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Digital Imaging and Communications in Medicine (DICOM)

6

Supplement 176: Second Generation Radiotherapy –

Tomotherapeutic and Robotic-Arm Treatment Modalities

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22 **DICOM Standards Committee, Working Group 7, Radiation Therapy**

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Table of Contents

84 **Foreword**

This Supplement introduces IODs necessary to support the Tomotherapeutic and Robotic-Arm
86 Treatment Modalities.

This document is an extension to the following parts of the published DICOM Standard:

88 PS3.2 Conformance

PS3.3 Information Object Definitions

90 PS3.4 Service Class Specifications

PS3.6 Data Dictionary

92 PS3.16 Content Mapping Resource

Scope and Field of Application

94 **<u>Introduction</u>**

This Supplement introduces new RT Radiation IODs for non-C-Arm treatment devices. It specifically
96 addresses Tomotherapeutic and Robotic-Arm Treatment Modalities.

The Supplement makes use of the real-world model and specifications introduced to the DICOM
98 Standard by Supplement 175. References, definitions, etc. not present in this supplement can be
found in the DICOM Standard.

100

Part 2 Addendum

102   **Add new SOP Classes to PS3.2 Table A.1-2 UID Values:**

UID Value	UID Name	Category
…		
1.2.840.10008.5.1.4.1.1.481.14	**Tomotherapeutic Radiation Storage**	**Transfer**
1.2.840.10008.5.1.4.1.1.481.15	**Robotic-Arm Radiation Storage**	**Transfer**

104

Part 3 Addendum

106

108   **Add the following columns in PS3.3 Section A.1.4, Table A.1-4b COMPOSITE INFORMATION OBJECT MODULES OVERVIEW – RADIOTHERAPY**

IODs / Modules	RT Radiation Set	C-Arm Photon-Electron Radiation	Tomo Rad	Rob Arm Rad
Patient	M	M	**M**	**M**
Clinical Trial Subject	U	U	**U**	**U**
General Study	M	M	**M**	**M**
Patient Study	U	U	**U**	**U**
Clinical Trial Study	U	U	**U**	**U**
General Series	M	M	**M**	**M**
Clinical Trial Series	U	U	**U**	**U**
Enhanced RT Series	M	M	**M**	**M**
General Equipment	M	M	**M**	**M**
Enhanced General Equipment	M	M	**M**	**M**
Frame Of Reference	**M**	M	**M**	**M**
…				
General Reference	**M**	**M**	**M**	**M**
Radiotherapy Common Instance	M	**M**	**M**	**M**
RT Dose Contribution	C			
RT Delivery Device Common			**M**	**M**
RT Radiation Common			**M**	**M**

IODs Modules	RT Radiation Set	C-Arm Photon- Electron Radiation	**Tomo Rad**	**Rob Arm Rad**
Tomotherapeutic Delivery Device			**M**	
Tomotherapeutic Beam			**M**	
Robotic-Arm Delivery Device				**M**
Robotic-Arm Path				**M**
…				
Common Instance Reference	M	M	**M**	**M**
SOP Common	M	M	**M**	**M**

110

Update the following in Section A.86.1:

A.86 RT SECOND GENERATION

A.86.1 RT Second Generation Objects

A.86.1.4 RT Radiation Set Information Object Definition

…

A.86.1.4.3 RT Radiation Set IOD Module Table

Table A.86.1.4-1
RT RADIATION SET IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Enhanced RT Series	C.36.3	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Frame of Reference	**Frame of Reference**	**C.7.4.1**	**M**
RT Radiation Set	General Reference	C.12.4	M
	RT Radiation Set	C.36.10	M
	RT Dose Contribution	C.36.11	C - Required if the dose delivered is tracked.
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M
	Radiotherapy Common Instance	C.36.4	M

…

A.86.1.5.4.2 RT Delivery Device Common Module

The Equipment Frame of Reference UID (300A,0675) shall be 1.2.840.10008.1.4.3.1**, which**
identifies the IEC 61217 Fixed Coordinate System Frame of Reference; see C.36.12.2.1.

The Frame of Reference identifies the Patient Coordinate System used to define the geometric setup
of the radiation beam with respect to the patient. The relationship of the patient-based coordinates to
the Equipment Frame of Reference is specified by a transformation (see 10.39).

The following Code Sequences shall have a value from the specified CID:

Code Sequence	CID
Radiation Dosimeter Unit Sequence (300A,0658)	Defined CID 9552 "C-Arm Photon-Electron Dosimeter Units"

The RT Device Distance Reference Location Code Sequence (300A,0659) shall contain the value (130358, DCM, "Nominal Radiation Source Location").

Add the following Section to A.86.1:

A.86.1.6 Tomotherapeutic Radiation Information Object Definition

A.86.1.6.1 Tomotherapeutic Radiation IOD Description

The Tomotherapeutic Radiation IOD represents the information required to describe a radiotherapy treatment on a serial or helical tomotherapeutic delivery device.

A.86.1.6.2 Tomotherapeutic Radiation IOD Entity-Relationship Model

See Figure A.86.1.1.1-1.

A.86.1.6.3 Tomotherapeutic Radiation IOD Module Table

Table A.86.1.6-1
TOMOTHERAPEUTIC RADIATION IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Enhanced RT Series	C.36.3	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Frame of Reference	Frame of Reference	C.7.4.1	M
RT Radiation	General Reference	C.12.4	M
	RT Delivery Device Common	C.36.12	M
	RT Radiation Common	C.36.13	M
	Tomotherapeutic Delivery Device	C.36.16	M
	Tomotherapeutic Beam	C.36.17	M
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M
	Radiotherapy Common Instance	C.36.4	M

A.86.1.6.4 Tomotherapeutic Radiation IOD Constraints

A.86.1.6.4.1 Modality Attribute

The value of Modality (0008,0060) shall be RTRAD.

