisition is performed with a relative table movement of (-30,40,50) mm vs. the first acquisition in the patient coordinates system. Therefore, for a given 3D slice “i” of the two volumes, the Image Position (Patient) (0020,0032) of the second volume is translated of (+30,-40,-50) mm vs. the Image Position (Patient) (0020,0032) of the first volume.

The two reconstructions are performed with the same number of rows, columns and slices, and both at the same resolution of 0.2 mm/voxel. Note that if the resolution was different, the Image Position (Patient) (0020,0032) of the second volume would be additionally translated by the shift of the TLHC pixels relative to the center of the volume, because both volumes are centered at the Isocenter.

The reconstructions are encoded in two X-Ray 3D Angiographic instances of Instance UIDs “Z1” and “Z2” respectively.

Attribute	Tag	Value
SOP Instance UID	(0008,0018)	= *UID „Z1“*
…..		
Frame of Reference UID	(0020,0052)	= *UID „D“*
…..		
Shared Functional Group Sequence	(5200,9229)	
Item 1		*Common to all frames of the X-Ray 3D*
…		
>Pixel Measures Sequence	(0028,9110)	
Item 1		
>>Slice Thickness	(0018,0050)	= **0.20**
>>Pixel Spacing	(0028,0030)	= **0.20**
>Plane Orientation Sequence	(0028,9116)	
Item 1		
>>Image Orientation (Patient)	(0020,0037)	= *same in both volumes*
…		
…..		
Per-Frame Functional Groups Sequence	(5200,9230)	
…		
Item i		*Frame "i" of the X-Ray 3D*
>Plane Position Sequence	(0020,9113)	
Item 1		
>>Image Position (Patient)	(0020,0032)	= **px\py\pz**
…		

Figure X.2.6-3
Attributes of the pre-intervention 3D reconstruction

Attribute	Tag	Value
SOP Instance UID	(0008,0018)	= *UID „Z2“*
…..		
Frame of Reference UID	(0020,0052)	= *UID „D“*
…..		
Shared Functional Group Sequence	(5200,9229)	
Item 1		*Common to all frames of the X-Ray 3D*
…		
>Pixel Measures Sequence	(0028,9110)	
Item 1		
>>Slice Thickness	(0018,0050)	= **0.20**
>>Pixel Spacing	(0028,0030)	= **0.20**
>Plane Orientation Sequence	(0028,9116)	
Item 1		
>>Image Orientation (Patient)	(0020,0037)	= *same in both volumes*
…		
…..		
Per-Frame Functional Groups Sequence	(5200,9230)	
…		
Item i		*Frame "i" of the X-Ray 3D*
>Plane Position Sequence	(0020,9113)	
Item 1		
>>Image Position (Patient)	(0020,0032)	= **px+30\py-40\pz-50**
…		

Figure X.2.6-4
Attributes of the post-intervention 3D reconstruction

X.2.7 Case #7: Spatial registration of 3D X-Ray Angiography with Enhanced XA

This application case is related to the spatial registration of the X-Ray 3D volume with a static projection acquisition on the same anatomical region during the procedure.

X.2.7.1 User Scenario

The image acquisition system performs two different 2D acquisitions at two different times of the interventional procedure: one rotational acquisition with a 3D reconstruction, and one static acquisition.

Between the two acquisitions, the table position has changed with respect to the Isocenter. As the acquisitions are performed with the X-Ray Detector centered on the Isocenter, in the second static acquisition the anatomical region of the 3D volume is not centered anymore at the Isocenter due to the table movement. It's assumed that there is still part of the anatomy of the 3D volume that is projected in the static acquisition.

During the intervention the 3D volume is segmented to extract some anatomy that is less or not visible in the static acquisition (e.g. injected vessels, heart chambers). The user will want to display such 3D anatomy over the 2D static image to visually assess the placement of interventional devices like guide wires, needles etc. The patient position on the table does not change during the procedure.

