Digital Imaging and Communications in Medicine (DICOM)

Supplement 176: Second Generation Radiotherapy –

New RT Radiations

DICOM Standards Committee, Working Group 7, Radiation Therapy

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Foreword

This Supplement in its current state represents the remaining sections of Supplement 147, revision 42, which is being split into several smaller attributes.

Attribute definitions, CID definitions and DICOM Controlled terminology are currently not part of this document, but remain in their entirety in Supplement 147 until it is ready for Public Comment. Then the remaining parts of these chapters will be moved to this document.

This Supplement specifies the additional IODs necessary to support the new Second Generation Radiotherapy IODs and operations.

This document 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 3.16	Content Mapping Resource

Scope and Field of Application

Introduction

Existing radiotherapy IODs were designed to provide a set of containers for use in communicating radiation therapy data of all types, in a generic and flexible way.

Since the development of the initial IODs, both radiation therapy practice and the DICOM Standard itself have evolved considerably. In particular, workflow management is now a key aspect of DICOM's domain of application, and the introduction of Unified Worklist and Procedure Step (by Supplement 74 in conjunction with Supplement 96) have begun the growth of radiation therapy into workflow management.

This supplement addresses the need for a new generation of IODs and processes required for use in radiation therapy. The general principles under which these IODs and processes have been developed are documented below.

The scope of this supplement is the introduction of new RT Radiation IODs representing treatment delivery devices that had no representation in the First Generation DICOM Radiotherapy model.

General Architectural Principles

The DICOM "STRATEGIC DOCUMENT Version 10.4, October 25, 2010" outlines a number of principles applicable across the entire DICOM standard. The key relevant points, and how this supplement addresses those concerns, are as follows:

- Image IOD development follows the “enhanced multi-frame” paradigm, rather than stacks of 2D SOP Instances. The new RT Dose Image follows this paradigm.

- Different representations of data are encoded in different IODs. This is in contrast to first-generation objects, where multiple different types of data are encoded in a single IOD, such as RT Structure Set.

- These new IODs do not define an architecture for the entire system, or functional requirements beyond behavior required for specific services. This is because the mode of manual exchange of objects (see PS3.17) supports an arbitrary system architecture. The worklist mode of operation does place some constraints on the architecture – for example, it implies the existence of one or more workflow servers that have knowledge of department-wide scheduling. The Radiation Oncology domain of the IHE initiative may adapt workflows that will utilize 2nd Generation Radiotherapy objects and define their usage in a clinical workflow, as it was done with Supplement 74 and the IHE-RO Technical Profile "Treatment and Delivery Workflow".

RT Architectural Principles

In addition to the general principles outlined above, additional principles specific to radiation therapy have been used in the development of this supplement:

- Support for available technologies: The new IODs are designed to support legacy and full-featured, modern equipment.

- Compatibility with First-Generation IODs: In general, where the technologies continue to be supported, it will be possible for the content of first-generation IODs to be re-encoded into the second generation IODs described in the supplement. However, such a translation will not be a basic re-encoding and will require additional information supplied by the translating device.

- New data representation approaches in DICOM: Where possible, use has been made of new and powerful approaches, such as 3D segmentation, mesh representation, rigid and deformable registrations.

- IODs specific to use cases: Explicit separate IODs have been developed for specific treatment modalities with the concept of RT Radiation IOD – for example, Tomotherapeutic, C-Arm, and Robotic beams are modeled separately. This allows more stringent conditions to be applied to the presence or absence of attributes within those IODs, and thereby increases the potential for interoperability.

- Expandability of concept: New treatment modalities currently not considered by this standard can be modeled along the existing RT Radiation IODs and be introduced later on, fitting into the existing concept.

- Workflow Management: The concept of workflow management using Unified Procedure Step has been fully integrated into the new IODs. However, specific instruction and result IODs needed for some of these workflows will be standardized in a subsequent supplement.

- New techniques in oncology: The existence of new treatment techniques (such as robotic therapy and tomotherapy) have been taken into account, along with new treatment strategies (such as image-guided therapy and adaptive therapy).

See Part 17 for descriptions of new radiotherapy entities and sample use cases.