A.86.1.6.4.2 RT Delivery Device Common Module

The Equipment Frame of Reference UID (300A,0675) shall be 1.2.840.10008.1.4.3.1, which identifies the IEC 61217 Fixed Coordinate System Frame of Reference; see C.36.12.2.1.

The Frame of Reference identifies the Patient Coordinate System used to define the geometric setup of the radiation beam with respect to the patient. The relationship of the patient-based coordinates to the Equipment Frame of Reference is specified by a transformation (see 10.39).

The following Code Sequence shall have a value from the identified CID:

Code Sequence	CID
Radiation Dosimeter Unit Sequence (300A,0658)	Defined CID 9557 "Tomotherapeutic Dosimeter Units"

The RT Device Distance Reference Location Code Sequence (300A,0659) shall contain the value (130358, DCM, "Nominal Radiation Source Location").

A.86.1.6.4.3 RT Radiation Common Module

The value of RT Record Flag (300A,0639) shall be NO.

The following Code Sequences shall have a value from the identified CIDs:

Code Sequence	CID
RT Treatment Technique Code Sequence (3010,0080)	Defined CID 9512 "Tomotherapeutic Radiotherapy Procedure Techniques"
Treatment Machine Special Mode Code Sequence (300A,0635)	Defined CID 9543 "Radiotherapy Treatment Machine Modes"

A.86.1.6.4.4 Radiotherapy Common Instance Module

The following code sequence shall have a value from the identified CID:

Code Sequence	CID
Author Identification Sequence (3010,0019)	Defined CID for Organizational Role Code Sequence (0044,010A) is CID 9555 "Radiotherapy Treatment Planning Person Roles"

A.86.1.7 Robotic-Arm Radiation Information Object Definition

A.86.1.7.1 Robotic-Arm Radiation IOD Description

The Robotic-Arm Radiation IOD specifies the Robotic Path and collimation parameters required to describe a radiotherapy treatment on a robotic-arm delivery device. A Robotic Path is a sequence of Robotic Nodes. A Robotic Node specifies a Radiation Source location for a Robotic-Arm delivery device.

A.86.1.7.2 Robotic-Arm Radiation IOD Entity-Relationship Model

170   See Figure A.86.1.1.1-1.

A.86.1.7.3 Robotic-Arm Radiation IOD Module Table

172

Table A.86.1.7-1
ROBOTIC-ARM RADIATION IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Enhanced RT Series	C.36.3	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Frame of Reference	Frame of Reference	C.7.4.1	M
RT Radiation	General Reference	C.12.4	M
	RT Delivery Device Common	C.36.12	M
	RT Radiation Common	C.36.13	M
	Robotic-Arm Delivery Device	C.36.18	M
	Robotic-Arm Path	C.36.19	M
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M
	Radiotherapy Common Instance	C.36.4	M

174

A.86.1.7.4 Robotic-Arm Radiation IOD Module Constraints

176   **A.86.1.7.4.1 Modality Attribute**

The value of Modality (0008,0060) shall be RTRAD.

178   **A.86.1.7.4.2 RT Delivery Device Common Module**

The Equipment Frame of Reference UID (300A,0675) shall be 1.2.840.10008.1.4.3.2, which identifies
180   the Standard Robotic-Arm Coordinate System Frame of Reference, see C.36.12.2.2.

The Frame of Reference identifies the Patient Coordinate System used to define the geometric setup
182   of the radiation beam with respect to the patient. The relationship of the patient-based coordinates to
the Equipment Frame of Reference is specified by a transformation (see 10.39).

184   The following code sequences shall have a value from the identified CID:

Code Sequence	CID

Radiation Dosimeter Unit Sequence (300A,0658)	Defined CID 9559 "Robotic Delivery Device Dosimeter Units"

186 The RT Device Distance Reference Location Code Sequence (300A,0659) shall contain the value (130358, DCM, "Nominal Radiation Source Location").

188 **A.86.1.7.4.3   RT Radiation Common Module**

The value of RT Record Flag (300A,0639) shall be NO.

190 The following code sequences shall have a value from the identified CID:

Code Sequence	CID
RT Treatment Technique Code Sequence (3010,0080)	Defined CID 9523 "Robotic Radiotherapy Procedure Techniques"
Treatment Machine Special Mode Code Sequence (300A,0635)	Defined CID 9543 "Radiotherapy Treatment Machine Modes"

192 **A.86.1.7.4.4   Radiotherapy Common Instance Module**

The following code sequence shall have a value from the identified CID:

Code Sequence	CID
Author Identification Sequence (3010,0019)	Defined CID for Organizational Role Code Sequence (0044,010A) is CID 9555 "Radiotherapy Treatment Planning Person Roles"

194

Update the following in Section C.36.2.2.5

C.36 RT SECOND GENERATION MODULES

…

C.36.2   RT Second Generation Macros

…

C.36.2.2   RT Second Generation Device Macros

…

C.36.2.2.5.1.1   Requirements for Changing Values within RT Control Point Sequence Attributes

…

At the first Sequence Item in RT Control Point Sequences (i.e. with an RT Control Point Index (300A,0600) equal to 1) all Attributes affected by this Section shall be present ~~(whether Type 1C or 2C)~~ **if applicable conditions are met**.

For Sequence Items other than the first Sequence Item Attributes shall be present **if applicable conditions are met and** ~~only if~~ the value is different from the previously populated value for the

same Attribute (in the case of a type 2C attribute, a null value is considered as a value). …

Update the following in Section C.36.2.2.6

C.36.2.2.6   External Beam Control Point General Macro

This Macro specifies the RT Control Point Attributes used to model external beam radiation.

