Digital Imaging and Communications in Medicine (DICOM)

Supplement 83: Enhanced XA Image Storage SOP Class/
Enhanced XRF Image Storage SOP Class

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VERSION: Final Text – 15 September, 2005

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Foreword

This supplement to the DICOM standard introduces the new enhanced X-Ray Angiographic and Radiofluoroscopy SOP Classes. The new multi-frame concepts, introduced with the enhanced MR SOP Classes, will be used as a baseline to allow new equipment to make use of new procedure requirements or extended image-processing methods.

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

PS 3.2	Conformance
PS 3.3	Information Object Definitions
PS 3.4	Service Class Specifications
PS 3.6	Data Dictionary
PS 3.15	Security and Systems Management Profiles
PS 3.16	Content Mapping Resource
PS 3.17	Explanatory Information

Scope and Field of Application

This supplement to the DICOM standard defines new storage SOP Classes for XA and XRF modalities replacing (but not retiring) the existing SOP Classes. These new SOP Classes are using the 'enhanced' multi-frame features introduced with the Enhanced MR Storage SOP Classes:

- Shared and per-frame functional group sequences
- Dimensions

Many acquisition and position parameters are stored on a frame-by-frame basis. This approach allows a flexible way of storing information about the acquisition and positioning of the patient and equipment. The number of parameters is extended, many are mandatory and a more precise value assigment is possible by using a float Value Representation.

The dimension mechanism allows having other properties than a time vector as single dimension and the number of dimension is not longer limited to one.

The movements of the various part of the equipment (table, positioner) can be expressed in an iso-center based coordinate system.

The enhanced XA IOD shares a significant amount of common information with the enhanced XRF IOD. The differences between the two IODs are that the enhanced XRF Image IOD includes a Tomography Acquisition module and the two IODs utilize different methods to specify positioner angles. The enhanced XRF Image IOD contains a single column angulation Data Element that uses an equipment based coordinate system, while enhanced XA Image IOD C-arm positioner angles are specified in a patient based coordinate system. RF applications that support a patient-based coordinate system with cranial/caudal, LAO/RAO angles may utilize the enhanced XA IOD.

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168 **Changes to NEMA Standards Publication PS 3.2-2004**

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170 **Part 2: Conformance**

Item #1: Add new SOP Classes in Table A.1-2

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Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.12.1.1	Enhanced XA Image Storage	Transfer
1.2.840.10008.5.1.4.1.1.12.2.1	Enhanced XRF Image Storage	Transfer
…		

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Changes to NEMA Standards Publication PS 3.3-2004

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Part 3: Information Object Definitions

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Item #2: Add new IODs in Table A.1-1

IODs Modules	Enh. XA	Enh. XRF
Patient	M	M
Specimen Identification	U	U
Clinical Trial subject	U	U
General Study	M	M
Patient Study	U	U
Clinical Trial Study	U	U
General Series	M	M
XA/XRF Series	M	M
Clinical Trial Series	U	U
Frame Of Reference	C	U
Synchronization	C	C
General Equipment	M	M
Enhanced General Equipment	M	M
Image Pixel	M	M
Enhanced Contrast/Bolus	C	C
Mask	U	U
Device	U	U
Intervention	U	U
Acquisition Context	M	M
Multi-frame Functional Groups	M	M
Multi-frame Dimension	U	U
Cardiac Synchronization	C	C
Respiratory Synchronization	C	C
X-Ray Tomography Acquisition		U
X-Ray Filtration	U	U
X-Ray Grid	U	U
Enhanced XA/XRF Image	M	M
XA/XRF Acquisition	C	C
X-Ray Image Intensifier	C	C

X-Ray Detector	**C**	**C**
XA/XRF Multi-frame Presentation	**U**	**U**
SOP Common	**M**	**M**

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Item #3: Add section to Annex A

A.X ENHANCED X-RAY ANGIOGRAPHIC IMAGE INFORMATION OBJECT DEFINITION

A.X.1 Enhanced XA Image IOD Description

This Section defines the enhanced Information Object for single plane X-Ray Angiographic Imaging that includes those data elements and information objects necessary for the interchange of digital X-Ray Angiographic data. This includes images of the heart and all blood vessels.

The enhanced XA IOD is also applicable to clinical areas other than angiography (e.g. Interventional Procedures, Myelography, Biopsy/Localization, and Neurology).

Notes: 1. For the purpose of X-Ray Angiography (XA), this enhanced IOD can be used to encode a single frame image, or a Cine Run, or a single multi-frame image with non-time related dimensions.

2. A typical study might include all the images generated between the time a patient gets on and gets off the procedure table. As several separable diagnostic or therapeutic processes may occur during a single study (e.g., pre-intervention CA, left ventriculography, and post-intervention CA), a series may be defined as comprising a set of images (single or Multi-Frame) associated with one such process within a study.

3. This enhanced IOD can be used to encode a single plane acquisition, or one plane of a biplane acquisition.

A.X.2 Enhanced XA Image IOD Entity-Relationship Model

The E-R Model in Section A.1.2 depicts those components of the DICOM Application Information Model that directly reference the enhanced X-Ray Angiographic Image IOD. Additionally, “Image” in Figure A.1-1 may represent a Single Frame or a Multi-Frame image. A frame denotes a two-dimensional organization of pixels recorded as a single exposure.

A.X.3 Enhanced XA Image IOD Module Table

Table A.X-1
ENHANCED X-RAY ANGIOGRAPHIC IMAGE IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	XA/XRF Series	C.8.X.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	C – Required if C-arm Positioner Tabletop Relationship (0018,9474) equals YES. May be present otherwise.
	Synchronization	C.7.4.2	C – Required if C-arm Positioner Tabletop Relationship (0018,9474) equals YES. May be present otherwise.
Equipment	General Equipment	C.7.5.1	M

	Enhanced General Equipment	C.7.5.1X	M
Image	Image Pixel	C.7.6.3	M
	Enhanced Contrast/Bolus	C.7.6.4b	C – Required if contrast media was applied and the system is able to register contrast usage.
	Mask	C.7.6.10	U
	Device	C.7.6.12	U
	Intervention	C.7.6.13	U
	Acquisition Context	C.7.6.14	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension Module	C.7.6.17	U
	Cardiac Synchronization	C.7.6.18.1	C – Required if cardiac synchronization was applied.
	Respiratory Synchronization	C.7.6.18.2	C – Required if respiratory synchronization was applied.
	X-Ray Filtration	C.8.7.10	U
	X-Ray Grid	C.8.7.11	U
	Enhanced XA/XRF Image	C.8.X.2	M
	XA/XRF Acquisition	C.8.X.3	C – Required if Image Type (0008,0008) Value 1 equals ORIGINAL. May be present otherwise.
	X-Ray Image Intensifier	C.8.X.4	C – Required if X-Ray Receptor Type (0018,9420) is present and equals IMG_INTENSIFIER.
	X-Ray Detector	C.8.X.5	C – Required if X-Ray Receptor Type (0018,9420) is present and equals DIGITAL_DETECTOR.
	XA/XRF Multi-frame Presentation	C.8.X.7	U
	SOP Common	C.12.1	M

A.X.3.1 Enhanced XA Image IOD Content Constraints

A.X.3.1.1 Modality Type Attribute

The Modality Type attribute (0008,0060) shall have the value XA.

A.X.3.1.2 Overlay Plane Module, Curve Module and VOI LUT Module

The Overlay Plane Module, Curve Module, VOI LUT Module and Softcopy Presentation LUT Module shall not be used in a Standard Extended SOP Class of the Enhanced XA Image.

Note: The VOI LUT function is provided by a Frame VOI LUT Functional Group.

A.X.3.1.3 Positioner Type

The Positioner Type (0018,1508) attribute shall have the value CARM if the XA/XRF Acquisition Module is present.

A.X.4 Enhanced XA Image Functional Group Macros

Table A.X-2 specifies the use of the Functional Group macros used in the Multi-frame Functional Groups Module for the Enhanced XA Image IOD.

Table A.X-2
ENHANCED XA IMAGE FUNCTIONAL GROUP MACROS

Functional Group Macro	Section	Usage
Frame Content	C.7.6.16.2.2	M – May not be used as a Shared Functional Group.
Referenced Image	C.7.6.16.2.5	U
Derivation Image	C.7.6.16.2.6	C – Required if the image or frame has been derived from another SOP Instance.
Cardiac Trigger	C.7.6.16.2.7	U
Frame Anatomy	C.7.6.16.2.8	M
Frame VOI LUT	C.7.6.16.2.10	M
Contrast/Bolus Usage	C.7.6.16.2.12	C – Required if the Enhanced Contrast/Bolus Module is present
Pixel Intensity Relationship LUT	C.7.6.16.2.X1	C – Required if Pixel Intensity Relationship (0028,1040) equals LOG. May be present otherwise.
Frame Pixel Shift	C.7.6.16.2.X3	U
Patient Orientation in Frame	C.7.6.16.2.X4	C– Required if C-arm Positioner Tabletop Relationship (0018,9474) is present and equals YES. May be present otherwise.
Frame Display Shutter	C.7.6.16.2.X5	U
XA/XRF Frame Characteristics	C.8.X.6.1	U
X-Ray Field of View	C.8.X.6.2	C – Required if Isocenter Reference System Sequence (0018,9462) is present.
X-Ray Exposure Control Sensing Regions	C.8.X.6.3	U
XA/XRF Frame Pixel Data Properties	C.8.X.6.4	M
X-Ray Frame Detector Parameters	C.8.X.6.5	C – Required if X-Ray Receptor Type (0018,9420) is present and equals DIGITAL_DETECTOR.
X-Ray Calibration Device Usage	C.8.X.6.6	U
X-Ray Object Thickness	C.8.X.6.7	U
X-Ray Frame Acquisition	C.8.X.6.8	U
X-Ray Projection Pixel Calibration	C.8.X.6.9	C– Required if C-arm Positioner Tabletop Relationship (0018,9474) is present and equals YES.

X-Ray Positioner	C.8.X.6.10	C– Required if Image Type (0008,0008) Value 1 equals ORIGINAL and C-arm Positioner Tabletop Relationship (0018,9474) is present and equals YES. May be present otherwise.
X-Ray Table Position	C.8.X.6.11	C– Required if Image Type (0008,0008) Value 1 equals ORIGINAL and C-arm Positioner Tabletop Relationship (0018,9474) is present and equals YES. May be present otherwise.
X-Ray Collimator	C.8.X.6.12	C– Required if Image Type (0008,0008) Value 1 equals ORIGINAL. May be present otherwise.
X-Ray Isocenter Reference System	C.8.X.6.13	U – May not be used if C-arm Positioner Tabletop Relationship (0018,9474) is not present or equals NO.
X-Ray Geometry	C.8.X.6.14	C – Required if Projection Pixel Calibration Sequence (0018,9401) is present. May be present otherwise.
Irradiation Event Identification	C.8.X.6.15	M

A.X.4.1 Enhanced XA Image Functional Group Macros Content Constraints

A.X.4.1.1 Frame Anatomy Function Group Macro

The Defined Context ID for the Anatomic Region Sequence (0008,2218) shall be CID X4032.

A.Y ENHANCED X-RAY RF IMAGE INFORMATION OBJECT DEFINITION

A.Y.1 Enhanced XRF Image IOD Description

The focus for this enhanced X-Ray RF Image IOD (XRF IOD) is to address the requirements for image transfer found in general Radiofluoroscopic applications performed on a table with a column. For applications performed on X-Ray RF acquisition systems that support a patient based coordinate system with cranial/caudal, LAO/RAO angles, etc. the enhanced XA Image IOD may be used.

Notes: 1. An example of a case where the enhanced XA IOD may be preferred to the enhanced RF IOD are RF acquisition system equipped with an X-Ray source and an image Receptor positioned by what is generally called a C-arm (e.g. Interventional Procedures, Myelography, Biopsy, and Neurology).

2. For the purpose of X-Ray Radiofluoroscopy, this IOD can be used to encode a single frame image, or a cine run, or a single multi-frame image with non-time related dimensions.

3. A typical study might include all the images generated between the time a patient gets on and gets off the procedure table. As several separable diagnostic or therapeutic processes may occur during a single study, a series may be defined as comprising a set of images (single or Multi-Frame) associated with one such process within a study.

A.Y.2 Enhanced XRF Image IOD Entity-Relationship Model

The E-R Model in Section A.1.2 depicts those components of the DICOM Application Information Model that directly reference the X-Ray RF Image IOD. Additionally, “Image” in figure A.1-1 may represent a Single Frame or a Multi-Frame image. A frame denotes a two-dimensional organization of pixels recorded as a single exposure.

A.Y.3 Enhanced XRF Image IOD Module Table

254 **Table A.Y.-1**
ENHANCED X-RAY RF IMAGE IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	XA/XRF Series	C.8.X.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	U
	Synchronization	C.7.4.2	U
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.1X	M
Image	Image Pixel	C.7.6.3	M
	Enhanced Contrast/Bolus	C.7.6.4b	C – Required if contrast media was applied and the system is able to register contrast usage.
	Mask	C.7.6.10	U
	Device	C.7.6.12	U
	Intervention	C.7.6.13	U
	Acquisition Context	C.7.6.14	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension Module	C.7.6.17	U
	Cardiac Synchronization	C.7.6.18.1	C - Required if cardiac synchronization was applied.
	Respiratory Synchronization	C.7.6.18.2	C - Required if respiratory synchronization was applied.
	X-Ray Tomography Acquisition	C.8.7.7	U
	X-Ray Filtration	C.8.7.10	U
	X-Ray Grid	C.8.7.11	U
	Enhanced XA/XRF Image	C.8.X.2	M

	XA/XRF Acquisition	C.8.X.3	C – Required if Image Type (0008,0008) Value 1 equals ORIGINAL. May be present otherwise.
	X-Ray Image Intensifier	C.8.X.4	C – Required if X-Ray Receptor Type (0018,9420) is present and equals IMG_INTENSIFIER.
	X-Ray Detector	C.8.X.5	C – Required if X-Ray Receptor Type (0018,9420) is present and equals DIGITAL_DETECTOR.
	XA/XRF Multi-frame Presentation	C.8.X.7	U
	SOP Common	C.12.1	M

A.Y.3.1 Enhanced XRF Image IOD Content Constraints

A.Y.3.1.1 Modality Type Attribute

The Modality Type attribute (0008,0060) shall have the value RF.

A.Y.3.1.2 Overlay Plane Module, Curve Module and VOI LUT Module

The Overlay Plane Module, Curve Module, VOI LUT Module and Softcopy Presentation LUT Module shall not be used in a Standard Extended SOP Class of the Enhanced XRF Image.

Note: The VOI LUT function is provided by a Frame VOI LUT Functional Group.

A.Y.3.1.3 Positioner Type

The Positioner Type (0018,1508) attribute shall have the value COLUMN if the XA/XRF Acquisition Module is present.

A.Y.4 Enhanced XRF Image Functional Group Macros

Table A.Y-2 specifies the use of the Functional Group macros used in the Multi-frame Functional Groups Module for the Enhanced XRF Image IOD.

Table A.Y-2
ENHANCED XRF IMAGE FUNCTIONAL GROUP MACROS

Functional Group Macro	Section	Usage
Frame Content	C.7.6.16.2.2	M – May not be used as a Shared Functional Group.
Referenced Image	C.7.6.16.2.5	U
Derivation Image	C.7.6.16.2.6	C – Required if the image or frame has been derived from another SOP Instance.
Cardiac Trigger	C.7.6.16.2.7	U
Frame Anatomy	C.7.6.16.2.8	M
Frame VOI LUT	C.7.6.16.2.10	M
Contrast/Bolus Usage	C.7.6.16.2.12	C – Required if the Enhanced Contrast/Bolus Module is present

Pixel Intensity Relationship LUT	C.7.6.16.2.X1	C – Required if Pixel Intensity Relationship (0028,1040) equals LOG. May be present otherwise.
Frame Pixel Shift	C.7.6.16.2.X3	U
Patient Orientation in Frame	C.7.6.16.2.X4	U
Frame Display Shutter	C.7.6.16.2.X5	U
XA/XRF Frame Characteristics	C.8.X.6.1	U
X-Ray Field of View	C.8.X.6.2	U
X-Ray Exposure Control Sensing Regions	C.8.X.6.3	U
XA/XRF Frame Pixel Data Properties	C.8.X.6.4	M
X-Ray Frame Detector Parameters	C.8.X.6.5	C – Required if X-Ray Receptor Type (0018,9420) is present and equals DIGITAL_DETECTOR.
X-Ray Calibration Device Usage	C.8.X.6.6	U
X-Ray Object Thickness	C.8.X.6.7	U
X-Ray Frame Acquisition	C.8.X.6.8	U
X-Ray Positioner	C.8.X.6.10	U
X-Ray Table Position	C.8.X.6.11	U
X-Ray Collimator	C.8.X.6.12	U
X-Ray Geometry	C.8.X.6.14	U
Irradiation Event Identification	C.8.X.6.15	M

274 **A.Y.4.1 Enhanced XRF Image Functional Group Macros Content Constraints**

A.Y.4.1.1 Frame Anatomy Function Group Macro

276 The Defined Context ID for the Anatomic Region Sequence (0008,2218) shall be CID X4032.

Item #4: Change Image Area Dose Product attribute name

C.4.16 Radiation Dose

Table C.4-16
RADIATION DOSE MODULE ATTRIBUTES

Attribute Name	Tag	Attribute Description
…		
Image **and Fluoroscopy** Area Dose Product	(0018,115E)	Total area-dose-product to which the patient was exposed, accumulated over the complete Performed Procedure Step and measured in dGy*cm*cm, including fluoroscopy. Notes: 1. The sum of the ~~**Image A**~~**a**rea ~~**D**~~**d**ose ~~**P**~~**p**roduct of all images of a Series or a Study may not result in the ~~**actual**~~**total** area dose product to which the patient was exposed. 2. This may be an estimated value based on assumptions about the patient's body size and habitus.
…		

Item #5: Add to section C.7

C.7.5.1X Enhanced General Equipment Module

Table C.7.5-X specifies the Attributes that identify and describe the piece of equipment that produced a Series of Composite Instances.