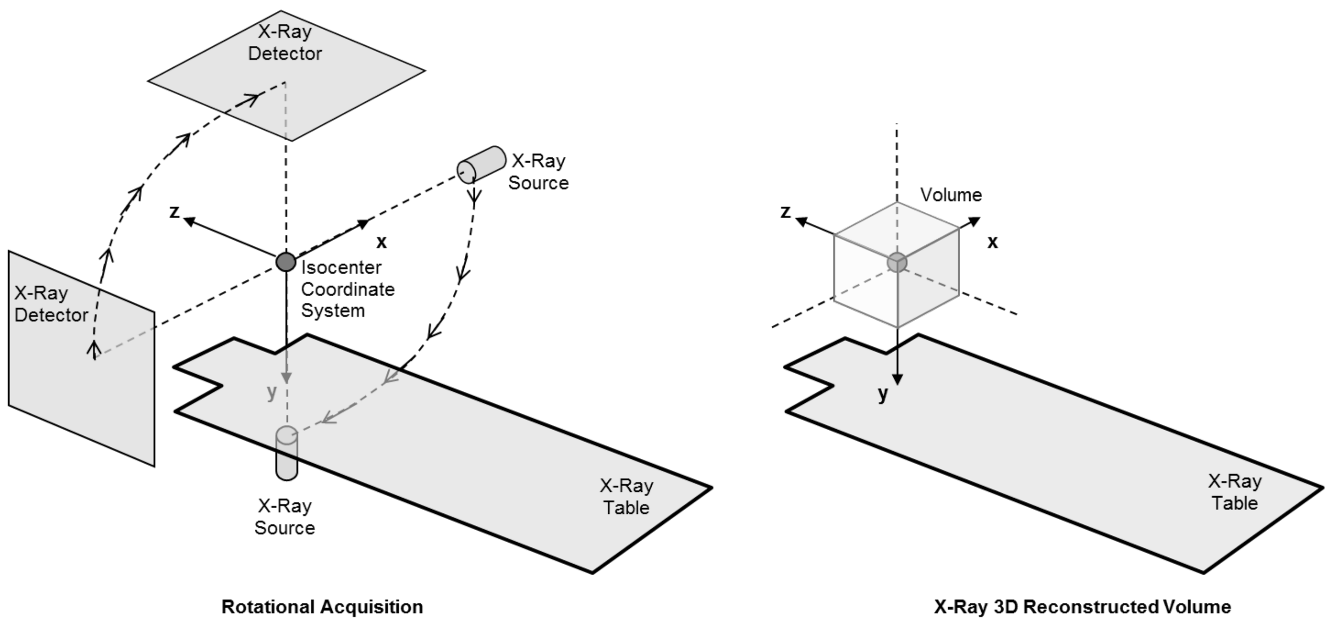


Figure X.2.7-1
Rotational acquisition and the corresponding 3D reconstruction

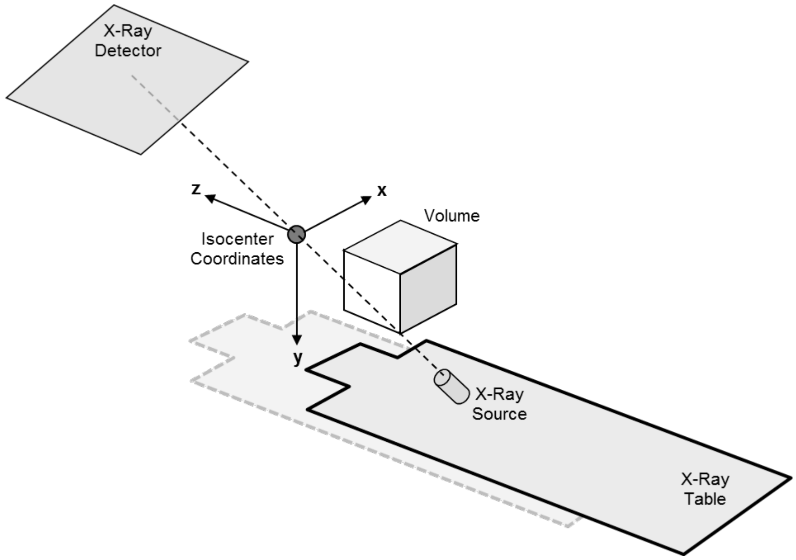


Figure X.2.7-2
Static Enhanced XA acquisition at different table position

X.2.7.2 Encoding outline

The two 2D acquisitions are encoded as two Enhanced XA Images, and both contain the attributes of the X-Ray Isocenter Reference System Macro (see PS3.3 C.8.19.6.13). The two XA instances (let’s call them “C1” and “C2”) are encoded in two different Series (“B1” and “B2”) of the same Study (“A”). They share the same Frame of Reference UID.