Table C.36.2.2.6-1
EXTERNAL BEAM CONTROL POINT GENERAL MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include Table C.36.2.2.5-1 "RT Control Point General Macro Attributes"			
Delivery Rate	(300A,063D)	2C	The intended nominal rate of delivery of the specified Cumulative Meterset (300A,063C). Required if the conditions in Section C.36.2.2.5.1.1 are satisfied. See Section C.36.2.2.5.1.
Delivery Rate Unit Sequence	(300A,063E)	1C	The unit of the Delivery Rate (300A,063D). Required if Delivery Rate (300A,063D) is present **and has a value**. See Section C.36.2.2.5.1. Only a single Item shall be included in this Sequence.
…			

220

Table C.36.2.2.7-1
RADIATION GENERATION MODE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Number of Radiation Generation Modes	(300A,0685)	1**C**	Number of Radiation Generation Modes defined in the Radiation Generation Mode Sequence (300A,067B). The Number shall be greater than zero. **Required if RT Radiation Physical and Geometric Content Detail Flag (300A,0638) equals FULL. May be present otherwise.**
Radiation Generation Mode Sequence	(300A,067B)	1**C**	Radiation Generation Modes defining the type of radiation and characteristics of the beam generated. Radiation Generation Modes shall characterize different primary beam fluence. The number of Items included in this Sequence shall equal the value of Number of Radiation Generation Modes (300A,0685). **Required if Number of Radiation Generation Modes (300A,0685) is present.**

222

224 **C.36.2.2.9   RT Beam Limiting Device Opening Macro**

This Macro defines the opening created by RT Beam Limiting Devices at a specific Control Point or
226 set of Control Points.

Table C.36.2.2.9-1
228 **RT BEAM LIMITING DEVICE OPENING MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Number of RT Beam Limiting Device Openings	(300A,0657)	1C	Number of RT Beam Limiting Device Openings in the RT Beam Limiting Device Opening Sequence (300A,0656). Required if Number of RT Beam Limiting Devices (300A,0641) is present and has a non-zero value.

Attribute Name	Tag	Type	Attribute Description
RT Beam Limiting Device Opening Sequence	(300A,0656)	1C	Beam limiting device (collimator) settings defining the opening for the current Control Point. Required if **Number of RT Beam Limiting Device Openings (300A,0657) is present and has a non-zero value** **and** the conditions in Section C.36.2.2.5.1.1 are satisfied. The number of Items included in this Sequence shall equal the value of Number of RT Beam Limiting Device Openings (300A,0657).
…			

230 | **Update the following in Section C.36.2.2.11**

C.36.2.2.11   Wedge Positions Macro

232   This Macro defines the positions of Wedges used in a specific Control Point or set of Control Points.

Table C.36.2.2.11-1
234   **WEDGE POSITIONS MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Number of Wedge Positions	(300A,0655)	1C	Number of Wedge Positions defined in the Wedge Position Sequence (300A,0116). Required if Number of Wedges (300A,00D0) is present and has a non-zero value.
Wedge Position Sequence	(300A,0116)	1C	Position for each Wedge for the current Control Point. Required if **Number of Wedge Positions (300A,0655) is present and has a non-zero value** **and** the conditions in Section C.36.2.2.5.1.1 are satisfied. The number of Items included in this Sequence shall equal the value of Number of Wedge Positions (300A,0655).
>Referenced Device Index	(300A,0607)	1	The value of Device Index (3010,0039) in Wedge Definition Sequence (300A,0651) for the Wedge being used.

236

238 **C.36.12   RT Delivery Device Common Module**

…

240 **C.36.12.2   Well-known Frame of Reference for Equipment**

…

242 **C.36.12.2.1   IEC 61217 Fixed Reference System Frame of Reference**

244 A value **The Well-known Value** of 1.2.840.10008.1.4.3.1 for Equipment Frame of Reference UID (300A,0675) defines the IEC 61217 Fixed Coordinate System Frame of Reference as follows:

- the Equipment Coordinate System is the IEC 61217 FIXED coordinate system.

246 - the Base Beam Modifier Coordinate System for all beam modifiers is the IEC 61217 GANTRY coordinate system. However, RT Radiation SOP Classes allow each Beam
248 Modifier Coordinate System to rotate independently from the Base Beam Modifier Coordinate System.

250 Note: **1.** IEC 61217 refers to the X-axis, Y-axis and Z-axis of the various coordinate systems. When referenced in this Standard the capital X/Y/Z is preserved which is not otherwise a DICOM
252 convention.
2. For the C-arm Photon-Electron Radiation IOD and the Tomotherapeutic Radiation IOD, the
254 **RT Beam Modifier Definition Distance (300A,0688) is the same as the Radiation Source-Axis Distance (300A,0640).**

256

C.36.12.2.2   Standard Robotic-Arm Coordinate System Frame of Reference

258 **The Well-known Value of 1.2.840.10008.1.4.3.2 for Equipment Frame of Reference UID (300A,0675) identifies the Standard Robotic-Arm Coordinate System Frame of Reference to**
260 **which each device is calibrated during installation.**

This coordinate system definition requires that two X-Ray detectors are present at the same
262 **height and the X-ray beams intersect.**

The right-handed coordinate system axes are oriented as follows, when viewed from the
264 **patient support device pedestal towards the delivery device:**

266 - **the x-axis is increasing to the right, parallel to the line between the centers of the X-ray detectors and perpendicular to gravity**

- **the z-axis is increasing away from the direction of gravity**

268 - **the y-axis is the cross-product of the z- and x-axis**

The origin of the coordinate system is the intersection of the central beams from each X-ray
270 **source, where the central beam is the line from the X-ray source to the center of the corresponding detector. The coordinate system definition is independent of the location of**
272 **the delivery device and the patient support system.**