Notes: 1. This table contains a subset of the attributes of General Equipment Module (Table C.7-8) but the Type Designation is changed into Type 1. Including this module in an IOD overwrites the Type Designation of the General Equipment Module.

2. The attributes are intended to be a primary identification of the system that produces the data (e.g., modality or workstation application providing the content of the SOP Instance) and not the identification of the component that encodes the SOP Instance (e.g., a commonly used DICOM encoding toolkit).

Table C.7.5-X
ENHANCED GENERAL EQUIPMENT MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Manufacturer	(0008,0070)	1	Manufacturer of the equipment that produced the composite instances.
Manufacturer's Model Name	(0008,1090)	1	Manufacturer's model name of the equipment that produced the composite instances.
Device Serial Number	(0018,1000)	1	Manufacturer's serial number of the equipment that produced the composite instances.
Software Versions	(0018,1020)	1	Manufacturer's designation of software version of the equipment that produced the composite instances.

Item #6: Extend Table C.7-12b with attribute Contrast/Bolus Agent Related Absorption

C.7.6.4b Enhanced Contrast/Bolus Module

Table C.7-12b specifies the Attributes that describe the contrast/bolus used in the acquisition of the Image.

Note: This module describes the contrast agents that may be present in the frames. The actual presence or non-presence of such contrast agents is indicated in the Contrast/Bolus Usage Functional Group Macro.

Table C.7-12b
ENHANCED CONTRAST/BOLUS MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
>Contrast/Bolus Ingredient Concentration	(0018,1049)	2	Milligrams of active ingredient per milliliter of agent.
>Contrast/Bolus Ingredient Opaque	**(0018,9425)**	**3**	**Absorption of the ingredient greater than the absorption of water (tissue).** **Enumerated Values:** **YES** **NO** **See Section C.7.6.4b.1.**
>Contrast Administration Profile Sequence	(0018,9340)	3	Sequence that describes one or more phases of contrast administered. If present, shall contain one or more Items.
…			

C.7.6.4b.1 Contrast/Bolus Ingredient Opaque

C.7.6.4b.1.1 Contrast/Bolus Ingredient Opaque for X-ray equipment

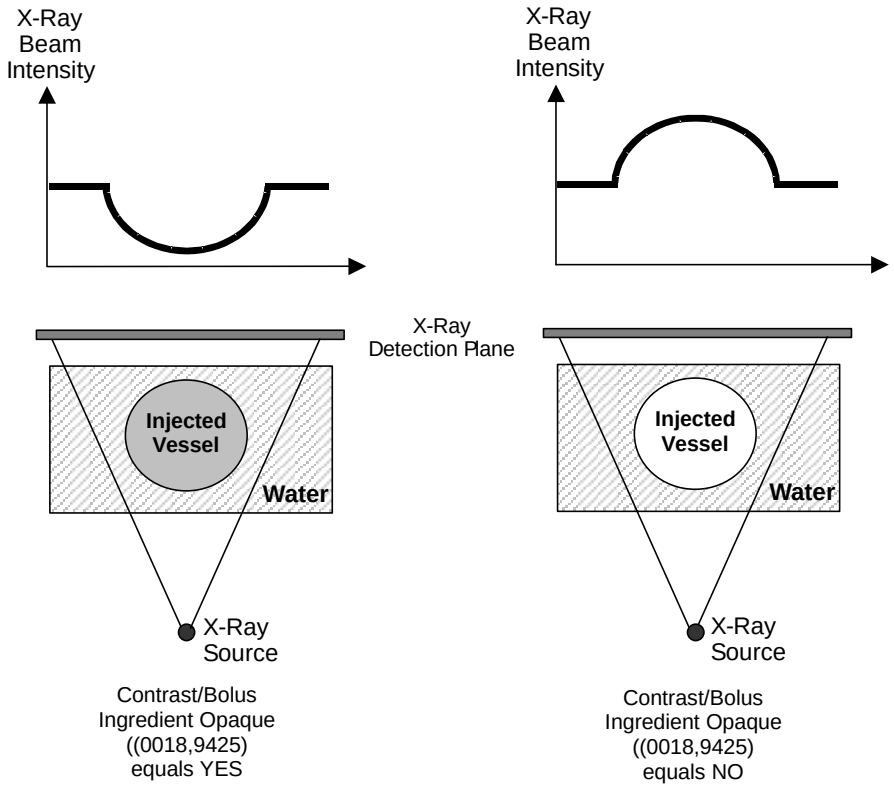
Contrast/Bolus Ingredient Opaque (0018,9425) attribute specifies the type of relative X-ray absorption of the contrast/bolus ingredient, compared to the X-ray absorption of water. The the meaning for the Enumerated Values are:

YES The contrast/bolus ingredient absorbs more X-ray photons than water;

NO The contrast/bolus ingredient absorbs less X-ray photons than water;

Note: The Contrast/Bolus Ingredient Opaque (0018,9425) attribute determines the sign of the gradient of X-Ray beam intensity from inside to outside the injected vessel, thus allowing optimal settings of the image processing applications (e.g. vessel edge detection, etc.), see Figure C.7.6.4b-1.

The relative gray level of the injected vessel with respect to the gray level of the water of Pixel Data (7FE0,0010) is determined by the Contrast/Bolus Ingredient Opaque (0018,9425) and by the Pixel Intensity Relationship Sign (0028,1041). For example, if the contrast/bolus ingredient is more radio graphically dense than water (i.e. YES), and the Pixel Intensity Relationship Sign (0028,1041) is –1, then the contrast/bolus ingredient is represented by higher values of Pixel Data than water.



320 **Figure C.7.6.4b-1**
X-ray beam intensity vs. Contrast/Bolus Ingredient Opaque

322 **Item #7: Create Display Shutter macro for use in Display Shutter Module and Functional Group**

C.7.6.11 Display Shutter Module

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326 **Table C.7-17**
DISPLAY SHUTTER MODULE

Attribute Name	Tag	Type	Attribute Description
Include 'Display Shutter Macro' Table C.7-17A.			
~~**Shutter Shape**~~	~~**(0018,1600)**~~	~~**1**~~	~~**Shape(s) of the shutter defined for display. Enumerated Values:**~~ ~~**RECTANGULAR**~~ ~~**CIRCULAR**~~ ~~**POLYGONAL**~~ ~~**This multi-valued Attribute shall contain at most one of each Enumerated Value.**~~
~~**Shutter Left Vertical Edge**~~	~~**(0018,1602)**~~	~~**1C**~~	~~**Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the left edge of the rectangular shutter with respect to pixels in the image given as**~~

			column.
Shutter Right Vertical Edge	(0018,1604)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the right edge of the rectangular shutter with respect to pixels in the image given as column.
Shutter Upper Horizontal Edge	(0018,1606)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the upper edge of the rectangular shutter with respect to pixels in the image given as row.
Shutter Lower Horizontal Edge	(0018,1608)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the lower edge of the rectangular shutter with respect to pixels in the image given as row.
Center of Circular Shutter	(0018,1610)	1C	Required if Shutter Shape (0018,1600) is CIRCULAR. Location of the center of the circular shutter with respect to pixels in the image given as row and column.
Radius of Circular Shutter	(0018,1612)	1C	Required if Shutter Shape (0018,1600) is CIRCULAR. Radius of the circular shutter with respect to pixels in the image given as a number of pixels along the row direction.
Vertices of the Polygonal Shutter	(0018,1620)	1C	Required if Shutter Shape (0018,1600) is POLYGONAL. Multiple Values where the first set of two values are: row of the origin vertex column of the origin vertex Two or more pairs of values follow and are the row and column coordinates of the other vertices of the polygon shutter. Polygon shutters are implicitly closed from the last vertex to the origin vertex and all edges shall be non-intersecting except at the vertices.
Shutter Presentation Value	(0018,1622)	3	The value used to replace those parts of the image occluded by the shutter, in P-Values, from a minimum of 0000H (black) up to a maximum of FFFFH (white). Note: The maximum P-Value for this Attribute may be different from the maximum P-Value from the output of the Presentation LUT, which may be less than 16 bits in depth.

328 **Table C.7-17A**
DISPLAY SHUTTER MACRO

Attribute Name	Tag	Type	Attribute Description
Shutter Shape	(0018,1600)	1	Shape(s) of the shutter defined for display. Enumerated Values: RECTANGULAR CIRCULAR POLYGONAL This multi-valued Attribute shall contain at most one of each Enumerated Value.
Shutter Left Vertical Edge	(0018,1602)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the left edge of the rectangular shutter with respect to pixels in the image given as column.
Shutter Right Vertical Edge	(0018,1604)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the right edge of the rectangular shutter with respect to pixels in the image given as column.
Shutter Upper Horizontal Edge	(0018,1606)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the upper edge of the rectangular shutter with respect to pixels in the image given as row.
Shutter Lower Horizontal Edge	(0018,1608)	1C	Required if Shutter Shape (0018,1600) is RECTANGULAR. Location of the lower edge of the rectangular shutter with respect to pixels in the image given as row.
Center of Circular Shutter	(0018,1610)	1C	Required if Shutter Shape (0018,1600) is CIRCULAR. Location of the center of the circular shutter with respect to pixels in the image given as row and column.
Radius of Circular Shutter	(0018,1612)	1C	Required if Shutter Shape (0018,1600) is CIRCULAR. Radius of the circular shutter with respect to pixels in the image given as a number of pixels along the row direction.
Vertices of the Polygonal Shutter	(0018,1620)	1C	Required if Shutter Shape (0018,1600) is POLYGONAL. Multiple Values where the first set of two values are: row of the origin vertex column of the origin vertex Two or more pairs of values follow and are the row and column coordinates of the other vertices of the polygon shutter. Polygon shutters are implicitly closed from the last vertex to the origin vertex and all edges shall be non-intersecting except at the vertices.

Shutter Presentation Value	(0018,1622)	3	~~The~~ **A single unsigned** value used to replace those parts of the image occluded by the shutter, **when rendered on a monochrome display. The units are specified** in P-Values, from a minimum of 0000H (black) up to a maximum of FFFFH (white). Note: The maximum P-Value for this Attribute may be outside the range of P-Values from the output of the Presentation LUT, which may be less than 16 bits in depth.
Shutter Presentation Color CIELab Value	**(0018,eee1)**	**3**	**A color triplet value used to replace those parts of the image occluded by the shutter, when rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See C.10.7.1.1.**

330

Item #8: Extend Section C.7.6.10.1.1 with Reverse TID subtraction and add Subtraction Item ID

332 **C.7.6.10 Mask Module**

Table C.7-16 specifies the Attributes that describe mask operations for a Multi-frame image.

334 **Table C.7-16**
MASK MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
>Subtraction Item ID	**(0028,9416)**	**1C**	**Identification of the Subtraction Item used to associate a certain Mask Sub-Pixel Shift (0028,6114) in the Frame Pixel Shift Functional Group.** **See C.7.6.16.2.X3.1.** **Required if SOP Class UID (0008,0016) equals "1.2.840.10008.5.1.4.1.1.12.1.1" or "1.2.840.10008.5.1.4.1.1.12.2.1". May be present otherwise.**

>Applicable Frame Range	(0028,6102)	~~3~~**1C**	Each pair of numbers in this multi-valued attribute specify a beginning and ending frame number inclusive of a range where this particular mask operation is valid. Discontinuous ranges are represented by multiple pairs of numbers. Frames in a Multi-frame Image are specified by sequentially increasing number values beginning with 1. If this Attribute is missing in this particular sequence item, then the mask operation is applicable throughout the entire Multi-frame Image, subject to certain limits as described in C.7.6.10.1.1. **Required if Mask Operation (0028,6101) equals REV_TID. May be present otherwise.**
…			
>Mask Sub-pixel Shift	(0028,6114)	3	A pair of floating point numbers specifying the fractional vertical [adjacent row spacing] and horizontal [adjacent column spacing] pixel shift applied to the mask before subtracting it from the contrast frame. See Section C.7.6.10.1.2. **Note: When the Frame Pixel Shift Functional Group is present the values of the Mask Pixel Shift attribute of that Functional Group prevails over the values specified in this module.**
>TID Offset	(0028,6120)	2C	**If Mask Operation is TID, s**pecifies the offset to be subtracted from the current frame number in order to locate the mask frame in TID mode. **If Mask Operation is REV_TID, specifies the initial offset to be subtracted from the first contrast frame number. See section C.7.6.10.1.1** If zero length, TID Offset defaults to 1. Required if Mask Operation (0028,6101) is TID **or REV_TID**.
>Mask Operation Explanation	(0028,6190)	3	Free form explanation of this particular mask operation.

>Mask Selection Mode	**(0028,9454)**	**3**	**Specifies the method of selection of the mask operations of this item.** **Defined Terms:** **SYSTEM** **USER**
…			

C.7.6.10.1 Mask Subtraction Attribute Descriptions

C.7.6.10.1.1 Mask Operation

Mask Operation (0028,6101) specifies a type of mask operation to be performed. The Defined Terms identifying the mask operation to be performed are as follows:

NONE (No Subtraction) No mask subtraction operation is specified;

AVG_SUB (Average Subtraction) The frames specified by the Mask Frame Numbers (0028,6110) are averaged together, shifted by the amount specified in the Mask Sub-pixel Shift (0028,6114), then subtracted from the contrast frames in the range specified in the Applicable Frame Range (0028,6102) . Contrast Frame Averaging (0028,6112) number of frames starting with the current frame are averaged together before the subtraction. If the Applicable Frame Range is not present in this sequence item, the Applicable Frame Range is assumed to end at the last frame number of the image minus Contrast Frame Averaging (0028,6112) plus one;

TID (Time Interval Differencing) The mask for each frame within the Applicable Frame Range (0028,6102) is selected by subtracting TID Offset (0028,6120) from the respective frame number. If the Applicable Frame Range is not present in this sequence item, the Applicable Frame Range is assumed to be a range where TID offset subtracted from any frame number with the range results in a valid frame number within the Multi-frame image.

Note: A positive value for TID Offset (0028,6120) means that the mask frame numbers are lower than the subtracted frame numbers. A negative TID Offset means that the mask frame numbers are higher than the subtracted frame numbers.

REV_TID (Reversed Time Interval Differencing) The number of the mask frame for each contrast frame within the Applicable Frame Range (0028,6102) is calculated by subtracting the TID Offset (0028,6120) from the first frame within the Applicable Frame Range, the TID Offset (0028,6120) +2 from the second frame within the Applicable Frame Range, the TID Offset (0028,6120) +4 from the third frame and so on. The Applicable Frame Range (0028,6102) shall be present.

When multiple pairs of frame numbers are specified in the Applicable Frame Range attribute, the beginning frame numbers (i.e. the first frame number in each pair) shall be in increasing order.

Algorithm to calculate the Mask Frame Number:

MFN = (FCFN – TID Offset) – (CFN – FCFN)

In which:

MFN = Mask Frame Number
CFN = Contrast Frame Number
FCFN = First Contrast Frame Number, the first frame number of the first pair in the Applicable Frame Range

Note: A positive value for TID Offset (0028,6120) means that the mask frame numbers are lower than the subtracted frame numbers. A negative TID Offset means that the mask frame numbers are higher than the subtracted frame numbers.

Note: Example of TID Offset, see Figure C.7.6.10-1:

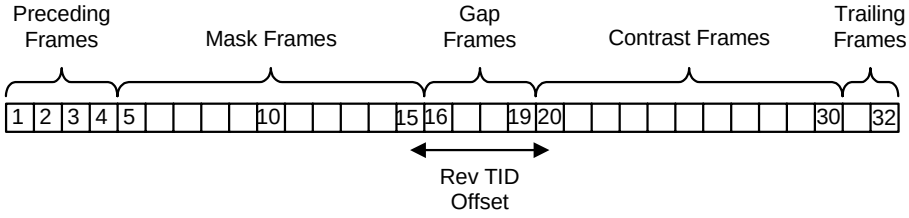


Figure C.7.6.10-1

Number of Frames: 32
Applicable Frame Range: 20 to 30
TID Offset: 5

For Calculating the TID Offset for Mask Operation REV_TID see table C.7.6.10-1:

Table C.7.6.10-1
Example Mask Frame Numbers for Mask Operation REV_TID

Contrast Frame Number (CFN) (Absolute value)	Mask Frame Number (MFN) (Absolute value)
20	15
21	14
22	13
…	…
28	7
29	6
30	5

In this example the acquisition of the mask frames starts with frame 5 and ends with frame 15. The acquisition of the contrast frames starts with frame 20 and ends with frame 30 (Applicable Frame Range). The number 5 for TID Offset indicates a gap between "end of mask frames" and "begin of contrast frames" of 4 frames, e.g. injection phase and/or time needed to drive C-arm in reverse. Additionally, in this example, the first 4 frames and the last two frames are not used for this Reversed Time Interval Differencing loop.

Item #9: Extend Section C.7.6.12 for use as calibration object

C.7.6.12 Device

Table C.7-18 describes the Attributes of devices **or calibration objects** (e.g., catheters, markers, baskets) that are associated with a study and/or image.