The volume dataset is encoded as an X-Ray 3D Angiographic instance (“Z1”).

The reconstructed volume contains one acquisition context consisting of all the frames of the corresponding source 2D XA Image. To display the volume over the projection image, both volume and projection image share the same Frame of Reference UID.

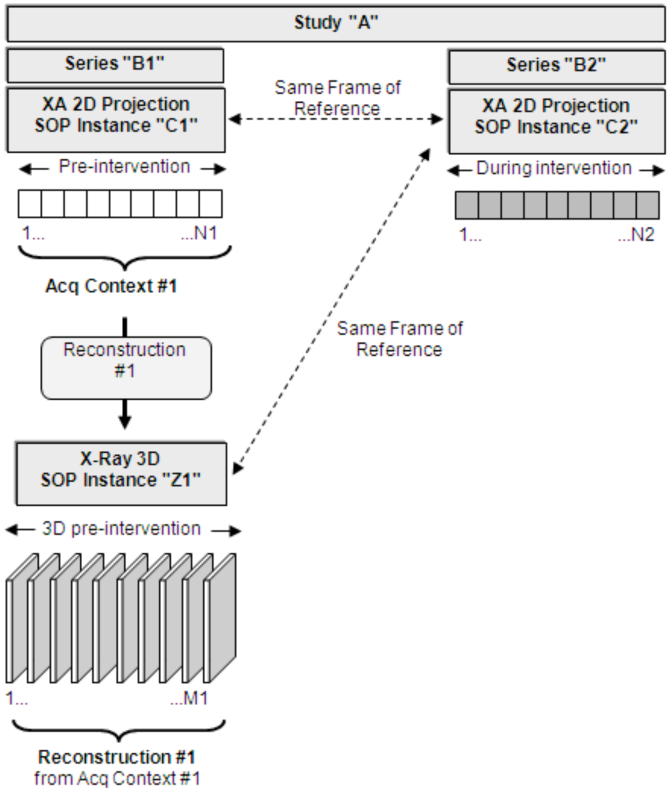


Figure X.2.7-3
Encoding of a 3D reconstruction and a registered 2D projection

X.2.7.3 Encoding details

X.2.7.3.1 Enhanced X-Ray Angiographic Image IOD

This scenario is based on the encoding of the 2D acquisition as an Enhanced XA Image, containing the attributes of the X-Ray Isocenter Reference System Macro (see PS3.3 C.8.19.6.13).

X.2.7.3.2 X-Ray 3D Angiographic Image IOD

X.2.7.3.2.1 Frame of Reference Module Recommendations

This module encodes the identifier for the spatial relationship, which will be the same for the volume and the projection image. The reconstruction application will assign the Frame of Reference UID to the reconstruction equal to the Frame of Reference UID of the Enhanced XA projection image.

X.2.7.3.2.2 Patient Orientation Module

This module encodes the patient position and orientation with respect to the table. It is supposed to contain the same values in the 3D volume and in the 2D static image.

X.2.7.3.2.3 Image - Equipment Coordinate Relationship Module

This module encodes the coordinate transformation matrix to allow the spatial registration of the volume with the Isocenter reference system of the angiographic equipment.

The reconstruction application defines the patient origin as an arbitrary point on the equipment. The 3D slices of the volume are all related to the patient coordinate system by the attributes Image Position (Patient) (0020,0032) and Image Orientation (Patient) (0020,0037).

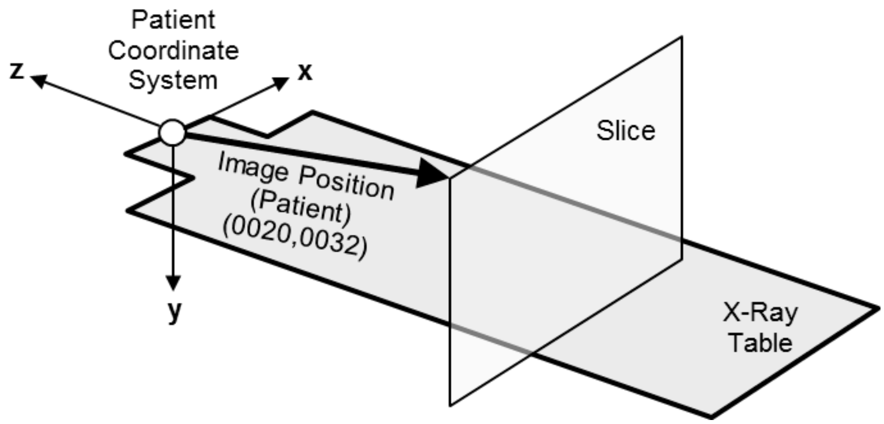


Figure X.2.7-4
Image Position of the slice related to an application-defined patient coordinates