Movements of the robot head are described in the Standard Robotic-Arm Coordinate System.
274 **The rotation of the robot head is expressed by a rotation of the Radiation Source Coordinate System with respect to the Standard Robotic-Arm Coordinate System. The origin of the**
276 **Radiation Source Coordinate System is defined at the RT Device Distance Reference**

278 **Location. The axes of the Radiation Source Coordinate System coincide with the Standard Robotic-Arm Coordinate System under the following conditions:**

- **the source position equals 0,0,0, and**
280 - **the pitch, roll, and yaw angles equal zero.**

282 **The Radiation Source Coordinate System is the parent system of the Base Beam Modifier Coordinate System. The Base Beam Modifier Coordinate System is negatively offset along the z-axis of the Radiation Source coordinate system by the RT Beam Modifier Definition Distance**
284 **(300A,0688).**
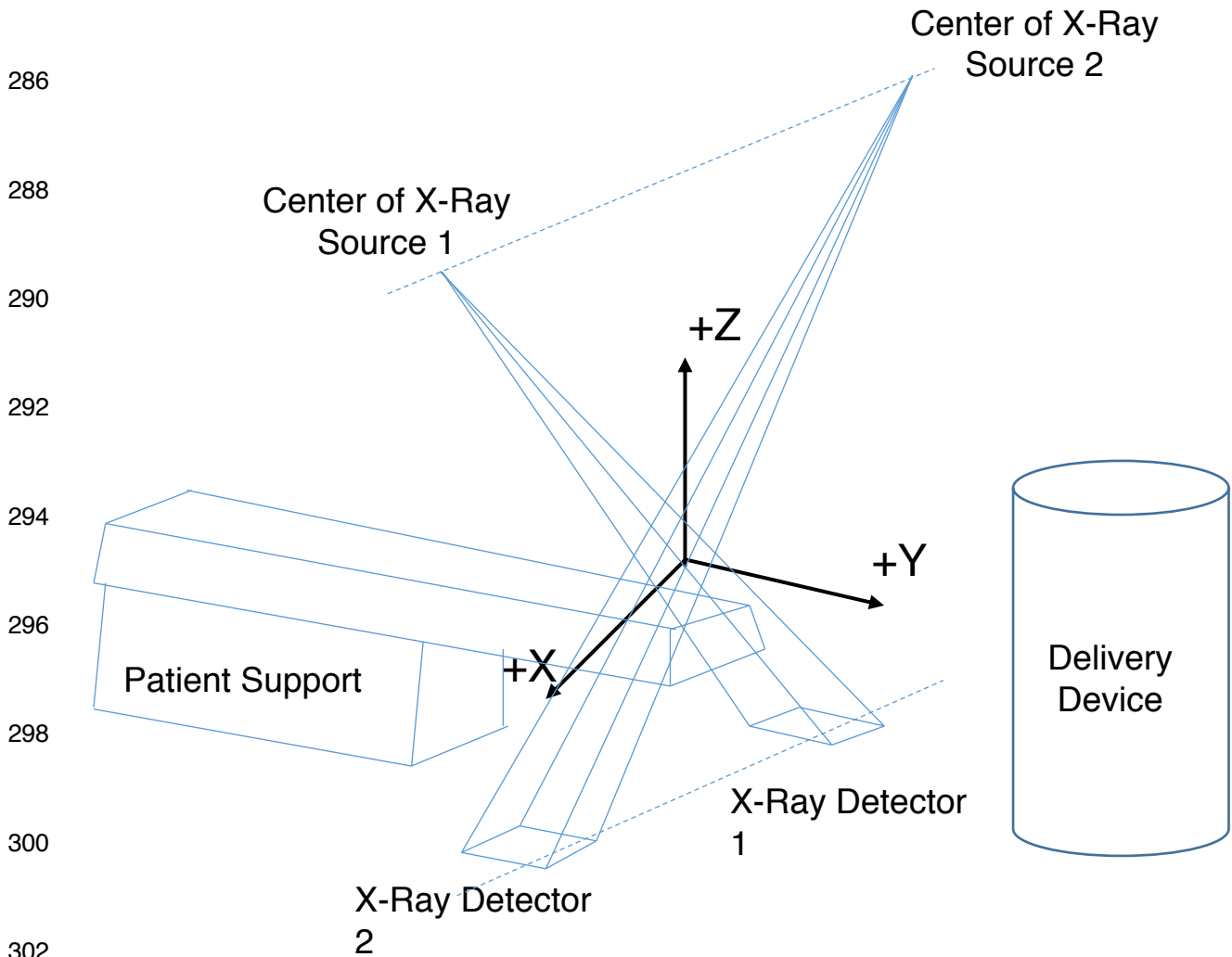
Figure C.36.12.2-1
304 **Standard Robotic-Arm Coordinate System**

306 **Update the following in PS3.3 Annex C, Section C.36.14 C-Arm Photon-Electron Delivery Device Module.**

308 **C.36.14   C-Arm Photon-Electron Delivery Device Module**

The C-Arm Photon-Electron Delivery Device Module **contains** ~~defines~~ ~~constant~~ C-Arm-specific
310 parameters pertaining to the physical device**. These parameters are** used to ~~deliver~~ **specify or
record** photon and electron treatments, including geometrical parameters of the collimation system.

312 …

Update the following in PS3.3 Annex C, Section C.36.15 C-Arm Photon-Electron Beam Module

314 **C.36.15   C-Arm Photon-Electron Beam Module**

The C-Arm Photon-Electron Beam Module specifies **or records** how a C-Arm photon or electron
316 treatment beam is to be **or was** delivered.