176 **Part 2 Addendum**

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

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UID Value	UID Name	Category
1.2.840.10008.5.1.4.1.1.481.XN.5.1	Tomotherapeutic Radiation Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.5.4	Multiple Fixed Source Radiation Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.5.5	Robotic Radiation Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.5.7	Multi-Axial Radiation Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.6.1	Tomotherapeutic Radiation Record Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.6.4	Multiple Fixed Source Radiation Record Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.6.5	Robotic Radiation Record Storage	Transfer
1.2.840.10008.5.1.4.1.1.481.XN.6.7	Multi-Axial Radiation Record Storage	Transfer

180 **Part 3 Addendum**

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

IODs Modules	Tomo Rad	Multi-Fixed Rad	Rob Rad	Multi-Axial Rad	Tomo Rec	Multi Fixed Rec	Rob Rec	Multi Axial Rec
Patient	M	M	M	M	M	M	M	M
Clinical Trial Subject	U	U	U	U	U	U	U	U
General Study	M	M	M	M	M	M	M	M
Patient Study	U	U	U	U	U	U	U	U
Clinical Trial Study	U	U	U	U	U	U	U	U
General Series	M	M	M	M	M	M	M	M
Clinical Trial Series	U	U	U	U	U	U	U	U
Enhanced RT Series	M	M	M	M	M	M	M	M
General Equipment	M	M	M	M	M	M	M	M
Enhanced General Equipment	M	M	M	M	M	M	M	M
Frame Of Reference	M	M	M	M	M	M	M	M
Synchronization								
Radiotherapy Common Instance	M	M	M	M	M	M	M	M
RT Delivery Device Common	M	M	M	M	M	M	M	M
RT Radiation Common	M	M	M	M	M	M	M	M

IODs Modules	Tomo Rad	Multi-Fixed Rad	Rob Rad	Multi-Axial Rad	Tomo Rec	Multi Fixed Rec	Rob Rec	Multi Axial Rec
Tomotherapeutic Delivery Device	M				M			
Tomotherapeutic Beam	M				M			
Multiple Fixed Source Delivery Device		M				M		
Multiple Fixed Source Beam Set		M				M		
Robotic Delivery Device			M				M	
Robotic Path			M				M	
Multi-Axial Delivery Device				M				M
Multi-Axial Beam				M				M
Image Pixel								
Acquisition Context								
Enhanced RT Dose								
Multi-frame Functional Groups								
Multi-frame Dimension								
Respiratory Synchronization								
Common Instance Reference Module	M	M	M	M	M	M	M	M
SOP Common	M	M	M	M	M	M	M	M

A.VV.1.6 Tomotherapeutic Radiation Information Object Definition

A.VV.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.VV.1.6.2 Tomotherapeutic Radiation IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.6.3 Tomotherapeutic Radiation IOD Module Table

Table A.VV.1.6-1
TOMOTHERAPEUTIC RADIATION IOD MODULES

IE	Module	Reference	Usage
Include 'RT Radiation IOD Modules Macro' Table A.VV.1.1.1-2			
RT Radiation	Tomotherapeutic Delivery Device	C.AA.F1	M
	Tomotherapeutic Beam	C.AA.F2	M

A.VV.1.6.3.1 RT Radiation Common Module in RT Radiation IOD Modules Macro

For the Tomotherapeutic Radiation IOD, the Code Sequence Macro in the Radiotherapy Procedure Technique Code Sequence (30xx,0C99) in the RT Radiation Common Module shall use Defined CID SUP147013.

A.VV.1.9 Multiple Fixed Source Radiation Information Object Definition

A.VV.1.9.1 Multiple Fixed Source Radiation IOD Description

The Multiple Fixed Source Radiation IOD represents the information required to describe a radiotherapy treatment on a multiple fixed source photon delivery device.

A.VV.1.9.2 Multiple Fixed Source Radiation IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.9.3 Multiple Fixed Source Radiation IOD Module Table

Table A.VV.1.9-1
MULTIPLE FIXED SOURCE RADIATION IOD MODULES

IE	Module	Reference	Usage
Include 'RT Radiation IOD Modules Macro' Table A.VV.1.1.1-2			
RT Radiation	Multiple Fixed Source Delivery Device	C.AA.H1	M
	Multiple Fixed Source Beam Set	C.AA.H2	M

A.VV.1.9.3.1 RT Radiation Common Module in RT Radiation IOD Modules Macro

For the Multiple Fixed Source Radiation IOD, the Code Sequence Macro in the Radiotherapy Procedure Technique Code Sequence (30xx,0C99) in the RT Radiation Common Module shall use Defined CID SUP147045.