Item #10: Extend Table C.7.6.16-3 with Frame Label attribute

C.7.6.16.2.2 Frame Content Macro

…

Table C.7.6.16-3
FRAME CONTENT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
>Frame Comments	(0020,9158)	3	User-defined comments about the frame.
>Frame Label	**(0020,9453)**	**3**	**Label corresponding to a specific dimension index value. Selected from a set of dimension values defined by the application.** **This attribute may be referenced by the Dimension Index Pointer (0020,9165) attribute in the Multi-frame Dimension Module.** **See C.7.16.2.2.1 for further explanation.**

C.7.6.16.2.2.1 Frame Label

The Frame Label attribute (0020,9453) can be used to label frames that need to be handled as a group in application. The Dimension Index Pointer (0020,9165) from the Dimension Module may point to this attribute if it is the base of a dimension.

Item #11: Change section C.7.6.16.2.7 to clarify the exact trigger delay time

C.7.6.16.2.7 Cardiac Trigger Macro

Table C.7.6.16-8 specifies the attributes of the Cardiac Trigger Functional Group macro.

Table C.7.6.16-8
CARDIAC TRIGGER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Cardiac Trigger Sequence	(0018,9118)	1	Identifies cardiac trigger delay for this frame. Only a single Item shall be permitted in this sequence.
>Trigger Delay Time	(0020,9153)	1	Trigger delay time in ms ~~**for the frame relative to**~~ **from** the ~~**last**~~ **previous** R-peak **to the value of the Frame Reference Datetime (0018,9151)**. See C.7.6.16.2.7.1 for further explanation.

Item #12: Change section C.7.6.16.2.10 to force the use of a VOI LUT sequence

C.7.6.16.2.10 Frame VOI LUT Macro

Table C.7.6.16-11 specifies the attributes of the Frame VOI LUT Functional Group macro.

Table C.7.6.16-11
FRAME VOI LUT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame VOI LUT Sequence	(0028,9132)	~~2~~**1**	Window Center and Width values applied to the frame. ~~**Zero or one item may be present**~~**Only one item is permitted in this sequence**.
…			

Item #13: Add to section C.7.6.16.2: Common Functional Groups

C.7.6.16.2.X1 Pixel Intensity Relationship LUT Macro

Table C.7.6.16-X2 specifies the attributes of the Pixel Intensity Relationship LUT Functional Group macro.

Table C.7.6.16-X2
PIXEL INTENSITY RELATIONSHIP LUT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Intensity Relationship LUT Sequence	(0028,9422)	1	Defines a sequence of Pixel Intensity Relationship LUTs. One or more items shall be present in this sequence. At least one item with LUT Function (0028,9474) equals TO_LINEAR LUT shall be present if Pixel Intensity Relationship (0028,1040) equals LOG. Only a single item with LUT Function (0028,9474) equals TO_LINEAR LUT shall be present.
>LUT Descriptor	(0028,3002)	1	Specifies the format of the LUT Data in this Sequence. See C.11.1.1 and C.7.6.16.2.X1.1 for further explanation.

>LUT Data	(0028,3006)	1	LUT Data in this Sequence.
>LUT Function	(0028,9474)	1	The transformation function this LUT applies to the stored pixel values. Defined Terms: TO_LOG TO_LINEAR

C.7.6.16.2.X1.1 Pixel Intensity Relationship LUT

The purpose of this Pixel Intensity Relationship LUT Sequence is to provide information to recalculate the pixel values proportional to the X-ray beam intensity from the stored pixel values. It is intended to be used by any application that needs transformed pixel values (e.g. scaled back to acquired pixel values) pixel values for further processing and not as replacement of the Modality LUT in the display pipeline, see Figure C.7.6.16-X1.

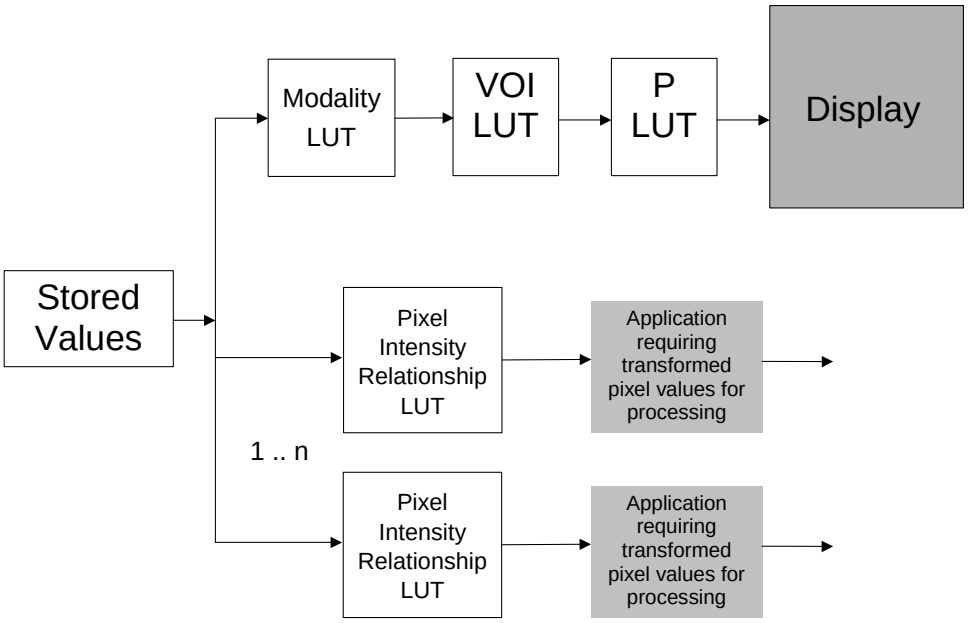


Figure C.7.6.16-X1
Purpose of Pixel Intensity Relationship LUT

C.7.6.16.2.X1.2 Pixel Intensity Relationship LUT Data Attribute

The number of bits in the LUT Data attribute (0028,3006) may be different from the value of Bit Stored attribute (0028,0101).

C.7.6.16.2.X3 Frame Pixel Shift Macro

Table C.7.6.16-X4 specifies the attributes of the Frame Pixel Shift Functional Group macro.

Table C.7.6.16-X4
FRAME PIXEL SHIFT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Pixel Shift Sequence	(0028,9415)	1	Sequence containing the pixel shift for a number of masks for this frame. One or more items shall be present in this sequence.
>Subtraction Item ID	(0028,9416)	1	Identifier of the Subtraction Item in the Mask Subtraction Sequence (0028,6100) to which this pixel shift is associated. See C.7.6.16.2.X3.1.
>Mask Sub-pixel Shift	(0028,6114)	1	A pair of floating point numbers specifying the fractional vertical [adjacent row spacing] and horizontal [adjacent column spacing] pixel shift applied to the mask before subtracting it from this contrast frame. Note: If no pixel shift has to be applied a pair of zero values should be specified. See Section C.7.6.10.1.2.

C.7.6.16.2.X3.1 Subtraction Item ID Description

Subtraction Item ID (0028,9416) specifies the ID of a subtraction operation to which the Mask Sub-pixel Shift (0028,6114) is associated. The Subtraction Item ID is also present in the Mask Subtraction Sequence (0028,6100) to allow this association.

When used as per-frame macro, the Subtraction Item ID (0028,9416) allows to specify different values of Mask Sub-pixel Shift (0028,6114) individually frame by frame, and relate them to a single item of the Mask Subtraction Sequence (0028,6100).

Note: There is no restriction in the number of Subtraction Item ID's associated to each contrast frame. The same contrast frame may be present in several items of the Mask Subtraction Sequence, each item having a different value of Subtraction Item ID.

When used as shared macro, the Subtraction Item ID (0028,9416) allows to specify one or more values of Mask Sub-pixel Shift that will be applied to all the frames of the Multi-frame image.

Note: Example of usage of Subtraction Item ID in a per-frame macro, see Figure C.7.6.16-X2:

In this example of Multi-Frame Image with 3 frames, one Mask Frame (i.e., Frame 1) is applied to the next two frames of the Multi-Frame image (i.e., Frames 2 and 3). Therefore, there is only one item in the Mask Subtraction Sequence, containing its own Subtraction Item ID value (i.e., 100). The Frame Pixel Shift Macro allows to define a Mask Sub-Pixel Shift different for each contrast frame.

First Frame Subtracted: Subtraction of Frame 1 (Mask) to Frame 2, with Sub-Pixel Shift 1.3\2.4

Second Frame Subtracted: Subtraction of Frame 1 (Mask) to Frame 3, with Sub-Pixel Shift 1.9\3.0

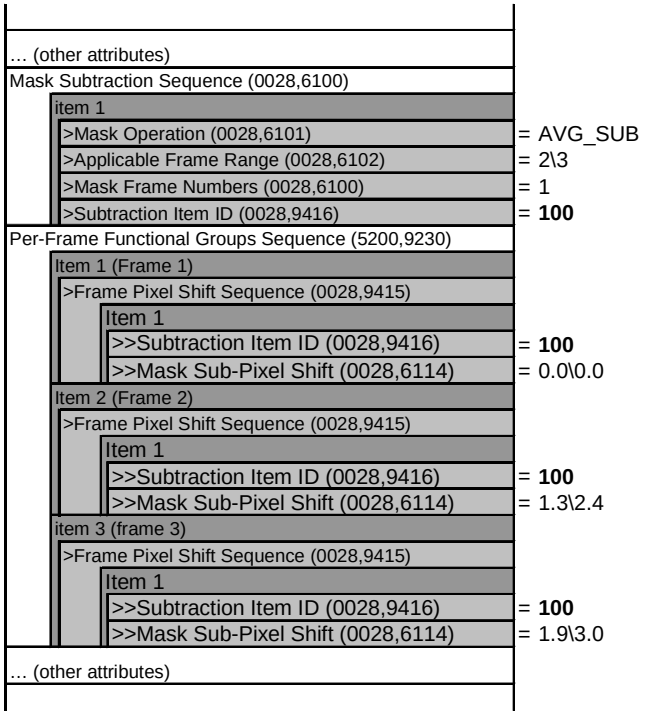


Figure C.7.6.16-X2
Example of usage of Subtraction Item ID in a per-frame Macro

C.7.6.16.2.X4 Patient Orientation in Frame Macro

Table C.7.6.16-X5 specifies the attributes of the Patient Orientation in Frame Functional Group macro.

Table C.7.6.16-X5
PATIENT ORIENTATION IN FRAME MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Patient Orientation in Frame Sequence	(0020,9450)	1	Sequence containing the row and column directions for this frame in the patient. Only a single Item shall be permitted in this sequence.
>Patient Orientation	(0020,0020)	1	Patient direction of the rows and columns of this frame. See C.7.6.1.1.1 for further explanation.

480 **C.7.6.16.2.X5 Frame Display Shutter**

Table C.7.6.16-X6 specifies the attributes of the Frame Display Shutter Functional Group macro.

482 **Table C.7.6.16-X6**
FRAME DISPLAY SHUTTER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Display Shutter Sequence	(0018,9472)	1	Sequence containing the display shutter parameters for this frame. Only a single Item shall be permitted in this sequence.
>*Include 'Display Shutter Macro' Table C.7-17A.*			

484

Item #14: Add Dimension Description Code Sequence attribute to Table C.7.6.17-1

486 **C.7.6.17 Multi-frame Dimension Module**

…

488 **Table C.7.6.17-1**
MULTI-FRAME DIMENSION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
>Dimension Organization UID	(0020,9164)	1C	Uniquely identifies a set of dimensions referenced within the containing SOP Instance. In particular the dimension described by this sequence item is associated with this Dimension Organization UID. See section C.7.6.17.2 for further explanation. Required if the value of the Dimension Index Sequence (0020,9222) contains Items
>Dimension Description Label	**(0020,9421)**	**3**	**Free text description that explains the meaning of the dimension.**

490

Item #15: Change Image Area Dose Product attribute name

C.8.7.2 X-Ray Acquisition Module

Table C.8-27
X-RAY ACQUISITION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
Image **and Fluoroscopy** Area Dose Product	(0018,115E)	3	X-Ray dose, measured in dGy*cm*cm, to which the patient was exposed for the acquisition of this image plus any non-digitally recorded fluoroscopy which may have been performed to prepare for the acquisition of this image. Note: The sum of the ~~**Image A**~~**a**rea ~~**D**~~**d**ose ~~**P**~~**p**roduct of all images of a Series or a Study may not result in the ~~**actual**~~**total** area dose product to which the patient was exposed

Item #16: Change Image Area Dose Product attribute name

C.8.7.8 X-Ray Acquisition Dose Module

…

Table C.8-33
X-RAY ACQUISITION DOSE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
Image **and Fluoroscopy** Area Dose Product	(0018,115E)	3	X-Ray dose, measured in dGy*cm*cm, to which the patient was exposed for the acquisition of this image plus any non-digitally recorded fluoroscopy which may have been performed to prepare for the acquisition of this image. Notes: 1. The sum of the ~~**Image A**~~**a**rea ~~**D**~~**d**ose ~~**P**~~**p**roduct of all images of a Series or a Study may not result in the ~~**actual**~~**total** area dose product to which the patient was exposed 2. This may be an estimated value based on assumptions about the patient's body size and habitus.
…			

Item #17: Replace Table C.8-71 and create DX Detector macro with common attribute for DX and XA/XRF IODs

C.8.11.4 DX Detector Module

Table C.8-71 contains IOD Attributes that describe a DX detector.

Table C.8-71
DX DETECTOR MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include 'Digital X-Ray Detector Macro' Table C.8-71b			
Detector Active Time	(0018,7014)	3	Time in mSec that the detector is active during acquisition of this image. Note: This activation window overlaps the time of the X-Ray exposure as defined by Exposure Time (0018,1150) and Detector Activation Offset From Exposure (0018,7016).
Detector Activation Offset From Exposure	(0018,7016)	3	Offset time in mSec that the detector becomes active after the X-Ray beam is turned on during acquisition of this image. May be negative.
Field of View Shape	(0018,1147)	3	Shape of the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010). Enumerated Values: RECTANGLE ROUND HEXAGONAL
Field of View Dimension(s)	(0018,1149)	3	Dimensions in mm of the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010). If Field of View Shape (0018,1147) is: RECTANGLE: row dimension followed by column. ROUND: diameter. HEXAGONAL: diameter of a circumscribed circle.

Field of View Origin	(0018,7030)	1C	Offset of the TLHC of a rectangle circumscribing the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010), before rotation or flipping, from the TLHC of the physical detector area measured in physical detector pixels as a row offset followed by a column offset. Required if Field of View Rotation (0018,7032) or Field of View Horizontal Flip (0018,7034) is present. See C.8.11.4.1.1 for further explanation.
Field of View Rotation	(0018,7032)	1C	Clockwise rotation in degrees of Field of View, that is the image pixels stored in Pixel Data (7FE0,0010), relative to the physical detector. Enumerated Values: 0, 90, 180, 270 Required if Field of View Horizontal Flip (0018,7034) is present. See C.8.11.4.1.1 for further explanation.
Field of View Horizontal Flip	(0018,7034)	1C	Whether or not a horizontal flip has been applied to the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010), after rotation relative to the physical detector as described in Field of View Rotation (0018,7032). Enumerated Values: NO YES Required if Field of View Rotation (0018,7032) is present. See C.8.11.4.1.1 for further explanation.
Imager Pixel Spacing	(0018,1164)	1	Physical distance measured at the front plane of the detector housing between the center of each image pixel specified by a numeric pair - row spacing value(delimiter) column spacing value in mm.

510 Table C.8-71b contains common attributes that describe digital X-ray detector.

Table C.8-71b
512 **DIGITAL X-RAY DETECTOR MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Detector Type	(0018,7004)	2	The type of detector used to acquire this image. Defined Terms: DIRECT = X-Ray photoconductor SCINTILLATOR = Phosphor used STORAGE = Storage phosphor FILM = Scanned film/screen
Detector Configuration	(0018,7005)	3	The physical configuration of the detector. Defined Terms: AREA = single or tiled detector SLOT = scanned slot, slit or spot
Detector Description	(0018,7006)	3	Free text description of detector.
Detector Mode	(0018,7008)	3	Text description of operating mode of detector (implementation specific).
Detector ID	(0018,700A)	3	The ID or serial number of the detector used to acquire this image.
Date of Last Detector Calibration	(0018,700C)	3	The date on which the detector used to acquire this image as identified in Detector ID (0018,700A) was last calibrated.
Time of Last Detector Calibration	(0018,700E)	3	The time at which the detector used to acquire this image as identified in Detector ID (0018,700A) was last calibrated.
Exposures on Detector Since Last Calibration	(0018,7010)	3	Total number of X-Ray exposures that have been made on the detector used to acquire this image as identified in Detector ID (0018,700A) since it was calibrated.
Exposures on Detector Since Manufactured	(0018,7011)	3	Total number of X-Ray exposures that have been made on the detector used to acquire this image as identified in Detector ID (0018,700A) since it was manufactured.
Detector Time Since Last Exposure	(0018,7012)	3	Time in Seconds since an exposure was last made on this detector prior to the acquisition of this image.
Detector Binning	(0018,701A)	3	Number of active detectors used to generate a single pixel. Specified as number of row detectors per pixel then column.
Detector Manufacturer Name	(0018,702A)	3	Name of the manufacturer of the detector component of the acquisition system
Detector Manufacturer's Model Name	(0018,702B)	3	Model name of the detector component of the acquisition system

Detector Conditions Nominal Flag	(0018,7000)	3	Whether or not the detector is operating within normal tolerances during this image acquisition. Enumerated Values: YES NO Note: This flag is intended to indicate whether or not there may have been some compromise of the diagnostic quality of the image due to some condition such as over-temperature, etc.
Detector Temperature	(0018,7001)	3	Detector temperature during exposure in degrees Celsius.
Sensitivity	(0018,6000)	3	Detector sensitivity in manufacturer specific units. Note: This value is intended to provide a single location where manufacturer specific information can be found for annotation on a display or film, that has meaning to a knowledgeable observer.
Detector Element Physical Size	(0018,7020)	3	Physical dimensions of each detector element that comprises the detector matrix, in mm. Expressed as row dimension followed by column. Note: This may not be the same as Detector Element Spacing (0018,7022) due to the presence of spacing material between detector elements.
Detector Element Spacing	(0018,7022)	3	Physical distance between the center of each detector element, specified by a numeric pair - row spacing value(delimiter) column spacing value in mm. Note: This may not be the same as the Imager Pixel Spacing (0018,1164), and should not be assumed to describe the stored image.
Detector Active Shape	(0018,7024)	3	Shape of the active area. Enumerated Value: RECTANGLE ROUND HEXAGONAL Note: This may be different from the Field of View Shape (0018,1147), and should not be assumed to describe the stored image.