Table C.36.15-1
318 **C-ARM PHOTON-ELECTRON BEAM MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Description
Number of RT Control Points	(300A,0604)	1	Number of RT Control Points in the C-Arm Photon-Electron Control Point Sequence (300A,062F). The value shall be equal to or greater than 2.
C-Arm Photon-Electron Control Point Sequence	(300A,062F)	1	Control Points used to model the beam delivery. The number of Items included in this Sequence shall equal the value of Number of RT Control Points (300A,0604).
>Include Table C.36.2.2.6-1 "External Beam Control Point General Macro Attributes"			*Defined CID 9550 "C-Arm Photon-Electron Delivery Rate Units"*
>Referenced Radiation Generation Mode Index	(300A,0605)	1C	The value of Radiation Generation Mode Index (300A,0601) in the Radiation Generation Mode Sequence (300A,067B) in this IOD that defines the Radiation Generation Mode used for this Control Point. Required if **Number of Radiation Generation Modes (300A,0685) is present** **and** the conditions in Section C.36.2.2.5.1.1 are satisfied.
…			

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320 **Add the following in PS3.3 Annex C, Section C.36 RT Second Generation Modules.**

C.36.16   Tomotherapeutic Delivery Device Module

322   The Tomotherapeutic Delivery Device Module contains tomotherapy-specific information pertaining to the physical device. These parameters are used to specify or record the treatment, including
324   geometrical parameters of the collimation system.

Table C.36.16-1
326   **TOMOTHERAPEUTIC DELIVERY DEVICE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Description
Radiation Source-Axis Distance	(300A,0640)	1	Distance in mm from the nominal Radiation Source location to the gantry rotation axis.
Include Table C.36.2.2.7-1 "Radiation Generation Mode Macro Attributes"			*Defined CID for Radiation Type Code Sequence (300A,067F) is CID 9525 "Radiation Therapy Particle".*
			Defined CID for Energy Unit Code Sequence (300A,0684) is CID 9521 "Radiotherapy Treatment Energy Unit".
			Defined CID for Radiation Fluence Modifier Code Sequence (300A,0683) is CID 9549 "Radiation Generation Mode Types".
Include Table C.36.2.2.8-1 "RT Beam Limiting Devices Definition Macro Attributes"			*Defined CID for Device Type Code Sequence (3010,002E) within 'RT Accessory Device Identification Macro' is CID 9541 "Beam Limiting Device Types".*

328   ### C.36.17   Tomotherapeutic Beam Module

The Tomotherapeutic Beam Module specifies or records how a tomotherapeutic treatment is to be or
330   was delivered.

Table C.36.17-1
332   **TOMOTHERAPEUTIC BEAM MODULE ATTRIBUTES**

| Attribute Name	Tag	Type	Description
Table Speed	(0018,9309)	1C	Nominal table speed in mm/s. Required if RT Record Flag (300A,0639) equals NO. May be present otherwise.

Attribute Name	Tag	Type	Description
Revolution Time	(0018,9305)	1C	Nominal time in seconds of one rotation of the gantry.
			Required if RT Treatment Technique Code Sequence (3010,0080) contains (130108, DCM, "Helical Beam") and if RT Record Flag (300A,0639) equals NO.
			May be present if RT Treatment Technique Code Sequence (3010,0080) contains (130108, DCM, "Helical Beam") and if RT Record Flag (300A,0639) equals YES.
Number of RT Control Points	(300A,0604)	1	Number of RT Control Points in the Tomotherapeutic Control Point Sequence (3010,0098).
			The value shall be equal to or greater than 2.
Tomotherapeutic Control Point Sequence	(3010,0098)	1	Control Points for the beam delivery.
			The number of Items included in this Sequence shall equal the value of Number of RT Control Points (300A,0604).
>*Include Table C.36.2.2.6-1 "External Beam Control Point General Macro Attributes"*			*Defined CID 9558 "Tomotherapeutic Dose Rate Units"*
>*Include Table C.36.2.2.9-1 "RT Beam Limiting Device Opening Macro Attributes"*			
>Referenced Radiation Generation Mode Index	(300A,0605)	1C	The value of Radiation Generation Mode Index (300A,0601) in the Radiation Generation Mode Sequence (300A,067B) in this IOD that defines the Radiation Generation Mode used for this Control Point.
			Required if Number of Radiation Generation Modes (300A,0685) is present
			and
			the conditions in Section C.36.2.2.5.1.1 are satisfied.
>Source Roll Angle	(300A,067A)	1C	Source roll angle in degrees of the Radiation Source at the Control Point with respect to the Equipment Coordinate System. The angle is a Continuous Rotation Angle, see C.36.1.1.5.
			See C.36.15.1.1 and C.36.12.1.1.
			Required if the conditions in Section C.36.2.2.5.1.1 are satisfied.

Attribute Name	Tag	Type	Description
>Tomotherapeutic Leaf Open Durations	(3010,0099)	1C	The time in seconds each leaf is open during the Control Point interval, see C.36.17.1.
			The number of leaves (N) is equal to Number of Parallel RT Beam Delimiters (300A,0648).
			N values shall be provided in the order of Parallel RT Beam Delimiter Boundaries (300A,0649).
			Required if RT Record Flag (300A,0639) equals NO
			and
			the conditions in Section C.36.2.2.5.1.1 are satisfied.
>Tomotherapeutic Leaf Initial Closed Durations	(3010,009A)	1C	The time in seconds each leaf is closed at the beginning of the Control Point interval, see C.36.17.1.
			The number of leaves (N) is equal to Number of Parallel RT Beam Delimiters (300A,0648).
			The N values shall be provided in the order of Parallel RT Beam Delimiter Boundaries (300A,0649).
			Required if RT Record Flag (300A,0639) equals NO
			and
			at least one leaf open time is not symmetrical about the mid-point of the Control Point interval
			and
			the conditions in Section C.36.2.2.5.1.1 are satisfied.