A.VV.1.10 Robotic Radiation Information Object Definition

A.VV.1.10.1 Robotic Radiation IOD Description

The Robotic Radiation IOD represents the information required to describe a radiotherapy treatment on a robotic delivery device, such as paths, nodes, and collimation type.

A.VV.1.10.2 Robotic Radiation IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.10.3 Robotic Radiation IOD Module Table

Table A.VV.1.10-1
ROBOTIC RADIATION IOD MODULES

IE	Module	Reference	Usage
Include 'RT Radiation IOD Modules Macro' Table A.VV.1.1.1-2			
RT Radiation	Robotic Delivery Device	C.AA.J1	M
	Robotic Path	C.AA.J2	M

A.VV.1.10.3.1 RT Radiation Common Module in RT Radiation IOD Modules Macro

For the Robotic Radiation IOD, the Code Sequence Macro in the Radiotherapy Procedure Technique Code Sequence (30xx,0C99) in the RT Radiation Common Module shall use Defined CID SUP147046.

A.VV.1.11 Multi-Axial Radiation Information Object Definition

A.VV.1.11.1 Multi-Axial Radiation IOD Description

The Multi-Axial Radiation IOD represents the information required to describe a radiotherapy treatment on a C-arm device having additional degrees of freedom in source positioning.

A.VV.1.11.2 Multi-Axial Radiation IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.11.3 Multi-Axial Radiation IOD Module Table

Table A.VV.1.11-1
MULTI-AXIAL RADIATION IOD MODULES

IE	Module	Reference	Usage
Include 'RT Radiation IOD Modules Macro' Table A.VV.1.1.1-2			
RT Radiation	Multi-Axial Delivery Device	C.AA.L1	M
	Multi-Axial Beam	C.AA.L2	M

A.VV.1.11.3.1 RT Radiation Common Module in RT Radiation IOD Modules Macro

For the Multi-Axial Radiation IOD, the Code Sequence Macro in the Radiotherapy Procedure Technique Code Sequence (30xx,0C99) in the RT Radiation Common Module shall use Defined CID SUP147012.

A.VV.1.15 Tomotherapeutic Radiation Record Information Object Definition

A.VV.1.15.1 Tomotherapeutic Radiation Record IOD Description

The Tomotherapeutic Radiation Record IOD records the radiation delivered using the Tomotherapeutic Radiation IOD.

A.VV.1.15.2 Tomotherapeutic Radiation Record IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.15.3 Tomotherapeutic Radiation Record IOD Module Table

Table A.VV.1.15-1
TOMOTHERAPEUTIC RADIATION RECORD IOD MODULES

IE	Module	Reference	Usage
Include 'Tomotherapeutic Radiation IOD Modules' Table A.VV.1.6-1			
Include 'RT Radiation Record IOD Modules Macro' Table A.VV.1.1.1-3			

A.VV.1.18 Multiple Fixed Source Radiation Record Information Object Definition

A.VV.1.18.1 Multiple Fixed Source Record Radiation IOD Description

The Multiple Fixed Source Radiation Record IOD records the radiation delivered using the Multiple Fixed Source Radiation IOD.

A.VV.1.18.2 Multiple Fixed Source Radiation Record IOD E-R Model

See Figure A.VV.1.1.1-1.

A.VV.1.18.3 Multiple Fixed Source Radiation Record IOD Module Table

Table A.VV.1.18-1
MULTIPLE FIXED SOURCE RADIATION RECORD IOD MODULES

IE	Module	Reference	Usage
Include 'Multiple Fixed Source Radiation IOD Modules' Table A.VV.1.9-1			
Include 'RT Radiation Record IOD Modules' Table A.VV.1.1.1-3			

A.VV.1.19 Robotic Radiation Record Information Object Definition

A.VV.1.19.1 Robotic Radiation Record IOD Description

The Robotic Radiation Record IOD records the radiation delivered using the Robotic Radiation IOD.