The patient is related to the Isocenter by the attribute Image to Equipment Mapping Matrix (0028,9520) which indicates the spatial transformation from the patient coordinates to the Isocenter coordinates. A point in the Patient Coordinate System (Bx, By, Bz) can be expressed in the Isocenter Coordinate System (Ax, Ay, Az) by applying the Image to Equipment Mapping Matrix as follows.

Figure X.2.7-5
Transformation from patient coordinates to Isocenter coordinates

The terms (T_x,T_y,T_z) of this matrix indicate the position of the patient origin (i.e. a fixed point on the table) in the Isocenter coordinate system.

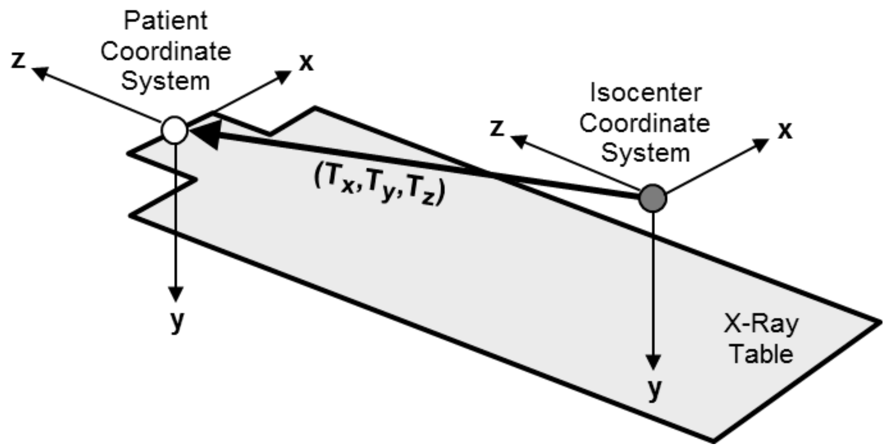


Figure X.2.7-6
Transformation of the patient coordinates relative to the Isocenter coordinates

Table X.2.7-1
IMAGE - EQUIPMENT COORDINATE RELATIONSHIP MODULE RECOMMENDATIONS

Attribute Name	Tag	Recommendation
Equipment Coordinate System Identification	(0028,9537)	The value will be ISOCENTER.

X.2.7.3.2.4 X-Ray 3D Angiographic Acquisition Module Recommendations

This module encodes the table position and angles used during the rotational acquisition to allow the spatial transformation of the volume points from the Isocenter coordinates to the table coordinates. See PS3.3 C.8.19.6.13.1 for further explanation about the spatial transformation from the Isocenter reference system to the table reference system.

As soon as the volume points are related to the table coordinate system, and assuming that the patient does not move on the table between the 2D acquisitions, the volume points can be projected on the image plane of any further projection acquisition even if the table has moved between the acquisitions. See PS3.3 C.8.19.6.13.1 for further explanation about the projection on the image plane of a point defined in the table coordinate system.

X.2.7.4 Example

In this example, one rotational image is acquired before the intervention. It is encoded with the Instance UID “C1”. Then a second projection static image is acquired during the intervention. It is encoded with the Instance UID “C2”. Both acquisitions are encoded as Enhanced XA SOP Class.

In both acquisitions, the patient position with respect to the table is head-first prone, and the table is not rotated nor tilted with respect to the Isocenter. Therefore, the axis of the patient coordinate system and the Isocenter coordinate system are aligned, and the 3x3 matrix M_{ij} of the Image to Equipment Mapping Matrix (0028,9520) is the identity.

In this example, the patient origin is defined by the application as a fixed point on the table; when the table position is zero, the patient origin is the point (0,0,200) in the Isocenter coordinates system (in mm).

During the rotational acquisition, the table position with respect to the Isocenter in the lateral direction [x] is +20mm, in the vertical direction [y] is +40mm, and in the longitudinal direction [z] is +60mm. Therefore, the terms (T_x,T_y,T_z) of the Image to Equipment Mapping Matrix (0028,9520) are (20,40,260).