334 **C.36.17.1   Tomotherapeutic Leaf Closed and Open Durations**

Typically, the Tomotherapeutic Leaf Open Durations (3010,0099) are symmetric about the mid-point
336   of the Control Point interval. If they are not, Tomotherapeutic Leaf Initial Closed Durations
(3010,009A) is present, which specifies the duration of time that each leaf is closed starting from this
338   Control Point. Tomotherapeutic Leaf Open Durations (3010,0099) then specifies the duration of time
that each leaf is open after Tomotherapeutic Leaf Initial Closed Durations (3010,009A).

340   For each leaf, the sum of the Tomotherapeutic Leaf Initial Closed Durations (3010,009A) and the
Tomotherapeutic Leaf Open Durations (3010,0099) shall not exceed the Control Point interval.
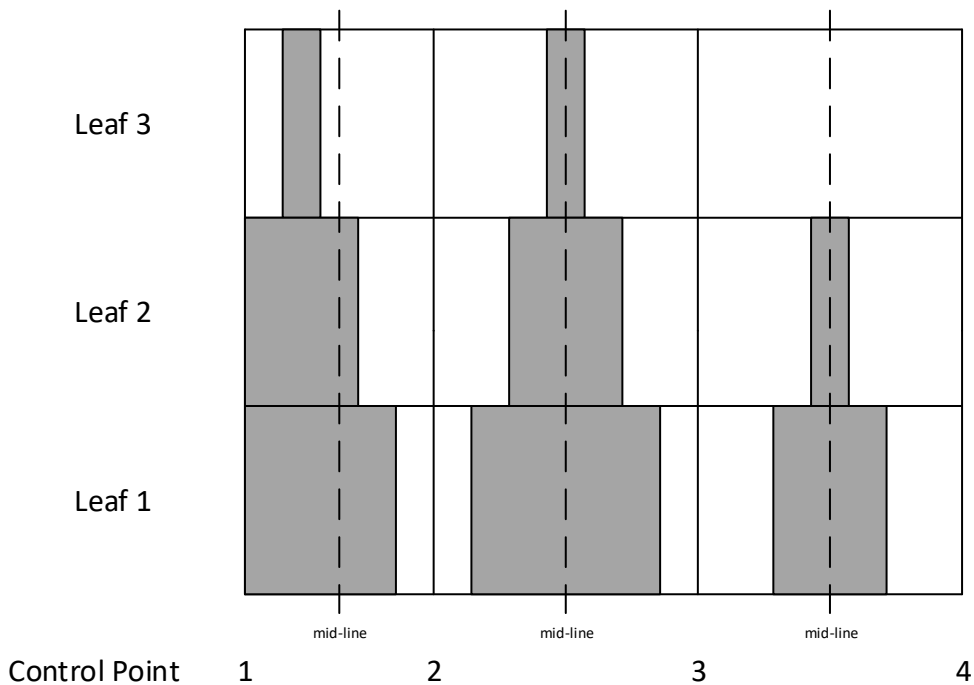
342

Figure C.36.17-1
Diagram of Tomotherapeutic Leaf Open and Closed Durations

344

Table C.36.17-2
Tomotherapeutic Leaf Open and Closed Durations

346

N Control Point Index	Attribute	Leaf 1	Leaf 2	Leaf 3
1	Tomotherapeutic Leaf Open Durations	0.4s	0.3s	0.1s
	Tomotherapeutic Leaf Closed Durations	0	0	0.1s
2	Tomotherapeutic Leaf Open Durations	0.5s	0.3s	0.1s
	Tomotherapeutic Leaf Closed Durations	Not present		
3	Tomotherapeutic Leaf Open Durations	0.3s	0.1s	0
	Tomotherapeutic Leaf Closed Durations	Not present		

348   In Figure C.36.17-1, the grey sections indicate when the leaves are open during radiation delivery.
      Table C.36.17-2 illustrates the use of Tomotherapeutic Leaf Open Durations (3010,0099) and
350   Tomotherapeutic Leaf Initial Closed Durations (3010,009A) based on the diagram. In the Control
      Point interval between Control Point 1 and 2, the leaf openings are not symmetric within the Control
352   Point interval, so Tomotherapeutic Leaf Initial Closed Durations (3010,009A) is provided.

In the Control Point interval between Control Point 2 and 3, all leaf opening durations are symmetric
354 about the mid-point of the Control Point interval, therefore only Tomotherapeutic Leaf Open Durations
(3010,0099) is provided.

356 **C.36.18   Robotic-Arm Delivery Device Module**

The Robotic-Arm Delivery Device Module contains robot-specific information pertaining to the
358 physical device. These parameters are used to specify or record the treatment, including geometric
parameters of the collimation system.

360 **Table C.36.18-1**
ROBOTIC-ARM DELIVERY DEVICE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Robotic Base Location Indicator	(3010,0090)	1	Informative manufacturer-specific description of the location of the base of the robot. The value is independent of the Equipment Coordinate System. Defined Terms: FLOOR_LEFT – Looking from the table towards the robot, the robot is floor-mounted to the viewer's left FLOOR_RIGHT – Looking from the table towards the robot, the robot is floor-mounted to the viewer's right FLOOR_CENTER – Looking from the table towards the robot, the robot is floor-mounted straight ahead of the viewer
Include Table C.36.2.2.7-1 "Radiation Generation Mode Macro Attributes"			*Defined CID for Radiation Type Code Sequence (300A,067F) is CID 9525 "Radiation Therapy Particle".* *Defined CID for Energy Unit Code Sequence (300A,0684) is CID 9521 "Radiotherapy Treatment Energy Unit".* *Defined CID for Radiation Fluence Modifier Code Sequence (300A,0683) is CID 9549 "Radiation Generation Mode Types".*
Include Table C.36.2.2.8-1 "RT Beam Limiting Devices Definition Macro Attributes"			*Defined CID for Device Type Code Sequence (3010,002E) within 'RT Accessory Device Identification Macro' is CID 9541 "Beam Limiting Device Types".*
Include Table C.36.2.2.14-1 "RT Accessory Holders Definition Macro Attributes"			

362

C.36.19   Robotic-Arm Path Module

364   The Robotic-Arm Path Module specifies or records how a Robotic Path treatment is to be delivered.
Multiple paths are encoded as separate RT Radiation instances referred to in the RT Radiation Set
366   IOD.