Detector Active Dimension(s)	(0018,7026)	3	Dimensions in mm of the active area. If Detector Active Shape(0018,7024) is: RECTANGLE: row dimension followed by column. ROUND: diameter. HEXAGONAL: diameter of a circumscribed circle. Note: This may be different from the Field of View Dimensions (0018,1149), and should not be assumed to describe the stored image.
Detector Active Origin	(0018,7028)	3	Offset of the TLHC of a rectangle circumscribing the active detector area from the TLHC of a rectangle circumscribing the physical detector area, measured in physical detector pixels as a row offset followed by a column offset. See C.8.11.4.1.1 for further explanation.

Item #18: Add to section C.8 MODALITY SPECIFIC MODULES

C.8.X.1 XA/XRF Series Module

The XA/XRF X-Ray IODs use the General Series module described in section C.7.3.1, specialized by the XA/XRFX Series Module, to describe the DICOM Series Entity specified in A.X and A.Y. It is defining what constitutes a Series for the context of projection XA/XRF device.

Table C.8-X1-1 specifies the Attributes that identify and describe general information about the XA/XRF Series.

Table C.8-X1-1
XA/XRF SERIES MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Type of equipment that originally acquired the data used to create the images in this Series. Enumerated Values: XA RF See section C.7.3.1.1.1 for further explanation.
Series Number	(0020,0011)	1	A number that identifies this Series.

Referenced Performed Procedure Step Sequence	(0008,1111)	1C	Uniquely identifies the Performed Procedure Step SOP Instance to which the Series is related (e.g. a Modality or General-Purpose Performed Procedure Step SOP Instance or Study Component SOP Instance). Only a single Item is permitted in this sequence. Required if the Modality Performed Procedure Step SOP Class, General Purpose Performed Procedure Step SOP Class or Study Component SOP Class is supported.
>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.
>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.

524 **C.8.X.2 Enhanced XA/XRF Image Module**

This section describes the Enhanced XA/XRF Image Module. Table C.8.X2-1 contains IOD Attributes that
526 describe a XA/XRF Image by specializing Attributes of the General Image and Image Pixel Modules, and adding additional Attributes.

528 **Table C.8.X2-1**
Enhanced XA/XRF Image Module Table

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See C.8.X.2.1.1 for specialization.
Plane Identification	(0018,9457)	1C	Identification of the plane used to acquire this image. Defined Terms: MONOPLANE PLANE A PLANE B Notes: 1. MONOPLANE may only be used for a single plane system 2. PLANE A and PLANE B must be used for two plane systems, independent if the acquisition is single plane or biplane. 3. The value has to be in accordance with Image Type (0008,0008) value 3. If this value is SINGLE PLANE all three Defined Term are applicable. Required if Image Type (0008,0008) Value 3 is not equal to UNDEFINED.
Acquisition Number	(0020,0012)	3	A number identifying the single continuous gathering of data over a period of time that resulted in this image.

Acquisition Datetime	(0008,002A)	1	The date and time that the acquisition of data that resulted in this image started. Note: The synchronization of this time with an external clock is specified in the Synchronization Module in Acquisition Time Synchronized (0018,1800).
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. Enumerated Values: 8 and 16.
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. Enumerated Values: 8 to 16. See C.8.X.2.1.2 for specialization.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. Shall be one less than the value in Bits Stored (0028,0101).
Samples per Pixel	(0028,0002)	1	Number of samples (color planes) in this image shall have a value of 1.
Pixel Representation	(0028,0103)	1	Data representation of the pixel samples. Shall have the value: 0000H = Unsigned Integer.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. Enumerated Values: MONOCHROME1 MONOCHROME2
Acquisition Protocol Name	(0018,9423)	3	User defined name of the protocol used to acquire this image.
Acquisition Protocol Description	(0018,9424)	3	User defined description of the protocol used to acquire this image.
Scan Options	(0018,0022)	3	Identifies any acquisition technique that was used during the acquisition of the image. Defined Terms: TOMO = Tomography CHASE = Bolus Chasing STEP = Stepping ROTA = Rotation
Content Qualification	(0018,9004)	1	Content Qualification Indicator Enumerated Values: PRODUCT RESEARCH SERVICE See C.8.13.2.1.1 for further explanation.

Patient Orientation Code Sequence	(0054,0410)	1C	Sequence that describes the orientation of the patient with respect to gravity. See C.8.11.5.1.2 for further explanation. Only a single Item shall be permitted in this Sequence. Required if Positioner Type (0018,1508) equals CARM and C-arm Positioner Tabletop Relationship (0018,9474) equals YES. May be present otherwise.
>*Include 'Code Sequence Macro' Table 8.8-1*.			Baseline Context ID 19
> Patient Orientation Modifier Code Sequence	(0054,0412)	1C	Patient Orientation Modifier. Required if needed to fully specify the orientation of the patient with respect to gravity. Only a single Item shall be permitted in this Sequence.
>>*Include 'Code Sequence Macro' Table 8.8-1*.			Baseline Context ID 20
Patient Gantry Relationship Code Sequence	(0054,0414)	2C	Sequence that describes the orientation of the patient with respect to the head of the table. See Section C.8.4.6.1.3 for further explanation. Only a single Item shall be permitted in this Sequence. Required if Positioner Type (0018,1508) equals CARM and C-arm Positioner Tabletop Relationship (0018,9474) equals YES. May be present otherwise.
>>*Include 'Code Sequence Macro' Table 8.8-1*.			Baseline Context ID 21
Examined Body Thickness	(0010,9431)	3	Body thickness in mm at examination location perpendicular to the table top for this series. Notes: 1. This is intended for estimation of the thickness of the patient at the tabletop, not for precise calculation of the size of the object in the X-Ray beam (see Calculated Anatomy Thickness (0018,9452) attribute). 2. For example, used to estimate the value range of the Distance Object to Table Top (0018,9403) attribute.
Burned In Annotation	(0028,0301)	1	Indicates that the image shall not contain burned in annotations. Enumerated Values: NO

Lossy Image Compression	(0028,2110)	1	Specifies whether an Image has undergone lossy compression. Enumerated Values: 00 = Image has NOT been subjected to lossy compression. 01 = Image has been subjected to lossy compression. See C.7.6.1.1.5 for further explanation.
Lossy Image Compression Ratio	(0028,2112)	1C	See C.7.6.1.1.5 for further explanation. Required if Lossy Image Compression (0028,2110) equals 01.
Lossy Image Compression Method	(0028,2114)	1C	A label for the lossy compression method(s) that have been applied to this image. See C.7.6.1.1.5 for further explanation. May be multi valued if successive lossy compression steps have been applied; the value order shall correspond to the values of Lossy Image Compression Ratio (0028,2112). Note: For historical reasons, the lossy compression method may also be described in Derivation Description (0008,2111). Required if Lossy Image Compression (0028,2110) equals 01.
Referenced Other Plane Sequence	(0008,9410)	1C	A sequence that identifies the SOP Class/Instance pairs of the corresponding plane for a Biplane acquisition device. Only a single Item shall be permitted in this Sequence. Required if Image Type (0008,0008) Value 3 is BIPLANE A or BIPLANE B.
>Include 'SOP Instance Reference Macro' Table C.10-3			
Referenced Image Evidence Sequence	(0008,9092)	1C	Full set of Composite SOP Instances referred to inside the Referenced Image Sequences of this SOP Instance. See C.8.13.2.1.2 for further explanation. One or more Items may be permitted in this sequence. Required if the Referenced Image Sequence (0008,1140) is present.
>Include 'SOP Instance Reference Macro' Table C.17-3			

Source Image Evidence Sequence	(0008,9154)	1C	Full set of Composite SOP Instances referred to inside the Source Image Sequences of this SOP Instance. See C.8.13.2.1.2 for further explanation. One or more Items may be permitted in this sequence. Required if the Source Image Sequence (0008,2112) is present.
>Include 'SOP Instance Reference Macro' Table C.17-3			
Referenced Instance Sequence	(0008,114A)	3	A sequence which provides reference to a set of non-image SOP Class/Instance pairs significantly related to this Image, including waveforms that may or may not be temporally synchronized with this image. One or more Items may be included in this sequence.
>Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if a Sequence Item is present.
>Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if a Sequence Item is present.
>Purpose of Reference Code Sequence	(0040,A170)	1	Code describing the purpose of the reference to the SOP Instances. Only a single Item shall be permitted in this sequence.
>>Include 'Code Sequence Macro' Table 8.8-1			*Defined Context ID is CID 7004 for referenced waveforms.*
Image Comments	(0020,4000)	3	User-defined comments about the image.
Quality Control Image	(0028,0300)	3	Indicates whether or not this image is a quality control or phantom image. Enumerated Values: YES NO If this Attribute is absent, then the image may or may not be a quality control or phantom image.
Icon Image Sequence	(0088,0200)	3	This icon image is representative of the Image.
> Include 'Image Pixel Macro' Table C.7-11b			See C.7.6.1.1.6 for further explanation.

Presentation LUT Shape	(2050,0020)	1	Specifies a predefined identity transformation for the Presentation LUT such that the output of all grayscale transformations, if any, are defined to be in P-Values. Enumerated Values: IDENTITY - output is in P-Values - shall be used if Photometric Interpretation (0028,0004) is MONOCHROME2 INVERSE - output after inversion is in P-Values - shall be used if Photometric Interpretation (0028,0004) is MONOCHROME1.

C.8.X.2.1 Enhanced XA/XRF Image Module Attribute Description

C.8.X.2.1.1 Image Type

The Image Type attribute identifies important image characteristics in a multiple valued data element. For X-Ray, Image Type is specialized as follows:

a. Value 1 shall identify the Pixel Data Characteristics in accordance with Section C.7.6.1.1.2; Enumerated Values are: ORIGINAL and DERIVED;

b. Value 2 shall identify the Patient Examination Characteristics in accordance with Section C.7.6.1.1.2; Enumerated Values are: PRIMARY and SECONDARY.

Note: X-Ray images generally use PRIMARY value for images captured from patient exposure.

c. Value 3 shall identify the image set in terms of the imaging planes. Enumerated Values are:

SINGLE PLANE	Image is a single plane acquisition;
BIPLANE A	Image is the first plane (e.g., Frontal) of a Bi-plane acquisition;
BIPLANE B	Image is the second plane (e.g., Lateral) of a Bi-plane acquisition
UNDEFINED	Image is created by using data from one or two planes (e.g., reconstructed projection). May only be used when Image Type Value 1 equals DERIVED.

d. Other Values are implementation specific (optional).

C.8.X.2.1.2 Bits Allocated and Bits Stored

548 Table C.8.X2-2 specifies the allowed combinations of Bits Allocated (0028,0100) and Bits Stored (0028,0101).

550 **Table C.8.X2-2**
ALLOWED COMBINATIONS OF ATTRIBUTE VALUES
552 **FOR BITS ALLOCATED AND BITS STORED**

Bits Allocated	Bits Stored
8	8
16	9 to16

554 C.8.X.3 XA/XRF Acquisition Module

Table C.8.X3-1 specifies the attributes of the XA/XRF Acquisition Module.

556 **Table C.8.X3-1**
XA/XRF ACQUISITION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
KVP	(0018,0060)	1	Average of the peak kilo voltage outputs of the X-Ray generator used for all frames.
Radiation Setting	(0018,1155)	1	Identify the general level of X-Ray dose exposure. Enumerated values are: SC = low dose exposure generally corresponding to fluoroscopic settings (e.g. preparation for diagnostic quality image acquisition); GR = high dose for diagnostic quality image acquisition (also called digital spot or cine);
X-Ray Tube Current in mA	(0018,9330)	1C	Average of the nominal X-ray tube currents in milliamperes for all frames. Required if Exposure in mAs (0018,9332) is not present. May be present otherwise.
Exposure Time in ms	(0018,9328)	1C	Duration of X-Ray exposure in milliseconds. See C.8.7.2.1.1. Required if Exposure in mAs (0018,9332) is not present. May be present otherwise.
Exposure in mAs	(0018,9332)	1C	The exposure expressed in milliampereseconds, for example calculated from Exposure Time and X-ray Tube Current. Required if either Exposure Time in ms (0018,9328) or X-Ray Tube Current in mA (0018,9330) are not present. May be present otherwise.
Average Pulse Width	(0018,1154)	1	Average width of X-Ray pulse in msec.

Acquisition Duration	(0018,9073)	1	The time in seconds needed for the complete acquisition. See C.7.6.16.2.2.1 for further explanation
Radiation Mode	(0018,115A)	1	Specifies X-Ray radiation mode. Defined Terms: CONTINUOUS PULSED
Focal Spot	(0018,1190)	3	Nominal focal spot size in mm used to acquire this image.
Anode Target Material	(0018,1191)	3	The primary material in the anode of the X-Ray source. Defined Terms: TUNGSTEN MOLYBDENUM RHODIUM
Rectification Type	(0018,1156)	3	Type of rectification used in the X-Ray generator. Defined Terms: SINGLE PHASE THREE PHASE CONST POTENTIAL
X-Ray Receptor Type	(0018,9420)	1	Identifies with type of X-ray receptor is used. Enumerated Values: IMG_INTENSIFIER DIGITAL_DETECTOR
Imager Pixel Spacing	(0018,1164)	1	Physical distance measured at the receptor plane of the detector between the centers of each pixel specified by a numeric pair – row spacing value (delimiter) column spacing value in mm. Note: These values are the actual pixel spacing distances of the stored pixel values of an image.
Distance Receptor Plane to Detector Housing	(0018,9426)	2	Distance in mm between the receptor plane and the detector housing. The direction of the distance is positive from receptor plane to X-Ray source. Note: 1. A negative value is allowed in the case of an image intensifier the receptor plane can be a virtual plane located outside the detector housing depending the magnification factor of the intensifier. A negative value is not applicable for the digital detector. 2. Used to calculate the pixel size of the plane in the patient when markers are used, and they are placed on the detector housing.

Positioner Type	(0018,1508)	1	Defined Terms: CARM COLUMN Notes: 1. The term CARM can apply to any positioner with 2 degrees of freedom of rotation of the X-Ray beam about the Imaging Subject. 2. The term COLUMN can apply to any positioner with 1 degree of freedom of rotation of the X-Ray beam about the Imaging Subject.
C-arm Positioner Tabletop Relationship	(0018,9474)	1C	Describes for C-arm positioner type systems if positioner and tabletop has the same geometrical reference system. Defined Terms: YES NO Note: The value NO is intended for mobile systems where there is no table fixed to the system Required if Positioner Type (0018,1508) equals CARM.
Acquired Image Area Dose Product	(0018,9473)	2	X-Ray dose, measured in dGy*cm*cm, to which the patient was exposed for the acquisition of this image only. Notes: 1. The sum of the Image Area Dose Product of all images of a Series or a Study may not result in the actual area dose product to which the patient was exposed. 2. This may be an estimated value based on assumptions about the patient's body size and habitus.

558

C.8.X.4 X-Ray Image Intensifier module

560 Table C.8.X4-1 specifies the attributes of the X-Ray Image Intensifier Module.

Table C.8.X4-1
562 **X-RAY IMAGE INTENSIFIER MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Intensifier Size	(0018,1162)	1	Physical diameter of the maximum active area X-Ray intensifier in mm. Note: This attribute does not specify the field of view. The attribute Field of View Dimension(s) in Float (0018,9461) is intended for this value.
Intensifier Active Shape	(0018,9427)	1	Shape of the active area used for acquiring this image. Enumerated Value: RECTANGLE ROUND HEXAGONAL Note: This may be different from the Field of View Shape (0018,1147), and should not be assumed to describe the stored image.
Intensifier Active Dimension(s)	(0018,9428)	1	Dimensions in mm of the active area used for acquiring this image. If Intensifier Active Shape (0018,9427) is: RECTANGLE: row dimension followed by column. ROUND: diameter. HEXAGONAL: diameter of the circle circumscribing the hexagon. Note: This may be different from the Field of View Dimension(s) in Float (0018,9461), and should not be assumed to describe the stored image.

564 C.8.X.5 X-Ray Detector Module

Table C.8.X5-1 contains IOD Attributes that describe an X-Ray detector.

566 **Table C.8.X5-1**
X-RAY DETECTOR MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include 'Digital X-Ray Detector Macro' Table C.8-71b			
Physical Detector Size	(0018,9429)	1	Dimensions of the physical detector measured in mm as a row size followed by a column size.

Position of Isocenter Projection	(0018,9430)	1C	Position of the Isocenter measured in physical detector elements as a row offset followed by a column offset from the TLHC of a rectangle circumscribing the physical detector area. Required if Isocenter Reference System Sequence (0018,9462) is present.

C.8.X.6 Enhanced XA/XRF Image Functional Group Macros

The following sections contain Functional Group macros specific to the Enhanced XA Image IOD.

Note: The attribute descriptions in the Functional Group Macros are written as if they were applicable to a single frame (i.e., the macro is part of the Per-frame Functional Groups Sequence). If an attribute is applicable to all frames (i.e. the macro is part of the Shared Functional Groups Sequence) the phrase "this frame" in the attribute description shall be interpreted to mean " for all frames".".