A.VV.1.19.2 Robotic Radiation Record IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.19.3 Robotic Radiation Record IOD Module Table

Table A.VV.1.19-1
ROBOTIC RADIATION RECORD IOD MODULES

IE	Module	Reference	Usage
Include 'Robotic Radiation IOD Modules' Table A.VV.1.10-1			
Include 'RT Radiation Record IOD Modules Table A.VV.1.1.1-3			

A.VV.1.20 Multi-Axial Radiation Record Information Object Definition

A.VV.1.20.1 Multi-Axial Radiation Record IOD Description

The Multi-Axial Radiation Record IOD records the radiation delivered using the Multi-Axial Radiation IOD.

A.VV.1.20.2 Multi-Axial Radiation Record IOD Entity-Relationship Model

See Figure A.VV.1.1.1-1.

A.VV.1.20.3 Multi-Axial Radiation Record IOD Module Table

Table A.VV.1.20-1
MULTI-AXIAL RADIATION RECORD IOD MODULES

IE	Module	Reference	Usage
Include 'Multi-Axial Radiation IOD Modules' Table A.VV.1.11-1			
Include 'RT Radiation Record IOD Modules' Table A.VV.1.1.1-3			

Add the following to PS3.3 Annex C:

C.AA.F1 Tomotherapeutic Delivery Device Module

The Tomotherapeutic Delivery Device Module contains tomotherapy-specific information pertaining to the physical device used to deliver the treatment, including geometrical parameters of the collimation system. This information is constant for all possible beam deliveries with this equipment.

Table C.AA.F1-1
TOMOTHERAPEUTIC DELIVERY DEVICE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Source-Axis Distance	(300A,00B4)	1	Radiation source to Gantry rotation axis distance of the equipment that is to be used for beam delivery (mm).
Include 'Beam Mode Macro' Table C.AA.2.19-1			
Include 'Accessory Holder Definition Macro' Table C.AA.2.26-1			
Tomotherapeutic Leaf Bank Definition Sequence	(30xx,1000)	1	Leaf slot positions for Leaf Banks. One or more Items shall be included in this sequence.
>Leaf Bank Offset	(30xx,1001)	1	Offset (in mm) of central axis of Leaf Bank in X-axis of IEC BEAM LIMITING DEVICE coordinate system, relative to the nominal central axis of the delivery machine.
>Number of Leaf Slots	(30xx,1002)	1	Number of leaf slots in the current Leaf Bank. See C.AA.F1.1.1.
>Binary MLC Leaf Slot Boundaries	(30xx,1003)	1	Boundaries of beam limiting device (collimator) leaves (in mm) in Y-axis of IEC BEAM LIMITING DEVICE coordinate system. Contains N+1 values, where N is the Number of Binary MLC Leaf Slots.

C.AA.F1.1 Tomotherapeutic Delivery Device Attribute Description

C.AA.F1.1.1 Leaf Slot Definition

A 'Leaf Slot' is a channel perpendicular to the binary collimator long axis that can be occluded by a leaf or leaves during treatment. A Leaf Slot may be occluded by a single leaf (for example, in the case of opposing banks of interleaved leaves), or by two leaves (in the case of opposed leaf pairs). The exact nature of these leaves is not described in this module: for the purpose of beam characterization it is sufficient to model the Leaf Slot dimensions only.

C.AA.F2 Tomotherapeutic Beam Module

The Tomotherapeutic Beam Module specifies how a tomotherapeutic treatment beam is to be delivered.