Table C.36.19-1
368   **ROBOTIC-ARM PATH MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Description
Robotic Path Node Set Code Sequence	(3010,0091)	1C	Node Set from which the Robotic Nodes referenced in the Robotic Path Control Point Sequence (3010,0097) were selected.
			Only a single Item shall be included in this Sequence.
			Required if RT Record Flag (300A,0639) is NO. May be present otherwise.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			Defined CID 9556 "Radiotherapy Robotic Paths"
Number of RT Control Points	(300A,0604)	1	Number of RT Control Points in the Robotic Path Control Point Sequence (3010,0097).
			The value shall be greater than or equal to 2.
Robotic Path Control Point Sequence	(3010,0097)	1	Control Points for the radiation delivery.
			The number of Items included in this Sequence shall equal the value of Number of RT Control Points (300A,0604).
>Include Table C.36.2.2.6-1 "External Beam Control Point General Macro Attributes"			Defined CID 9560 "Robotic Delivery Device Dose Rate Units"
>Referenced Radiation Generation Mode Index	(300A,0605)	1C	The value of Radiation Generation Mode Index (300A,0601) in the Radiation Generation Mode Sequence (300A,067B) in this IOD that defines the Radiation Generation Mode used for this Control Point.
			Required if Number of Radiation Generation Modes (300A,0685) is present
			and
			the conditions in Section C.36.2.2.5.1.1 are satisfied.

Attribute Name	Tag	Type	Description
>Robotic Node Identifier	(3010,0092)	1C	Identifier of the individual Robotic Node (point in space) along the Robotic Path. See Note 1. Required if the conditions in Section C.36.2.2.5.1.1 are satisfied.
>RT Treatment Source Coordinates	(3010,0093)	1C	Coordinates (x,y,z) in mm of the Radiation Source Coordinate System origin in the Equipment Coordinate System. Required if RT Record Flag (300A,0639) is NO and the conditions in Section C.36.2.2.5.1.1 are satisfied. May be present if RT Record Flag (300A,0639) is YES and the conditions in Section C.36.2.2.5.1.1 are satisfied. See C.36.12.2.2.
>Radiation Source Coordinate System Yaw Angle	(3010,0094)	1C	Rotation angle in degrees of the Radiation Source Coordinate System about the z-axis of the Equipment Coordinate System, see C.36.12.2.2. Required if RT Record Flag (300A,0639) is NO and the conditions in Section C.36.2.2.5.1.1 are satisfied. May be present if RT Record Flag (300A,0639) is YES and the conditions in Section C.36.2.2.5.1.1 are satisfied.

Attribute Name	Tag	Type	Description
>Radiation Source Coordinate System Roll Angle	(3010,0095)	1C	Rotation angle in degrees of the Radiation Source Coordinate System about its y-axis after the Radiation Source Coordinate System Yaw Angle (3010,0094) is applied. Required if RT Record Flag (300A,0639) is NO and the conditions in Section C.36.2.2.5.1.1 are satisfied. May be present if RT Record Flag (300A,0639) is YES and the conditions in Section C.36.2.2.5.1.1 are satisfied.
>Radiation Source Coordinate System Pitch Angle	(3010,0096)	1C	Rotation angle in degrees of the Radiation Source Coordinate System about its x-axis after the Radiation Source Coordinate System Roll Angle (3010,0095) is applied. Required if RT Record Flag (300A,0639) is NO and the conditions in Section C.36.2.2.5.1.1 are satisfied. May be present if RT Record Flag (300A,0639) is YES and the conditions in Section C.36.2.2.5.1.1 are satisfied.
>Include Table C.36.2.2.9-1 "RT Beam Limiting Device Opening Macro Attributes"			

370   Note 1:   The values of Robotic Node Identifer (3010,0092) within the Robotic Path Control Point Sequence (3010,0097) may identify Robotic Node positions that are pre-defined in the device configuration.
372   This Attribute is distinct from the RT Control Point Index (300A,0600), which simply indexes items within the Robotic Path Control Point Sequence (3010,0097).

374

376 **Add the following to PS3.4, Appendix B.5, Table B.5-1**

SOP Class Name	SOP Class UID	IOD Spec (defined in PS 3.3)
Tomotherapeutic Radiation Storage	**1.2.840.10008.5.1.4.1.1.481.14**	**Tomotherapeutic Radiation IOD**
Robotic-Arm Radiation Storage	**1.2.840.10008.5.1.4.1.1.481.15**	**Robotic-Arm Radiation IOD**