C.8.X.6.1 XA/XRF Frame Characteristics Macro

Table C.8.X6-1 specifies the attributes of the XA/XRF Frame Characteristics Functional Group macro.

Table C.8.X6-1
XA/XRF FRAME CHARACTERISTICS MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
XA/XRF Frame Characteristics Sequence	(0018,9412)	1	A sequence that describes general characteristics of this frame. Only a single Item shall be permitted in this sequence.
>Derivation Description	(0008,2111)	3	A text description of how this frame was derived. See C.8.7.1.1.5 for further explanation.
>Derivation Code Sequence	(0008,9215)	3	A coded description of how this frame was derived. See C.7.6.1.1.3 for further explanation.
>>*Include 'Code Sequence Macro' Table 8.8-1*			Defined Context ID is 7203.
>Acquisition Device Processing Description	(0018,1400)	3	Indicates any visual processing performed on the frame prior to exchange. See Section C.8.7.1.1.3.
>Acquisition Device Processing Code	(0018,1401)	3	Code representing the device-specific processing associated with the frame (e.g. Organ Filtering code) Note: This Code is manufacturer specific but provides useful annotation information to the knowledgeable observer.

C.8.X.6.2 X-Ray Field of View Macro

Table C.8.X6-2 specifies the attributes of the X-Ray Field of View Functional Group macro.

584 **Table C.8.X6-2**
X-RAY FIELD OF VIEW MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Field of View Sequence	(0018,9432)	1	Sequence containing the field of view for this frame. One or more items may be included in this sequence.
>Field of View Shape	(0018,1147)	3	Shape of the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010). Enumerated Values: RECTANGLE ROUND HEXAGONAL
>Field of View Dimension(s) in Float	(0018,9461)	3	Dimensions in mm of the Field of View, that is the image pixels stored in Pixel Data (7FE0,0010). If Field of View Shape (0018,1147) is: RECTANGLE: row dimension followed by column. ROUND: diameter. HEXAGONAL: diameter of the circle circumscribing the hexagon.
>Field of View Origin	(0018,7030)	1C	Offset of the TLHC of a rectangle circumscribing the Field of View, i.e., the image pixels stored in Pixel Data (7FE0,0010) before rotation or flipping, from the TLHC of the physical detector area measured in physical detector pixels as a row offset followed by a column offset. See C.8.11.4.1.1 for further explanation. Required if X-Ray Receptor Type (0018,9420) is present and equals DIGITAL_DETECTOR.
>Field of View Rotation	(0018,7032)	1	Clockwise rotation in degrees of Field of View, i.e., the image pixels stored in Pixel Data (7FE0,0010), relative to the physical detector. Enumerated Values: 0, 90, 180, 270 See C.8.11.4.1.1 for further explanation.

>Field of View Horizontal Flip	(0018,7034)	1	Whether or not a horizontal flip has been applied to the Field of View, i.e., the image pixels stored in Pixel Data (7FE0,0010), after rotation relative to the physical detector as described in Field of View Rotation (0018,7032). Enumerated Values: NO YES See C.8.11.4.1.1 for further explanation.
>Field of View Description	(0018,9433)	3	Manufacturer defined description of the field of view selected during acquisition.

C.8.X.6.3 X-Ray Exposure Control Sensing Regions Macro

Table C.8.X6-3 specifies the attributes that describe the region targeted as area where the x-ray dose value is estimated.

Table C.8.X6-3
X-RAY EXPOSURE CONTROL SENSING REGIONS MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Exposure Control Sensing Regions Sequence	(0018,9434)	1	Sequence containing the Exposure Control Sensing Region for this frame. One or more items may be included in this sequence.
>Exposure Control Sensing Region Shape	(0018,9435)	1	Shape of the Exposure Control Sensing Region. Enumerated Values: RECTANGULAR CIRCULAR POLYGONAL
>Exposure Control Sensing Region Left Vertical Edge	(0018,9436)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is RECTANGULAR. Location of the left edge of the rectangular Exposure Control Sensing Region expressed as effective pixel column. See C.8.X.6.3.1.
>Exposure Control Sensing Region Right Vertical Edge	(0018,9437)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is RECTANGULAR. Location of the right edge of the rectangular Exposure Control Sensing Region expressed as effective pixel column. See C.8.X.6.3.1.
>Exposure Control Sensing Region Upper Horizontal Edge	(0018,9438)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is RECTANGULAR. Location of the upper edge of the rectangular Exposure Control Sensing Region expressed as effective pixel row. See C.8.X.6.3.1.

>Exposure Control Sensing Region Lower Horizontal Edge	(0018,9439)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is RECTANGULAR. Location of the lower edge of the rectangular Exposure Control Sensing Region expressed as effective pixel row. See C.8.X.6.3.1.
>Center of Circular Exposure Control Sensing Region	(0018,9440)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is CIRCULAR. Location of the center of the circular Exposure Control Sensing Region expressed as effective pixel row and column. See C.8.X.6.3.1.
>Radius of Circular Exposure Control Sensing Region	(0018,9441)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is CIRCULAR. Radius of the circular Exposure Control Sensing Region expressed as effective number of pixels along the row direction. See C.8.X.6.3.1.
>Vertices of the Polygonal Exposure Control Sensing Region	(0018,9442)	1C	Required if Exposure Control Sensing Region Shape (0018,9435) is POLYGONAL. Multiple Values where the first set of two values are: row of the origin vertex; column of the origin vertex. Two or more pairs of values follow and are the effective pixel row and column coordinates of the other vertices of the polygon Exposure Control Sensing Region. Polygon Exposure Control Sensing Regions are implicitly closed from the last vertex to the origin vertex and all edges shall be non-intersecting except at the vertices. See C.8.X.6.3.1.

C.8.X.6.3.1 X-Ray Exposure Control Sensing Regions attributes

The Exposure Control Sensing Region Left Vertical Edge (0018,9436), Exposure Control Sensing Region Right Vertical Edge (0018,9437), Exposure Control Sensing Region Upper Horizontal Edge (0018,9438), Exposure Control Sensing Region Lower Horizontal Edge (0018,9439) and Center of Circular Exposure Control Sensing Region (0018,9440) may have a negative value when the point defined by the attribute lies outside the left or upper border of the pixel data matrix. The top left pixel of the image has a pixel row and column value of 1.

C.8.X.6.4 XA/XRF Frame Pixel Data Properties Macro

600 Table C.8.X6-4 specifies the attributes of the Frame Pixel Data Properties Functional Group macro.

Table C.8.X6-4

602 **XA/XRF FRAME PIXEL DATA PROPERTIES MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Frame Pixel Data Properties Sequence	(0028,9443)	1	Sequence containing the pixel data properties for this frame. Only a single Item shall be permitted in this sequence.
>Pixel Intensity Relationship	(0028,1040)	1	The relationship between the Pixel and the X-Ray beam intensity. See C.8.X.6.4.1.
>Pixel Intensity Relationship Sign	(0028,1041)	1	The sign of the relationship between the Pixel sample values stored in Pixel Data (7FE0,0010) and the X-Ray beam intensity. Enumerated Values: 1 = Lower pixel values correspond to less X-Ray beam intensity -1 = Higher pixel values correspond to less X-Ray beam intensity See C.8.11.3.1.2 for further explanation.
>Geometrical Properties	(0028,9444)	1	Geometrical characteristics of the pixel data to indicate whether pixel spacing is uniform for all pixels or not. Enumerated Values: UNIFORM NON_UNIFORM
>Geometric Maximum Distortion	(0028,9445)	2C	The percentage of the maximum deviation of the pixel spacing values of images for which the geometric properties are non-uniform. Note: This attribute may be used to judge the result of measurements, 3D reconstructions, etc. Required if Geometrical Properties (0028,9444) equals NON_UNIFORM.

>Image Processing Applied	(0028,9446)	1	The type or a combination of types of image processing applied to the pixel data before being stored. Defined Terms: DIGITAL_SUBTR HIGH_PASS_FILTER LOW_PASS_FILTER MULTI_BAND_FLTR FRAME_AVERAGING NONE

604 **C.8.X.6.4.1 Pixel Intensity Relationship**

Pixel Intensity Relationship (0028,1040) shall identify the relationship of the pixel values to the X-Ray
606 beam intensity. Defined terms are:

LIN — Approximately proportional to X-Ray beam intensity.

LOG — Non-linear " Log Function"; A Pixel Intensity Relationship LUT shall be included with the image to allow it to be mapped back to its proportional value to X-Ray beam intensity.

OTHER — Not proportional to X-Ray beam intensity. If a TO_LINEAR Pixel Intensity Relationship LUT item is supplied, scaling back to X-Ray beam intensity is possible.

Notes: 1. When the relationship can be better defined (e.g., square root data) a more precise Defined Term can be used than OTHER.

2. Providing a TO_LINEAR Pixel Intensity Relationship LUT is encouraged.

608 **C.8.X.6.5 X-Ray Frame Detector Parameters Macro**

Table C.8.X6-5 specifies the attributes containing the X-Ray Frame Detector Parameters Functional Group
610 macro.

Table C.8.X6-5
612 **X-RAY FRAME DETECTOR PARAMETERS MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Frame Detector Parameters Sequence	(0018,9451)	1	Sequence containing the detector properties for this frame. Only a single Item shall be permitted in this sequence.
>Detector Active Time	(0018,7014)	3	Time in mSec that the detector is active during acquisition of this image. Note: This activation window overlaps the time of the X-Ray exposure as defined by Exposure Time in ms (0018,9328) and Detector Activation Offset From Exposure (0018,7016).

>Detector Activation Offset From Exposure	(0018,7016)	3	Offset time in mSec that the detector becomes active after the X-Ray beam is turned on during acquisition of this image. May be negative.

C.8.X.6.6 X-Ray Calibration Device Usage Macro

Table C.8.X6-6 specifies the attributes containing the X-Ray Calibration Device Usage Functional Group macro.

Table C.8.X6-6
X-RAY CALIBRATION DEVICE USAGE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Calibration Sequence	(0018,9455)	1	Sequence containing the calibration flag for this frame. Only a single Item shall be permitted in this sequence.
>Calibration Image	(0050,0004)	1	Indicates whether a reference object (phantom) of known size is present in the frame and was used for calibration. Enumerated Values: YES NO Note: Device is identified using the Device module. See C.7.6.12.

C.8.X.6.7 X-Ray Object Thickness Macro

Table C.8.X6-7 specifies the attributes containing the X-Ray Object Thickness Group macro.

Table C.8.X6-7
X-RAY OBJECT THICKNESS MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Object Thickness Sequence	(0018,9456)	1	Sequence containing object thickness for this frame. Only a single Item shall be permitted in this sequence.
>Calculated Anatomy Thickness	(0018,9452)	1	The physical thickness in mm of the anatomic region of interest as specified in the Anatomic Region Sequence (0008,2218) in the direction of the center of the beam. Note: The value takes in account the position relative to object and the X-Ray source – detector axis.

C.8.X.6.8 X-Ray Frame Acquisition Macro

Table C.8.X6-8 specifies the attributes containing the X-Ray Frame Acquisition Functional Group macro.

Table C.8.X6-8
X-RAY FRAME ACQUISITION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Acquisition Sequence	(0018,9417)	1	Sequence containing the acquisition parameters for this frame. Only a single Item shall be permitted in this sequence.
>KVP	(0018,0060)	1	Exact peak kilo voltage output of the X-Ray generator used for this frame.
>X-Ray Tube Current in mA	(0018,9330)	1	Exact Nominal X-ray tube current in milliamperes applied during the Acquisition Duration (0018,9220) for this frame.

C.8.X.6.8.1 X-Ray Frame Acquisition Sequence Attributes

These attribute may only be used if the information is available on a frame-by-frame base. The average values for these attributes of all frames shall be stored in the same attribute in the XA/XRF Acquisition Module (Section C.8.X.3).

C.8.X.6.9 X-Ray Projection Pixel Calibration Macro

Table C.8.X6-9 specifies the attributes of the X-Ray Projection Pixel Calibration Functional Group macro.

Table C.8.X6-9
X-RAY PROJECTION PIXEL CALIBRATION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Projection Pixel Calibration Sequence	(0018,9401)	1	A sequence that describes the geometrical position of the patient relative to the equipment. Only a single Item shall be permitted in this sequence.
>Distance Object to Table Top	(0018,9403)	2	Distance between the anatomic region of interest of observation and table top in mm. Notes: 1.This value is always positive, the object is assumed to be above the table. 2.The value of this attribute is depending on the patient position on the tabletop (supine, left or right decubitus, etc.)

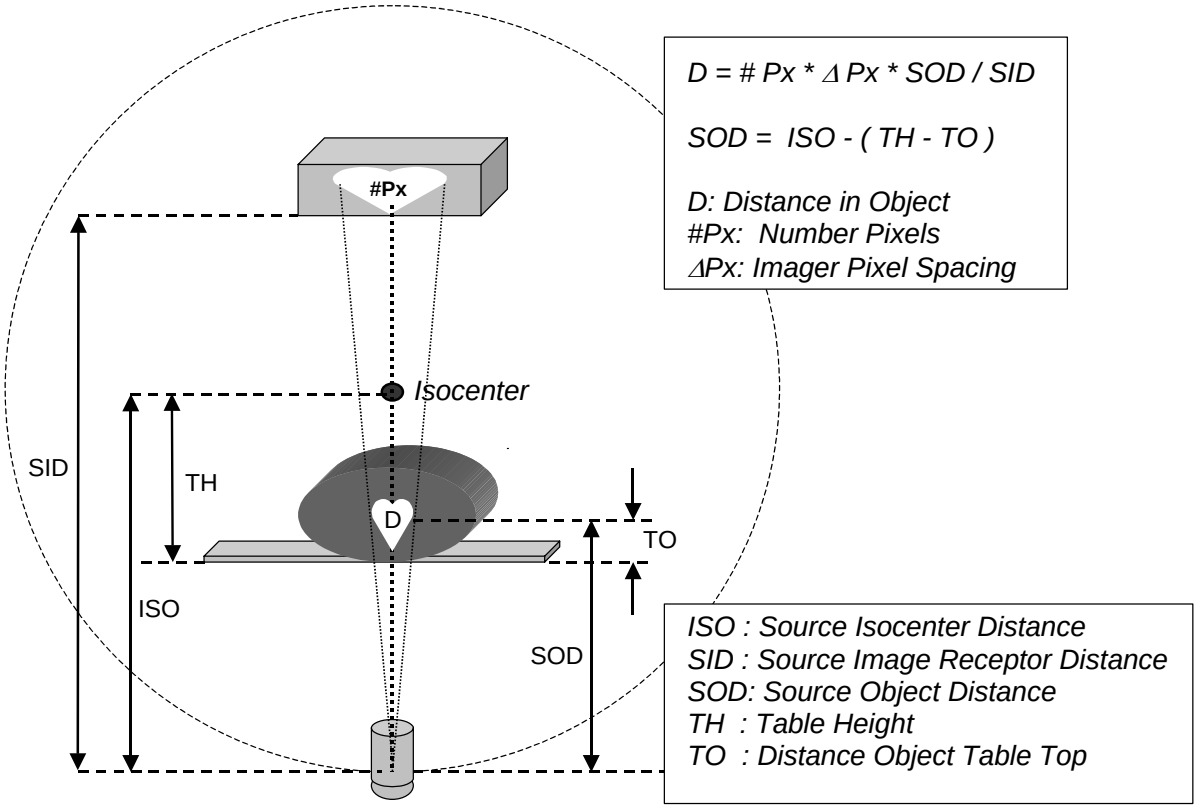
>Object Pixel Spacing in Center of Beam	(0018,9404)	1C	Physical distance within the anatomic region of interest in the center of the beam and perpendicular to the beam between the center of each pixel, specified by a numeric pair adjacent row spacing (delimiter) adjacent column spacing in mm. See C.8.X.6.9.1 Required if Distance Object to Table Top (0018,9403) is not empty. Note: This value is provided besides the values that are the input parameters of the calibration algorithm.
>Table Height	(0018,1130)	1C	The distance of the top of the patient table to the center of rotation of the source (i.e. the isocenter) in mm. A positive value indicates that the tabletop is below the isocenter. Note: All the distances are measured perpendicular to the Table Top plane. Required if Image Type (0008,0008) Value 1 is ORIGINAL, may be present otherwise.
>Beam Angle	(0018,9449)	1C	The equipment related angle in degrees of the X-Ray beam relative to the perpendicular to the tabletop plane. An angle from 0 to +90 degrees indicates that the X-Ray source is below the table. The valid range is 0 to +180 degrees. Required if Image Type (0008,0008) Value 1 is ORIGINAL, may be present otherwise.

C.8.X.6.9.1 Project Calibration Method

The X-Ray Projection Pixel Calibration Macro defines the attributes needed to completely describe the specific inputs and results from projection image pixel calibration based on isocenter reference. The attributes are provided to allow usage of calibration result as well as recalibration. The below included figures illustrate the relationship of the attributes. The term ISO refers to Distance Source to Isocenter attribute (0018,9402). The Imager Pixel Spacing (0018,1164) is defined in the XA/XRF Acquisition Module.

Note: The equipment related Beam Angle attribute (0018,9449) shall be consistent with the patient oriented Positioner Primary Angle (0018,1510) and Positioner Secondary Angle (0018,1511) together with the patient orientation on the table specified in Patient Orientation Code Sequence (0054,0410) attributes.