During the second acquisition, the table position with respect to the Isocenter in the lateral direction [x] is +40mm, in the vertical direction [y] is +30mm, and in the longitudinal direction [z] is +20mm.

Consequently, the second acquisition is performed with a relative table translation of (30,-10,-50) mm vs. the first acquisition in the Isocenter coordinate system. The positioner primary angle is -30 deg. (RAO) and the secondary angle is 20 deg. (CRA). The distances from the source to the Isocenter and from the source to the detector are 780 mm and 1200 mm respectively.

The reconstruction is encoded in an X-Ray 3D Angiographic instance of Instance UID “Z1”.

Attribute	Tag	Value
SOP Instance UID	(0008,0018)	= *UID “Z1”*
......		
Frame of Reference UID	(0020,0052)	= *UID “D”*
......		
Image to Equipment Mapping Matrix	(0028,9520)	= **1\0\0\20\0\1\0\40\0\0\1\260\0\0\0\1**
Equipment Coordinate System Identification	(0028,9537)	= **ISOCENTER**
......		
Contributing Sources Sequence	(0018,9506)	
Item 1		
>Contributing SOP Instances Reference Sequence	(0020,9529)	
Item 1		
>>Referenced Series Sequence	(0008,1115)	
Item 1		
>>>Referenced Instance Sequence	(0008,114a)	
Item 1		
>>>>Referenced SOP Class UID	(0008,1150)	= *XA Image or Enhanced XA Image*
>>>>Referenced SOP Instance UID	(0008,1155)	= *UID “C1”*
>>>Series Instance UID	(0020,000e)	= *UID “B1”*
>>Study Instance UID	(0020,000d)	= *UID “A”*
>… *(other attributes from the contributing image sources)*		
......		
X-Ray 3D Acquisition Sequence	(0018,9507)	
Item 1		*Acquisition context #1*
>Source Image Sequence	(0008,2112)	
Item 1		
>>Referenced SOP Class UID	(0008,1150)	= *Enhanced XA Image*
>>Referenced SOP Instance UID	(0008,1155)	= *UID “C1”*
>Table X Position to Isocenter	(0018,9466)	= **20.0**
>Table Y Position to Isocenter	(0018,9467)	= **40.0**
>Table Z Position to Isocenter	(0018,9468)	= **60.0**
>Table Horizontal Rotation Angle	(0018,9469)	= **0.0**
>Table Head Tilt Angle	(0018,9470)	= **0.0**
>Table Cradle Tilt Angle	(0018,9471)	= **0.0**
>… *(other attributes of this acquisition context)*		

Figure X.2.7-7
Attributes of the pre-intervention 3D reconstruction

Attribute	Tag	Value
SOP Instance UID	(0008,0018)	= *UID "C2"*
.....		
Frame of Reference UID	(0020,0052)	= *UID "D"*
...		
X-Ray Receptor Type	(0018,9420)	= **DIGITAL_DETECTOR**
Positioner Type	(0018,1508)	= **CARM**
C-arm Positioner Tabletop Relationship	(0018,9474)	= **YES**
...		
Per-Frame Functional Groups Sequence	(5200,9230)	
...		
Item i		
>Isocenter Reference System Sequence	(0018,9462)	
Item 1		
>>Positioner Isocenter Primary Angle	(0018,9463)	= **-30.0**
>>Positioner Isocenter Secondary Angle	(0018,9464)	= **20.0**
>>Positioner Isocenter Detector Rotation Angle	(0018,9465)	= **0.0**
>>Table X Position to Isocenter	(0018,9466)	= **50.0**
>>Table Y Position to Isocenter	(0018,9467)	= **30.0**
>>Table Z Position to Isocenter	(0018,9468)	= **10.0**
>>Table Horizontal Rotation Angle	(0018,9469)	= **0.0**
>>Table Head Tilt Angle	(0018,9470)	= **0.0**
>>Table Cradle Tilt Angle	(0018,9471)	= **0.0**
>X-Ray Geometry Sequence	(0018,9476)	
Item 1		
>>Distance Source to Isocenter	(0018,9402)	= **780.0**
>>Distance Source to Detector	(0018,1110)	= **1200.0**

Figure X.2.7-8
Attributes of the Enhanced XA during the intervention