378

> **Add the following data elements to PS3.6:**

382 **6 REGISTRY OF DICOM DATA ELEMENTS**

(3010,0090)	Robotic Base Location Indicator	RoboticBaseLocationIndicator	CS	1
(3010,0091)	Robotic Path Node Set Code Sequence	RoboticPathNodeSetCodeSequence	SQ	1
(3010,0092)	Robotic Node Identifier	RoboticNodeIdentifier	UL	1
(3010,0093)	RT Treatment Source Coordinates	RTTreatmentSourceCoordinates	FD	3
(3010,0094)	Radiation Source Coordinate System Yaw Angle	RadiationSourceCoordinateSystemYaw Angle	FD	1
(3010,0095)	Radiation Source Coordinate System Roll Angle	RadiationSourceCoordinateSystemRoll Angle	FD	1
(3010,0096)	Radiation Source Coordinate System Pitch Angle	RadiationSourceCoordinateSystemPitch Angle	FD	1
(3010,0097)	Robotic Path Control Point Sequence	RoboticPathControlPointSequence	SQ	1
(3010,0098)	Tomotherapeutic Control Point Sequence	TomotherapeuticControlPointSequence	SQ	1
(3010,0099)	Tomotherapeutic Leaf Open Durations	TomotherapeuticLeafOpenDurations	FD	1-n
(3010,009A)	Tomotherapeutic Leaf Initial Closed Durations	TomotherapeuticLeafInitialClosedDurati ons	FD	1-n

384

386   **ANNEX A   REGISTRY OF DICOM UNIQUE IDENTIFIERS (UID) (NORMATIVE)**

Table A-1 UID Values

UID Value	UID NAME	UID TYPE	Part
1.2.840.10008.5.1.4.1.1.481.14	Tomotherapeutic Radiation Storage	SOP Class	PS3.4
1.2.840.10008.5.1.4.1.1.481.15	Robotic-Arm Radiation Storage	SOP Class	PS3.4
1.2.840.10008.1.4.3.2	Standard Robotic-Arm Coordinate System Frame of Reference	Well-known Frame of Reference	PS3.3

388

Table A-2. Well-known Frames of Reference

UID Value	UID Name	Normative Reference
1.2.840.10008.1.4.3.2	Standard Robotic-Arm Coordinate System Frame of Reference	See PS3.3 C.36.12.2.2.

390

Table A-3 Context Group UID Values

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.1307	9556	Radiotherapy Robotic Node Sets
1.2.840.10008.6.1.1308	9557	Tomotherapeutic Dosimeter Units
1.2.840.10008.6.1.1309	9558	Tomotherapeutic Dose Rate Units
1.2.840.10008.6.1.1310	9559	Robotic Delivery Device Dosimeter Units
1.2.840.10008.6.1.1311	9560	Robotic Delivery Device Dose Rate Units

392

Part 16 Addendum

Add the following new CIDs to PS3.16, Annex B:

CID 9556   **RADIOTHERAPY ROBOTIC NODE SETS**

Context ID 9556

Radiotherapy Robotic Node Sets

Resources: HTML l FHIR JSON l FHIR XML l IHE SVS XML

Type: Extensible

Version: 20200117

UID: 1.2.840.10008.6.1.1307

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	130362	Head Node Set
DCM	130363	Body Node Set
DCM	130364	Trigeminal Node Set
DCM	130365	QA Node Pair
DCM	130366	QA Node

CID 9557   **TOMOTHERAPEUTIC DOSIMETER UNITS**

Context ID 9557

Tomotherapeutic Dosimeter Units

Resources: HTML l FHIR JSON l FHIR XML l IHE SVS XML

Type: Non-Extensible

Version: 20200117

UID: 1.2.840.10008.6.1.1308

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
UCUM	s	s
UCUM	{MU}	Monitor Units

CID 9558   **TOMOTHERAPEUTIC DOSE RATE UNITS**

Context ID 9558

Tomotherapeutic Dose Rate Units

Resources: HTML l FHIR JSON l FHIR XML l IHE SVS XML

Type: Non-Extensible

416

Version: 20200117

UID: 1.2.840.10008.6.1.1309

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
UCUM	Gy/s	Gy/s
UCUM	{MU}/s	Monitor Units/s

418

CID 9559   ROBOTIC DELIVERY DEVICE DOSIMETER UNITS

420   **Context ID 9559**

Robotic Delivery Device Dosimeter Units

422   **Resources: HTML l FHIR JSON l FHIR XML l IHE SVS XML**

Type: Non-Extensible

424   **Version: 20200117**

UID: 1.2.840.10008.6.1.1310

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
UCUM	{MU}	Monitor Units

426

CID 9560   ROBOTIC DELIVERY DEVICE DOSE RATE UNITS

428   **Context ID 9560**

Robotic Delivery Device Dose Rate Units

430   **Resources: HTML l FHIR JSON l FHIR XML l IHE SVS XML**

Type: Non-Extensible

432   **Version: 20200117**

UID: 1.2.840.10008.6.1.1311

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
UCUM	Gy/s	Gy/s

434

	Add the following to PS3.16, Section 2.1:

436

2.1 General

438 …

440 [IEC 60601-2-44] IEC. . Medical Electrical Equipment - Part 2-44: Particular Requirements for the Safety of X-Ray Equipment for Computed Tomography.

442 **[IEC 60601-2-64] IEC. . Medical Electrical Equipment - Part 2-64: Particular requirements for the basic safety and essential performance of light ion beam medical electrical equipment.**

…

	Add the following section to PS3.16, Section 3:

444

3.7 Radiotherapy

446 Monitor Units (MU)
A unit of radiation output used to quantify a Meterset. See PS3.3, C.36.1.1.3.

	Add the following to the table in PS3.16, Annex D:

448

ANNEX D DICOM CONTROLLED TERMINOLOGY DEFINITIONS (NORMATIVE)

450

Code Value	Code Meaning	Definition	Notes
130362	Head Node Set	Set of Robotic Nodes that can be used for targets associated with the patient's head.	
130363	Body Node Set	Set of Robotic Nodes that can be used for targets within the patient's body, excluding the head.	
130364	Trigeminal Node Set	Set of Robotic Nodes that can be used for targets near the patient's trigeminal nerve.	
130365	QA Node Pair	Two Robotic Nodes for Quality Assurance, for example daily checks.	
130366	QA Node	Single Robotic Node for Quality Assurance.	