2 **Table C.8A.F2-1**
TOMOTHERAPEUTIC BEAM MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Radiation Particle	(30xx,5110)	1	Particle Type of Radiation. Defined Terms: PHOTON ELECTRON PROTON
Maximum Binary MLC Jaw 1 Opening	(30xx,1005)	1	Position (in mm) of Jaw 1 (IEC Y1) edge defining the maximum extent of the opening for the current Beam, as defined by IEC BEAM LIMITING DEVICE coordinate system.
Maximum Binary MLC Jaw 2 Opening	(30xx,1006)	1	Position (in mm) of Jaw 2 (IEC Y2) edge defining the maximum extent of the opening at the current Beam, as defined by IEC BEAM LIMITING DEVICE coordinate system.
Tomotherapeutic Nominal Couch Speed	(30xx,1007)	1	Nominal Couch Speed for beam (mm/sec).
Tomotherapeutic Nominal Gantry Period	(30xx,1008)	1C	Nominal Gantry Period for beam (seconds). Required if Code Value in Radiotherapy Procedure Technique Code Sequence (30xx,0C99) is (S147240, 99SUP147, “Helical Beam”). May be present otherwise.
Tomotherapeutic Nominal Delivery Pitch	(30xx,1009)	1C	Nominal Delivery Pitch for beam. Required if Code Value in Radiotherapy Procedure Technique Code Sequence (30xx,0C99) is (S147240, 99SUP147, “Helical Beam”). May be present otherwise.
Tomotherapeutic Control Point Sequence	(30xx,1010)	1	Control points used to model the beam delivery. Two or more Items shall be included in this sequence.
>Include 'External Beam Control Point General Attributes Macro' Table C.AA.2.17-1			
>Beam Mode Index	(30xx,0113)	1	Uniquely references the Beam Mode identified by Beam Mode Index (30xx,0113) in Beam Mode Sequence (30xx,51C0).

Attribute Name	Tag	Type	Description
>Gantry Roll Continuous Angle	(30xx,51B5)	1C	Continuous gantry angle of radiation source at the Control Point in IEC GANTRY coordinate system with respect to IEC FIXED REFERENCE coordinate system (degrees). Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1 and C.AA.G2.1.2.
>Binary MLC Jaw 1 Opening	(30xx,1024)	1C	Position (in mm) of Jaw 1 (IEC Y1) edge defining the extent of the opening at the current Control Point, as defined by IEC Beam Limiting Device coordinate system. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point.
>Binary MLC Jaw 2 Opening	(30xx,1025)	1C	Position (in mm) of Jaw 2 (IEC Y2) edge defining the extent of the opening at the current Control Point, as defined by IEC Beam Limiting Device coordinate system. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point.
>Tomotherapeutic Leaf Open Percentages	(30xx,1030)	1C	Percentage of projection time jaw leaves are open during the projection following the Control Point for the current leaf bank. Value multiplicity is equal to Number of Leaf Slots. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point.
>Tomotherapeutic Leaf Open Start Percentages	(30xx,1031)	1C	Percentage of projection time at which jaw leaves open during the projection following the Control Point for the current leaf bank. Value multiplicity is equal to Number of Leaf Slots. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. and if one or more leaf open times are not symmetrical about the projection center. May be present otherwise.

C.AA.H1 Multiple Fixed Source Delivery Device Module

The Multiple Fixed Source Delivery Device Module contains multiple fixed source device-specific information pertaining to the physical device used to deliver the treatment, including geometrical parameters of the collimation system. This information is constant for all possible beam deliveries with this equipment.

Table C.AA.H1-1
MULTIPLE FIXED SOURCE DELIVERY DEVICE MODULE

Attribute Name	Tag	Type	Description
Radiation Source Sequence	(30xx,5130)	1	The radiation sources of the device. One or more Items shall be included in this sequence.
>Radiation Source Label	(30xx,5131)	1	Identification label for the Radiation Source. The label shall be unique within the sequence.
>Radiation Source Collimator Size	(30xx,513B)	1	Diameter (full width at half maximum) in the machine isocenter of the beam originating from the radiation source through the collimator (mm).
>Radiation Source Distance	(30xx,5132)	2	Source to isocenter distance (mm).
>Radiation Source Theta	(30xx,5133)	1	The theta angle from the isocenter to the radiation source (degrees). See C.AA.H1.1.1.
>Radiation Source Phi	(30xx,5134)	1	The phi angle from the isocenter to the radiation source (degrees). See C.AA.H1.1.1.

C.AA.H1.1 Multiple Fixed Source Delivery Device Attribute Description

C.AA.H1.1.1 Radiation Source Angles

Radiation Source Theta (30xx,5133) is the angle from the Z axis of the equipment coordinate system to the vector from the isocenter to the source. Radiation Source Phi (30xx,5134) is the angle from the X axis of the device coordinate system to the projection of the vector from the isocenter to the source on the XY plane of the device coordinate system.