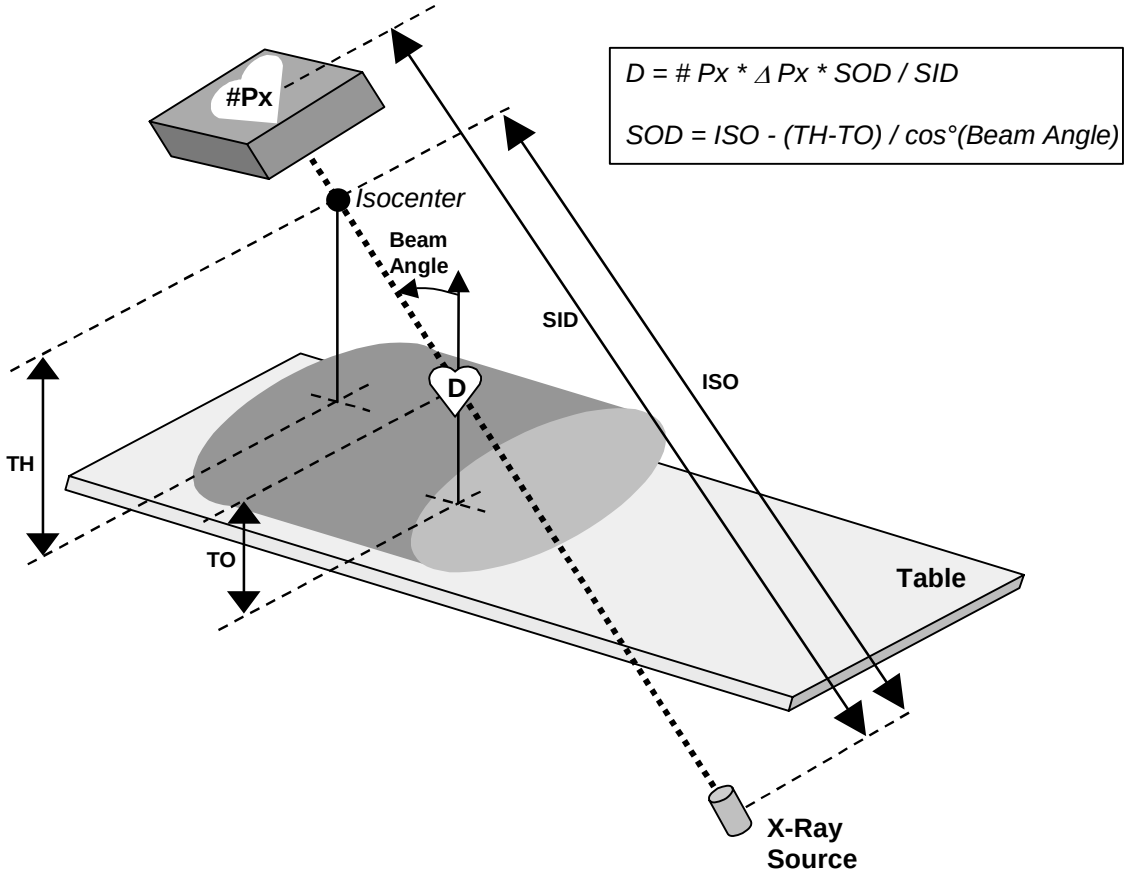
The Figures C.8.X6-1 and C.8.X6-2 illustrate the usage of the attributes under the conditions laid out above.



650

Figure C.8.X6-1

652 **Project Calibration without angulation of the X-Ray beam (Beam Angle = 0)**



654 **Figure C.8.X6-2**
Project Calibration with angulation of the X-Ray beam (Beam Angle not equal 0)

656 **C.8.X.6.9.2 Object Pixel Spacing in Center of Beam**

The value provided for the Beam Angle (0018,9449) attribute shall correspond to the other attribute values
658 within this module and according to the mathematic terms listed in section C.8.X.6.9.1.

The terms listed will result in infinite result when used with 90-degree beam angles.

660 It is outside the scope of this Standard to define reasonable limits for single input values in the above-mentioned terms, or to define the mathematical accuracy of applications using those terms.

662 Note: It may be reasonable to limit automatic calculations to a narrow range of +/- 60 degrees for Beam Angle and inform users about possible deviations in the calibration result when exceeding such range limits.

664

C.8.X.6.10 X-Ray Positioner Macro

Table C.8.X7-10 specifies the attributes of the X-Ray Positioner Functional Group macro. If included into the Shared Functional Groups Sequence (5200,9229) no DYNAMIC motion was performed during acquisition. If included in the Per-frame Functional Groups Sequence (5200,9230) the indication of a DYNAMIC motion is given.

Table C8.X7-10
X-RAY POSITIONER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Positioner Position Sequence	(0018,9405)	1	A sequence that describes the geometrical position of the positioner. Only a single Item shall be permitted in this sequence.
>Positioner Primary Angle	(0018,1510)	1C	Position of the X-Ray Image Intensifier about the patient from the RAO to LAO direction where movement from RAO to vertical is positive. See C.8.7.5.1.2. Required if Positioner Type (0018,1508) equals CARM.
>Positioner Secondary Angle	(0018,1511)	1C	Position of the X-Ray Image Intensifier about the patient from the CAU to CRA direction where movement from CAU to vertical is positive. See C.8.7.5.1.2 Required if Positioner Type (0018,1508) equals CARM.
>Column Angulation (Patient)	(0018,9447)	1C	Angle of the X-Ray beam in degree relative to an orthogonal axis to the detector plane. Positive values indicate that the tilt is towards the head of the patient. Notes: 1. The detector plane is assumed to be parallel to the table plane 2. This attribute differentiates form the attribute Column Angulation (0018,1450) by using the patient based coordinate system instead of the equipment based coordinate system. Required if Positioner Type (0018,1508) equals COLUMN.

C.8.X.6.11 X-Ray Table Position Macro

Table C.8.X6-11 specifies the attributes of the X-Ray Table Position Functional Group macro.

Table C.8.X6-11
X-RAY TABLE POSITION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Table Position Sequence	(0018,9406)	1	A sequence that describes the geometrical position of the table top. Only a single Item shall be permitted in this sequence.
>Table Top Vertical Position	(300A,0128)	1	Table Top Vertical position with respect to an arbitrary chosen reference by the equipment in (mm). Table motion downwards is positive
>Table Top Longitudinal Position	(300A,0129)	1	Table Top Longitudinal position with respect to an arbitrary chosen reference by the equipment in (mm). Table motion towards LAO is positive assuming that the patient is positioned supine and its head is in normal position.
>Table Top Lateral Position	(300A,012A)	1	Table Top Lateral position with respect to an arbitrary chosen reference by the equipment in (mm). Table motion towards CRA is positive assuming that the patient is positioned supine and its head is in normal position.
>Table Horizontal Rotation Angle	(0018,9469)	1	Rotation of the table in the horizontal plane (clockwise when looking from above the table).
>Table Head Tilt Angle	(0018,9470)	1	Angle of the head-feet axis of the table in degrees relative to the horizontal plane. Positive values indicate that the head of the table is upwards.
>Table Cradle Tilt Angle	(0018,9471)	1	Angle of the left-right axis of the table in degrees relative to the horizontal plane. Positive values indicate that the left of the table is upwards.

C.8.X.6.11.1 X-Ray Table Position Macro Attribute Description

The Table Top Position attributes of the Table Position Sequence (0018,9406) specify the geometrical position of the Table in the three spatial directions (i.e. Vertical, Longitudinal and Lateral) relative to the Table Top plane (see Figure C.8.X6-3). The absolute reference point to which the Table positions are related is arbitrarily defined by the manufacturer.

The Table Angle attributes of the Table Position Sequence (0018,9406) specify the rotation and tilt of the Table Top Plane with respect to a plane arbitrarily defined by the manufacturer (usually the horizontal plane).

The Table Top Position attributes allow to describe the incremental translation of the Table top between frames of the same Multi-frame image, and between frames of different images, provided that the Table Angles are not modified between these frames.

When the table angles are modified between two frames, the Table Position Sequence (0018,9406) does not allow to characterize the relationship between the two table positions in an absolute reference coordinate system. For this purpose, the X-Ray Isocenter Reference System Macro has to be used.

Note: The incremental table translation may be used, in conjunction with the Positioner Position Sequence attributes (0018,9405), for simple 2D-2D registration applications (object tracking, pixel shift…), assuming that the patient position is fixed on the table. For more complex registration applications, and in order to properly handle the changes in the table angles, it is recommended to use the X-Ray Isocenter Reference System Macro attributes.

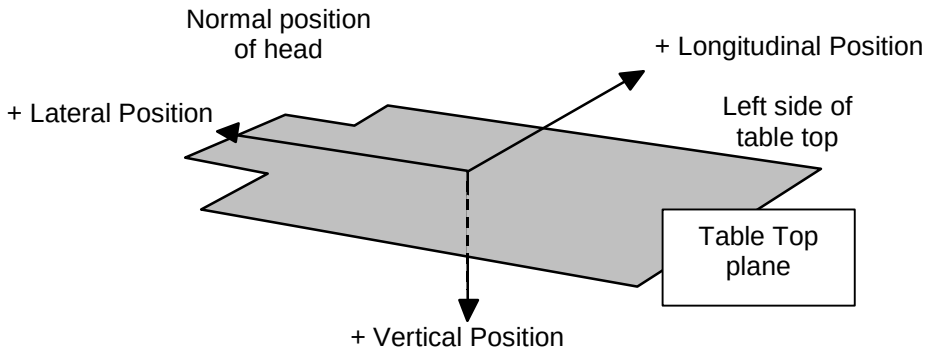


Figure C.8.X6-3
Table Position Vectors

C.8.X.6.12 X-Ray Collimator Macro

Table C.8.X6-12 specifies the attributes of the X-Ray Collimator Functional Group macro.

Table C.8.X6-12
X-RAY COLLIMATOR MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Collimator Shape Sequence	(0018,9407)	1	A sequence that describes the collimator shape. Only a single Item shall be permitted in this sequence.
>Collimator Shape	(0018,1700)	1	Shape(s) of the collimator. Enumerated Values: RECTANGULAR CIRCULAR POLYGONAL This multi-valued Attribute shall contain at most one of each Enumerated Value.
>Collimator Left Vertical Edge	(0018,1702)	1C	Required if Collimator Shape (0018,1700) is RECTANGULAR. Location of the left edge of the rectangular collimator expressed as effective pixel column. See C.8.7.3.1.1 and C.8.X.6.12.1.

>Collimator Right Vertical Edge	(0018,1704)	1C	Required if Collimator Shape (0018,1700) is RECTANGULAR. Location of the right edge of the rectangular collimator expressed as effective pixel column. See C.8.7.3.1.1 and C.8.X.6.12.1.
>Collimator Upper Horizontal Edge	(0018,1706)	1C	Required if Collimator Shape (0018,1700) is RECTANGULAR. Location of the upper edge of the rectangular collimator expressed as effective pixel row. See C.8.7.3.1.1 and C.8.X.6.12.1.
>Collimator Lower Horizontal Edge	(0018,1708)	1C	Required if Collimator Shape (0018,1700) is RECTANGULAR. Location of the lower edge of the rectangular collimator expressed as effective pixel row. See C.8.7.3.1.1 and C.8.X.6.12.1.
>Center of Circular Collimator	(0018,1710)	1C	Required if Collimator Shape (0018,1700) is CIRCULAR. Location of the center of the circular collimator expressed as effective pixel row and column. See C.8.7.3.1.1 and C.8.X.6.12.1.
>Radius of Circular Collimator	(0018,1712)	1C	Required if Collimator Shape (0018,1700) is CIRCULAR. Radius of the circular collimator expressed as effective number of pixels along the row direction. See C.8.7.3.1.1 and C.8.X.6.12.1.
>Vertices of the Polygonal Collimator	(0018,1720)	1C	Required if Collimator Shape (0018,1700) is POLYGONAL. Multiple Values where the first set of two values are: row of the origin vertex; column of the origin vertex. Two or more pairs of values follow and are the effective pixel row and column coordinates of the other vertices of the polygon collimator. Polygon collimators are implicitly closed from the last vertex to the origin vertex and all edges shall be non-intersecting except at the vertices. See C.8.X.6.12.1.

706 **C.8.X.6.12.1 X-Ray Collimator attributes**

The top left pixel of the image has a pixel row and column value of 1.

C.8.X.6.13 X-Ray Isocenter Reference System Macro

Table C.8.X6-13 specifies the attributes of the X-Ray Isocenter Reference System Functional Group macro.

Table C.8.X6-13
X-RAY ISOCENTER REFERENCE SYSTEM MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Isocenter Reference System Sequence	(0018,9462)	1	A sequence that describes the Isocenter Reference Coordinate System (O, X, Y, Z). Only a single Item shall be permitted in this sequence.
>Positioner Isocenter Primary Angle	(0018,9463)	1	Position of the X-Ray center beam in the isocenter reference system in the X direction (deg). See C.8.X.6.13.1.2 for further explanation.
>Positioner Isocenter Secondary Angle	(0018,9464)	1	Position of the X-Ray center beam in the isocenter reference system in the Z direction (deg). See C.8.X.6.13.1.2 for further explanation.
>Positioner Isocenter Detector Rotation Angle	(0018,9465)	1	Rotation of the X-Ray detector plane (deg). See C.8.X.6.13.1.2 for further explanation.
>Table X Position to Isocenter	(0018,9466)	1	X position of the Table Reference Point with respect to the Isocenter (mm). See C.8.X.6.13.1.3 for further explanation.
>Table Y Position to Isocenter	(0018,9467)	1	Y position of the Table Reference Point with respect to the Isocenter (mm). See C.8.X.6.13.1.3 for further explanation.
>Table Z Position to Isocenter	(0018,9468)	1	Z position of the Table Reference Point with respect to the Isocenter (mm). See C.8.X.6.13.1.3 for further explanation.
>Table Horizontal Rotation Angle	(0018,9469)	1	Rotation of the table in the horizontal plane. See C.8.X.6.13.1.3 for further explanation.
>Table Head Tilt Angle	(0018,9470)	1	Angle of the head-feet axis of the table in degrees relative to the horizontal plane. See C.8.X.6.13.1.3 for further explanation.

>Table Cradle Tilt Angle	(0018,9471)	1	Angle of the left-right axis of the table in degrees relative to the horizontal plane. See C.8.X.6.13.1.3 for further explanation.

C.8.X.6.13.1 Isocenter Reference System Attribute Description

The Isocenter Reference System Attributes describe the 3D geometry of the X-Ray equipment composed by the X-Ray positioner and the X-Ray table.

These attributes define three coordinate systems in the 3D space:

- Isocenter coordinate system
- Positioner coordinate system
- Table coordinate system

The Isocenter Reference System attributes describe the relationship between the 3D coordinates of a point in the table coordinate system and the 3D coordinates of such point in the positioner coordinate system (both systems moving in the equipment), by using the Isocenter coordinate system that is fixed in the equipment.

Note: PS 3.17 Annex X describes the transformations necessary to transpose between coordinate systems.

C.8.X.6.13.1.1 Isocenter Coordinate System

The Isocenter coordinate system (O,X,Y,Z) of the equipment is defined as follows:

- Origin O is on the System Isocenter
- +Y DOWNWARD (gravity)
- +X, +Z directions in the horizontal plane (gravity plane). Directions arbitrarily defined by the manufacturer

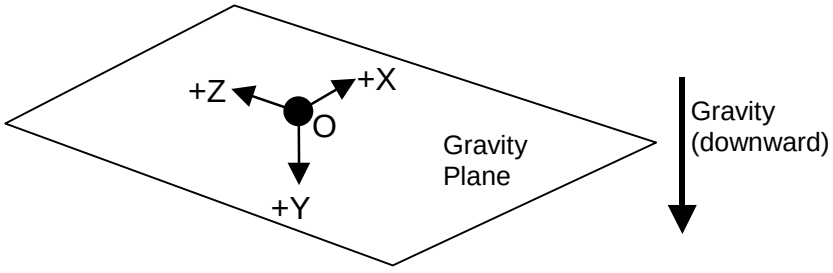


Figure C.8.X6-4
Isocenter Coordinate System

C.8.X.6.13.1.2 Positioner Coordinate System

The positioner coordinate system (O_p, X_p, Y_p, Z_p) is defined as follows:

- Origin O_p, is the origin of the Isocenter coordinate system O
- X_p axis is parallel to the horizontal scan-lines of the detector (rows). Positive direction from left to right of the detector plane looking towards the source.

- Z_p axis is parallel to the vertical scan-lines of the detector (columns). Positive direction from bottom to top of the detector plane looking towards the source.
- Y_p is the axis from the isocenter to the X-Ray source. Positive direction from the Isocenter to the X-Ray Source. This axis is so-called the X-Ray center beam.

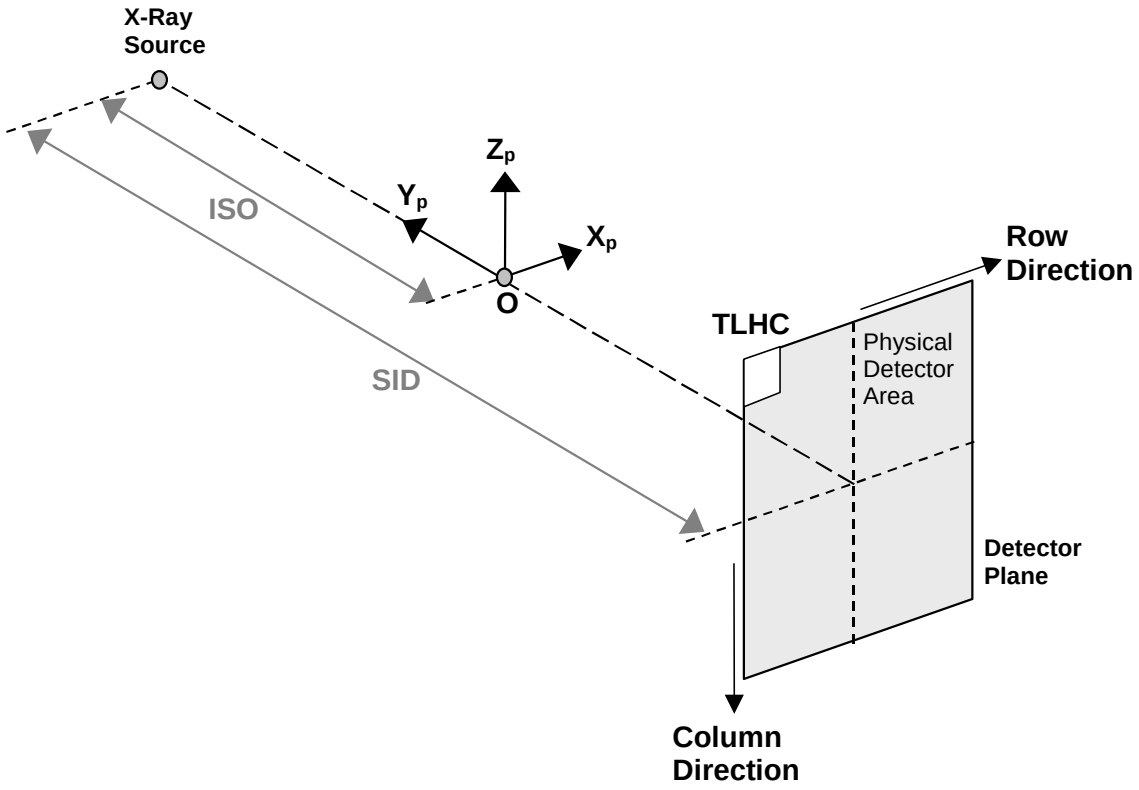


Figure C.8.X6-5
Positioner Coordinate System

Note: The quantities **SID** and **ISO** are specified by the attributes Distance Source to Detector (0018,1110) and Distance Source to Isocenter (0018,9402) respectively.

The Positioner coordinate system (O_p, X_p, Y_p, Z_p) is characterized, with respect to the Isocenter coordinate system (O, X, Y, Z), by two angles describing the X-Ray center beam, and a third angle describing the rotation of the X-Ray detector plane. These angles are relative to the Isocenter reference system, and independent from the patient position on the equipment.

Positioner Isocenter Primary Angle (0018,9463) (so-called **Ap_1** in Figure C.8.X6-6) is defined in the plane XY, as the angle between the plane YZ and the plane Y_pZ. The axis of rotation of this angle is the Z axis. Angle from –Y to +X is positive. The valid range of this angle is –180 to +180 degrees.

Positioner Isocenter Secondary Angle (0018,9464) (so-called **Ap_2** in Figure C.8.X6-6) is defined in the plane Y_pZ, as the angle of the *X-Ray Center Beam* (i.e. Y_p) relative to the XY plane. The axis of rotation of

this angle is perpendicular to the plane Y_pZ. Angle from the plane XY to +Z is positive. The valid range of this angle is –180 to +180 degrees.

Positioner Isocenter Detector Rotation Angle (0018,9465) (so-called **Ap_3** in Figure C.8.X6-6 and in Figure C.8.X6-7) is defined in the detector plane, as the angle of the vertical scan-lines of the detector (i.e. Z_p) relative to the intersection between the detector plane and the plane Y_pZ. The sign of this angle is positive clockwise when facing on to the detector plane (see figure C.8.X6-7). The valid range of this angle is –180 to +180 degrees.

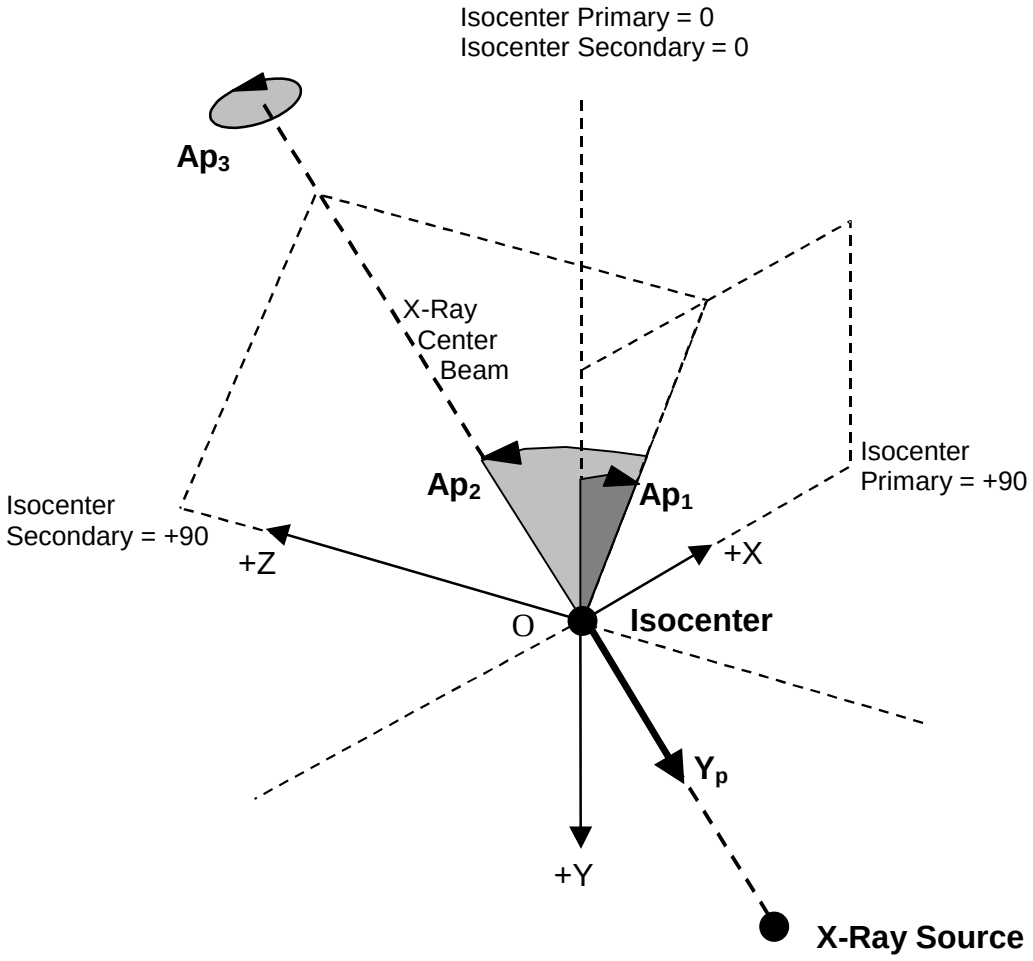


Figure C.8.X6-6
Positioner Isocenter Angles

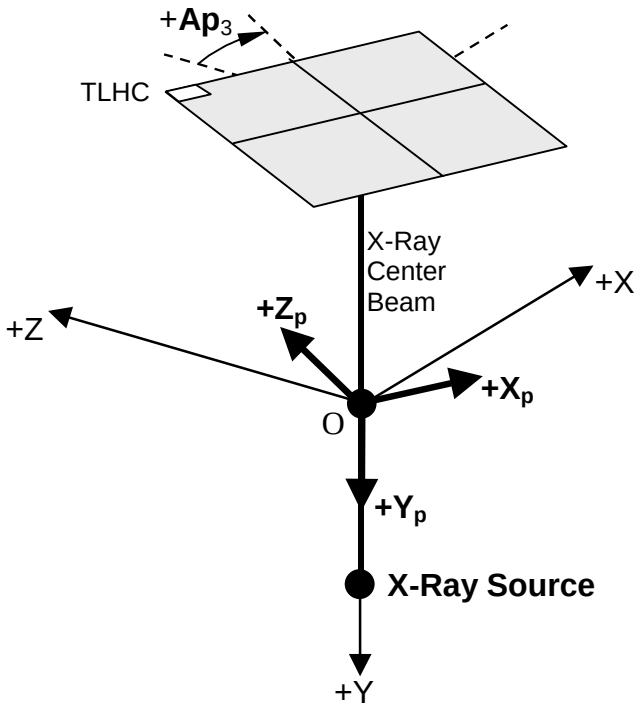


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Figure C.8.X6-7
776 **Positioner Isocenter Detector Rotation Angle when Ap_1=0 and Ap_2=0**

C.8.X.6.13.1.3 Table Coordinate System

778 The table coordinate system (O_t, X_t, Y_t, Z_t) is defined as follows:

- Origin O_t, so-called Table Reference Point, is on the Table Top plane
780 - $+X_t$ direction to the TABLE LEFT
- $+Z_t$ direction to the TABLE HEAD
782 - $+Y_t$ direction to the TABLE DOWN

784 The table coordinate system (O_t, X_t, Y_t, Z_t) is characterized, with respect to the Isocenter coordinate system (O, X, Y, Z), by a 3D translation and 3 angles describing the tilting and rotation:

786 **Table X Position to Isocenter (0018,9466)** (so-called $\mathbf{T_X}$ in Figure C.8.X6-8) is defined as the translation of the Table Reference Point O_t with respect to the Isocenter system in the X direction. Table motion towards +X is positive.

788 **Table Y Position to Isocenter (0018,9467)** (so-called $\mathbf{T_Y}$ in Figure C.8.X6-8) is defined as the translation of the Table Reference Point O_t with respect to the Isocenter system in the Y direction. Table motion 790 towards +Y is positive.

792 **Table Z Position to Isocenter (0018,9468)** (so-called $\mathbf{T_Z}$ in Figure C.8.X6-8) is defined as the translation of the Table Reference Point O_t with respect to the Isocenter system in the Z direction. Table motion towards +Z is positive.

794 Note: A translation of ($\mathbf{T_X}$, $\mathbf{T_Y}$, $\mathbf{T_Z}$) = (0, 0, 0) means that the Table Reference Point O_t is at the System Isocenter.

Table Horizontal Rotation Angle (so-called **At_1** in Figure C.8.X6-9) is defined in the horizontal plane XZ, as the angle of the projection of the +Zt axis in the XZ plane relative to the +Z axis. The axis of rotation of this angle is the vertical axis crossing the Table Reference Point Ot. Zero value is defined when the projection of +Zt in the XZ plane is equal to +Z. Angle from +Z to +X is positive. The valid range of this angle is -180 to +180 degrees.

Table Head Tilt Angle (so-called **At_2** in Figure C.8.X6-9) is defined in the vertical plane containing Z_t (i.e. YZ_t), as the angle of the $+Z_t$ axis relative to the horizontal plane XZ. The axis of rotation of this angle is defined as the intersection between the horizontal plane XZ and the plane X_tY_t. Zero value is defined when $+Z_t$ is contained in the horizontal plane XZ. Angle from horizontal (plane XZ) to –Y direction (upwards) is positive, indicating that the head of the table is above the horizontal plane. The valid range of this angle is -45 to +45 degrees.

Table Cradle Tilt Angle (so-called **At_3** in Figure C.8.X6-9) is defined in the X_tY_t plane, as the angle of the $+X_t$ axis relative to the intersection between the X_tY_t plane and the horizontal plane XZ. The axis of rotation of this angle is the axis Z_t. Zero value is defined when $+X_t$ is contained in the horizontal plane XZ. Angle from horizontal (plane XZ) to –Y direction (upwards) is positive, indicating that the left of the table is above the horizontal plane. The valid range of this angle is -45 to +45 degrees.

Note: The angles **At_1** ,**At_2** and **At_3** are independent from any specific mechanical design of the table rotation axis defined by a manufacturer. In particular, they don't require the three rotation axis to cross on a single point. If a mechanical rotation axis does not cross the Table Reference Point O_t , a mechanical rotation around this axis will generate a change in one or more table angles as well as a translation of the Table Reference Point.

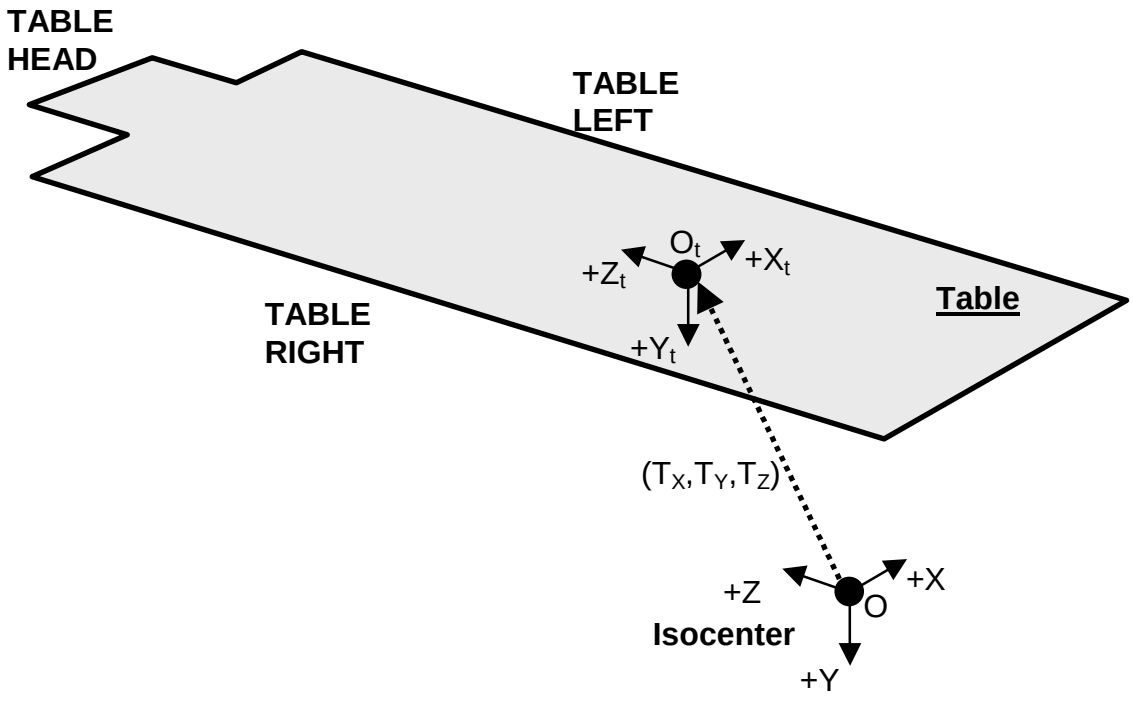

Figure C.8.X6-8
Table Translation with respect to the Isocenter Reference System

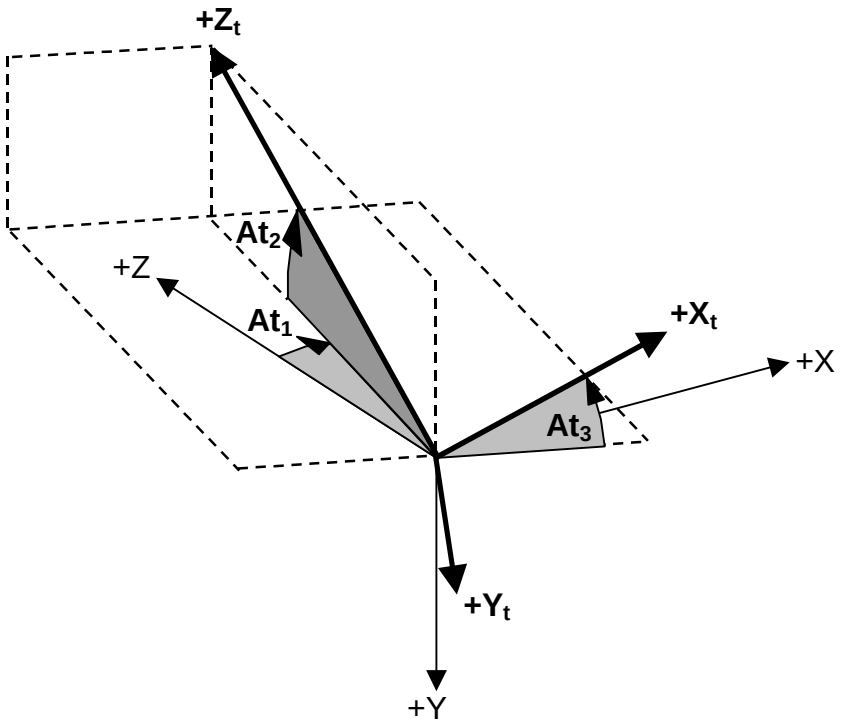

Figure C.8.X6-9
Table Angulations with respect to the Isocenter Reference System

C.8.X.6.13.2 Relationship Patient Coordinate System

The Isocenter Reference System attributes allow expressing the positioner angulations (i.e. X-Ray Center Beam direction) as a vector in the table coordinate system. If the relationship between the X-ray table and the patient is known, it is possible to express any vector of the table coordinate system as a direction in the patient.

Therefore, the Isocenter Reference System attributes allow calculating the positioner angulations in the patient-based coordinate system if the following attributes are present:

- Patient Orientation Code Sequence (0054,0410)
- Patient Orientation Modifier Code Sequence (0054,0412)

Further, the Isocenter Reference System attributes allow calculating the patient anatomical directions (i.e. left, right, head, feet, anterior, posterior) of the rows and columns of the stored image, if the following attributes are present:

- Patient Orientation Code Sequence (0054,0410)
- Patient Orientation Modifier Code Sequence (0054,0412)
- Field of View Rotation (0018,7032)
- Field of View Horizontal Flip (0018,7034)

For registration purposes, a given point fixed in the patient (object of interest) that is defined in the table coordinate system can be expressed as row and column coordinates of the stored image if the relationship between the positioner coordinate system and the stored image is fully characterized. Therefore, the

Isocenter Reference System attributes allow calculating the projection of a point of the patient as row and column coordinates of the stored image, if the following attributes are present:

- Frame of Reference UID (0020,0052) and must be equal for all images involved in the registration
- Field of View Rotation (0018,7032)
- Field of View Horizontal Flip (0018,7034)
- Imager Pixel Spacing (0018,1164)
- Distance Source to Isocenter (0018,9402)
- Distance Source to Detector (0018,1110)

In addition for a system equipped with a digit al detector the following attributes need to be present:

- Detector Element Spacing (0018,7022)
- Field of view Origin (0018,7030)
- Position of Isocenter Projection (0018,9430)

C.8.X.6.14 X-Ray Geometry Macro

Table C.8.X6-14 specifies the attributes containing the X-Ray Geometry Functional Group macro.

Table C.8.X6-14
X-RAY GEOMETRY MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
X-Ray Geometry Sequence	(0018,9476)	1	Sequence containing the geometric properties for this frame. Only a single Item shall be permitted in this sequence.
>Distance Source to Isocenter	(0018,9402)	1	Distance from source to isocenter in mm.
>Distance Source to Detector	(0018,1110)	1	Distance from source to receptor plane perpendicular to the receptor plane in mm. Note: This value is traditionally referred to as Source Image Receptor Distance (SID).

C.8.X.6.15 Irradiation Event Identification Macro

Table C.8.X6-15 specifies the attributes containing the Irradiation Event Identification Functional Group macro.

Table C.8.X6-15
IRRADIATION EVENT IDENTIFICATION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Irradiation Event Identification Sequence	(0018,9477)	1	Sequence containing the Irradiation Event Identification for this frame. Only a single Item shall be permitted in this sequence.
Irradiation Event UID	(0008,3010)	1	Unique identification of the irradiation event(s) associated with the acquisition of this image.

866

C.8.X.7 XA/XRF Multi-frame Presentation Module

868 Table C.8.X7-1 specifies the Attributes of a XA/XRF Multi-frame Presentation Image.

Table C.8.X7-1

870 **XA/XRF MULTI-FRAME PRESENTATION MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Preferred Playback Sequencing	(0018,1244)	3	Describes the preferred playback sequencing for a multi-frame image. Enumerated Values: 0 = Looping (1,2...n,1,2,...n,1,2,....n,...) 1 = Sweeping (1,2,...n,n -1,...2,1,2,...n,...)
Frame Display Sequence	(0008,9458)	3	Sequence that specifies the display frame rate of a selected set of frames. The Items are ordered in increasing frame number. The range of the frames may not overlap and the ranges shall be adjacent. One or more items may be included.
>Start Trim	(0008,2142)	1	The Frame Number of the first frame of the set of frames to be displayed in this Item.
>Stop Trim	(0008,2143)	1	The Frame Number of the last frame of the set of frames to be displayed in this Item.
>Skip Frame Range Flag	(0008,9460)	1	A flag indicating that the range of frames in this item may be skipped. Defined Terms: DISPLAY SKIP
>Recommended Display Frame Rate in Float	(0008,9459)	1	Recommended rate at which the frames of this Item should be displayed in frames/second.
Recommended Viewing Mode	(0028,1090)	2	Specifies the recommended viewing protocol(s). Defined terms: SUB = subtraction with mask images NAT = native viewing of image as stored Note: If an implementation does not recognize the defined term for Recommended Viewing Mode (0028,1090), reverting to native display mode is recommended.
Display Filter Percentage	(0028,9411)	2	Edge enhancement filter percentage that is recommended by the pixel data creator as filter presetting for display purposes. The value of 100% corresponds to the maximum filter strength that can be applied by a specific application displaying the image.

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Changes to NEMA Standards Publication PS 3.4-2004

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Digital Imaging and Communications in Medicine (DICOM)

Part 4: Service Class Specifications

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Item #19: Add SOP Classes to Table B.5-1

B.5 STANDARD SOP CLASSES

Table B.5-1
Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification (defined in PS 3.3)
Enhanced XA Image Storage	1.2.840.10008.5.1.4.1.1.12.1.1	
Enhanced XRF Image Storage	1.2.840.10008.5.1.4.1.1.12.2.1	

Item #20: Add SOP Classes to Table I.4-1

I.4 MEDIA STORAGE SOP CLASSES

Table I.4-1
Media Storage Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification
Enhanced XA Image Storage	1.2.840.10008.5.1.4.1.1.12.1.1	IOD defined in PS 3.3
Enhanced XRF Image Storage	1.2.840.10008.5.1.4.1.1.12.2.1	IOD defined in PS 3.3

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900 **Changes to NEMA Standards Publication PS 3.6-2004**

Digital Imaging and Communications in Medicine (DICOM)

902 **Part 6: Data Dictionary**

Item #21: Change Image Area Dose Product attribute name

Tag	Name	VR	VM
…			
(0018,115E)	Image **and Fluoroscopy** Area Dose Product	DS	1
…			

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Item #22: Add the following rows to Section 6

Tag	Name	VR	VM
(0008,3010)	Irradiation Event UID	UI	1
(0008,9410)	Referenced Other Plane Sequence	SQ	1
(0008,9458)	Frame Display Sequence	SQ	1
(0008,9459)	Recommended Display Frame Rate in Float	FL	1
(0008,9460)	Skip Frame Range Flag	CS	1

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Tag	Name	VR	VM
(0010,9431)	Examined Body Thickness	FL	1

Tag	Name	VR	VM
(0018,9401)	Projection Pixel Calibration Sequence	SQ	1
(0018,9402)	Distance Source to Isocenter	FL	1
(0018,9403)	Distance Object to Table Top	FL	1
(0018,9404)	Object Pixel Spacing in Center of Beam	FL	2
(0018,9405)	Positioner Position Sequence	SQ	1
(0018,9406)	Table Position Sequence	SQ	1
(0018,9407)	Collimator Shape Sequence	SQ	1
(0018,9412)	XA/XRF Frame Characteristics Sequence	SQ	1
(0018,9420)	X-Ray Receptor Type	CS	1
(0018,9423)	Acquisition Protocol Name	LO	1
(0018,9424)	Acquisition Protocol Description	LT	1
(0018,9425)	Contrast/Bolus Ingredient Opaque	CS	1
(0018,9426)	Distance Receptor Plane to Detector Housing	FL	1
(0018,9427)	Intensifier Active Shape	CS	1
(0018,9428)	Intensifier Active Dimension(s)	FL	1-2
(0018,9429)	Physical Detector Size	FL	2
(0018,9430)	Position of Isocenter Projection	US	2
(0018,9432)	Field of View Sequence	SQ	1

Tag	Name	VR	VM
(0018,9433)	Field of View Description	LO	1
(0018,9434)	Exposure Control Sensing Regions Sequence	SQ	1
(0018,9435)	Exposure Control Sensing Region Shape	CS	1
(0018,9436)	Exposure Control Sensing Region Left Vertical Edge	SS	1
(0018,9437)	Exposure Control Sensing Region Right Vertical Edge	SS	1
(0018,9438)	Exposure Control Sensing Region Upper Horizontal Edge	SS	1
(0018,9439)	Exposure Control Sensing Region Lower Horizontal Edge	SS	1
(0018,9440)	Center of Circular Exposure Control Sensing Region	SS	2
(0018,9441)	Radius of Circular Exposure Control Sensing Region	US	1
(0018,9442)	Vertices of the Polygonal Exposure Control Sensing Region	SS	2-n
(0018,9447)	Column Angulation (Patient)	FL	1
(0018,9449)	Beam Angle	FL	1
(0018,9451)	Frame Detector Parameters Sequence	SQ	1
(0018,9452)	Calculated Anatomy Thickness	FL	1
(0018,9455)	Calibration Sequence	SQ	1
(0018,9456)	Object Thickness Sequence	SQ	1
(0018,9457)	Plane Identification	CS	1
(0018,9461)	Field of View Dimension(s) in Float	FL	1-2
(0018,9462)	Isocenter Reference System Sequence	SQ	1
(0018,9463)	Positioner Isocenter Primary Angle	FL	1
(0018,9464)	Positioner Isocenter Secondary Angle	FL	1
(0018,9465)	Positioner Isocenter Detector Rotation Angle	FL	1
(0018,9466)	Table X Position to Isocenter	FL	1
(0018,9467)	Table Y Position to Isocenter	FL	1
(0018,9468)	Table Z Position to Isocenter	FL	1
(0018,9469)	Table Horizontal Rotation Angle	FL	1
(0018,9470)	Table Head Tilt Angle	FL	1
(0018,9471)	Table Cradle Tilt Angle	FL	1
(0018,9472)	Frame Display Shutter Sequence	SQ	1
(0018,9473)	Acquired Image Area Dose Product	FL	1
(0018,9474)	C-arm Positioner Tabletop Relationship	CS	1
(0018,9476)	X-Ray Geometry Sequence	SQ	1
(0018,9477)	Irradiation Event Identification Sequence	SQ	1

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Tag	Name	VR	VM
(0020,9421)	Dimension Description Label	LO	1

Tag	Name	VR	VM
(0020,9450)	Patient Orientation in Frame Sequence	SQ	1
(0020,9453)	Frame Label	LO	1

Tag	Name	VR	VM
(0028,9411)	Display Filter Percentage	FL	1
(0028,9415)	Frame Pixel Shift Sequence	SQ	1
(0028,9416)	Subtraction Item ID	US	1
(0028,9422)	Pixel Intensity Relationship LUT Sequence	SQ	1
(0028,9443)	Frame Pixel Data Properties Sequence	SQ	1
(0028,9444)	Geometrical Properties	CS	1
(0028,9445)	Geometric Maximum Distortion	FL	1
(0028,9446)	Image Processing Applied	CS	1-n
(0028,9454)	Mask Selection Mode	CS	1
(0028,9475)	LUT Function	CS	1

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Item #23: Add the following rows to Table A-1

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.12.1.1	Enhanced XA Image Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.12.2.1	Enhanced XRF Image Storage	SOP Class	PS 3.4

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Changes to NEMA Standards Publication PS 3.15-2004

922 # Digital Imaging and Communications in Medicine (DICOM)

Part 15: Security and System Management Profiles

924

Item #24: Add to Section C2 and C3

C.2 CREATOR RSA DIGITAL SIGNATURE PROFILE

…

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

C.3 AUTHORIZATION RSA DIGITAL SIGNATURE PROFILE

…

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

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Changes to NEMA Standards Publication PS 3.16-2004

970 ## Digital Imaging and Communications in Medicine (DICOM)

Part 16: Content Mapping Resource

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Item #25: Add the following codes to CID 8:

CID 8 Angiographic Interventional Devices

Context ID 8
Angiographic Interventional Devices

Type: Extensible Version: yyyymmdd

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SNM3	A-25500	Stent, NOS
SNM3	A-26800	Catheter, NOS
SNM3	A-81080	Laser
SNM3	C-20005	Glue
SNM3	A-25600	Atherectomy device
SNM3	A-25614	Embolization ball
SNM3	A-26912	Percutaneous transluminal angioplasty balloon
SNM3	A-25612	Embolization coil
SNM3	A-25612	Gianturco coil
SNM3	A-27322	Detachable balloon
SNM3	A-26A06	Fixed object
SNM3	A-26A08	Grid
SNM3	A-26802	Guiding catheter
SNM3	A-25616	Embolization particulate
SNM3	A-25610	Rotational atherectomy device
SNM3	A-10141	Measuring ruler
DCM	**122485**	**Sphere**

Item #26: Add the following CID's to Part 16 Annex B:

CID 4005 XA/XRF Anatomy Imaged

Context ID 4005
XA/XRF Anatomy Imaged

Type: Extensible Version: 20050822

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
INCLUDE CID 3010 Cardiovascular Anatomic Locations		
INCLUDE CID 4031 Common Anatomic Regions		

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992 **Changes to NEMA Standards Publication PS 3.17-2004**

Digital Imaging and Communications in Medicine (DICOM)

994 **Part 17: Explanatory Information**

Item #27: Add new Annex:

Annex X X-Ray Isocenter Reference Transformations (Informative)

X.1 INTRODUCTION

The Isocenter Reference System Attributes describe the 3D geometry of the X-Ray equipment composed by the X-Ray positioner and the X-Ray table.

These attributes define three coordinate systems in the 3D space:

- Isocenter coordinate system
- Positioner coordinate system
- Table coordinate system

The Isocenter Reference System attributes describe the relationship between the 3D coordinates of a point in the table coordinate system and the 3D coordinates of such point in the positioner coordinate system (both systems moving in the equipment), by using the Isocenter coordinate system that is fixed in the equipment.

X.2 POSITIONER COORDINATE SYSTEM TRANSFORMATIONS

Any point of the Positioner coordinate system (P_{Xp}, P_{Yp}, P_{Zp}) can be expressed in the Isocenter coordinate system (P_X, P_Y, P_Z) by applying the following transformation:

$$(P_X, P_Y, P_Z)^T = (R_2 \cdot R_1)^T \cdot (R_3^T \cdot (P_{Xp}, P_{Yp}, P_{Zp})^T)$$

And inversely, any point of the Isocenter coordinate system (P_X, P_Y, P_Z) can be expressed in the Positioner coordinate system (P_{Xp}, P_{Yp}, P_{Zp}) by applying the following transformation:

$$(P_{Xp}, P_{Yp}, P_{Zp})^T = R_3 \cdot ((R_2 \cdot R_1) \cdot (P_X, P_Y, P_Z)^T)$$

Where R_1, R_2 and R_3 are defined as follows:

$$R_1 = \begin{pmatrix} \cos(Ap_1) & \sin(Ap_1) & 0 \\ -\sin(Ap_1) & \cos(Ap_1) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$R_2 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(Ap_2) & -\sin(Ap_2) \\ 0 & \sin(Ap_2) & \cos(Ap_2) \end{pmatrix}$$

$$R_3 = \begin{pmatrix} \cos(Ap_3) & 0 & -\sin(Ap_3) \\ 0 & 1 & 0 \\ \sin(Ap_3) & 0 & \cos(Ap_3) \end{pmatrix}$$

X.3 TABLE COORDINATE SYSTEM TRANSFORMATIONS

Any point of the table coordinate system (P_{Xt}, P_{Yt}, P_{Zt}) (see Figure A-1) can be expressed in the Isocenter Reference coordinate system (P_X, P_Y, P_Z) by applying the following transformation:

$$(P_X, P_Y, P_Z)^T = (R_3 \cdot R_2 \cdot R_1)^T \cdot (P_{Xt}, P_{Yt}, P_{Zt})^T + (T_X, T_Y, T_Z)^T$$

And inversely, any point of the Isocenter coordinate system (P_X, P_Y, P_Z) can be expressed in the table coordinate system (P_{Xt}, P_{Yt}, P_{Zt}) by applying the following transformation:

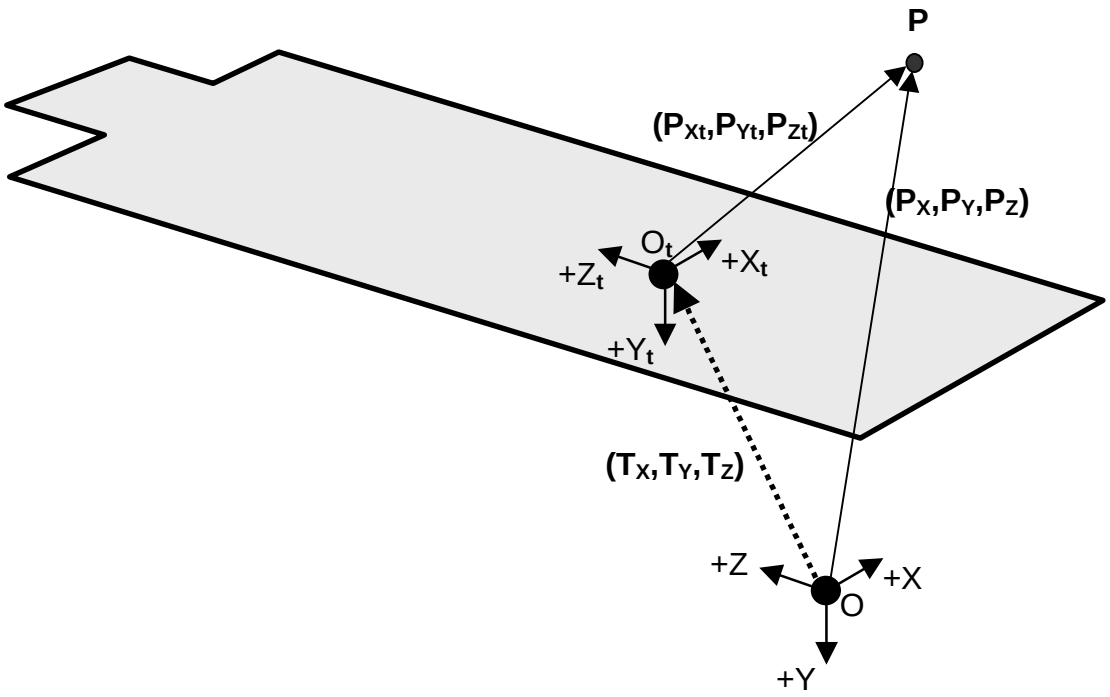
$$(P_{Xt}, P_{Yt}, P_{Zt})^T = (R_3 \cdot R_2 \cdot R_1) \cdot ((P_X, P_Y, P_Z)^T - (T_X, T_Y, T_Z)^T)$$

Where $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{R_3}$ are defined as follows:

$$R_1 = \begin{pmatrix} \cos(At_1) & 0 & -\sin(At_1) \\ 0 & 1 & 0 \\ \sin(At_1) & 0 & \cos(At_1) \end{pmatrix}$$

$$R_2 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(At_2) & \sin(At_2) \\ 0 & -\sin(At_2) & \cos(At_2) \end{pmatrix}$$

$$R_3 = \begin{pmatrix} \cos(At_3) & -\sin(At_3) & 0 \\ \sin(At_3) & \cos(At_3) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$



1028 **Figure A-1**
Coordinates of a Point "P" in the Isocenter and Table coordinate systems

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