C.AA.H2 Multiple Fixed Source Beam Set Module

The Multiple Fixed Source Beam Set Module specifies how a multiple fixed source treatment beam is to be delivered. In this context “beam” refers to a radiation for a period of time from multiple radiation sources.

Table C.8A.H2-1
MULTIPLE FIXED SOURCE BEAM SET MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description

Attribute Name	Tag	Type	Description
Radiation Particle	(30xx,5110)	1	Particle Type of Radiation. Defined Terms: PHOTON
Radiation Source Pattern Sequence	(30xx,513C)	1	Radiation source patterns. One or more Items shall be included in this sequence.
>Radiation Source Pattern Label	(30xx,513D)	1	Identification label for the Radiation Source Pattern. The label shall be unique within this sequence.
>Radiation Source Pattern Source Sequence	(30xx,513F)	1	Radiation sources used for the enclosing pattern. One or more Items shall be included in this sequence.
>>Referenced Radiation Source Label	(30xx,513A)	1	Uniquely identifies the Radiation Source described in the Radiation Source Sequence (30xx,5130) by a reference to the Radiation Source Label (30xx,5131).
Radiation Source Control Point Sequence	(30xx,5137)	1	Control points used to model the radiation delivery. The sequence shall contain an even number of Items, where each pair marks the start and end of a radiation. Two or more Items shall be included in this sequence.
>Include 'External Beam Control Point General Attributes Macro' Table C.AA.2.17-1			
>Referenced Radiation Source Pattern	(30xx,513E)	1C	Uniquely identifies the Radiation Source Pattern described in the Radiation Source Pattern Sequence (30xx,513C) by a reference to the Radiation Source Pattern Label (30xx,513D). Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.

C.AA.J1 Robotic Delivery Device Module

The Robotic Delivery Device Module contains robot-specific information pertaining to the physical device used to deliver the treatment, including geometrical parameters of the collimation system. This information is constant for all possible beam deliveries with this equipment.

Table C.AA.J1-1
ROBOTIC DELIVERY DEVICE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description

Attribute Name	Tag	Type	Description
Robotic Device Geometry	(30xx,0F03)	1	Imaging geometry with which this path is associated. Defined Terms: NORMAL MIRROR
Include 'Beam Mode Macro' Table C.AA.2.19-1			
Include 'RT Beam Limiting Device Definition Macro' Table C.AA.2.20-1			
Include 'Accessory Holder Definition Macro' Table C.AA.2.26-1			

C.AA.J2 Robotic Path Module

The Robotic Path Module specifies how a robotic path is to be delivered. Each SOP Instance corresponds to a single robotic "path". Multiple paths are encoded as separate Radiation instances defined by reference in the Radiation Set IOD.

Table C.AA.J2-1
ROBOTIC PATH MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Radiation Particle	(30xx,5110)	1	Particle Type of Radiation. Defined Terms: PHOTON ELECTRON PROTON
Robotic Path Identifier Sequence	(30xx,0F15)	1	Path Set identifier. Only a single Item shall be included in this sequence.
>Include 'Code Sequence Macro' Table 8.8-1.			*Defined CID SUP147011.*
Robotic Control Point Sequence	(30xx,0F50)	1	Control points used to model the beam delivery. Two or more Items shall be included in this sequence.
>Include 'External Beam Control Point General Attributes Macro' Table C.AA.2.17-1			
>Beam Mode Index	(30xx,0113)	1	Uniquely references the Beam Mode identified by Beam Mode Index (30xx,0113) in Beam Mode Sequence (30xx,51C0).
>Robotic Path Node Number	(30xx,0F33)	1	A unique number that determines the sequence of delivery of individual nodes within the path. The value of node numbers increases monotonically, but may be non-contiguous. See Note 1.

Attribute Name	Tag	Type	Description
>RT Treatment Source Coordinate	(30xx,0F40)	1	Coordinates (x,y,z) of the source of the beam in the equipment defined original (device) coordinate system.
>RT Treatment Target Coordinate	(30xx,0F44)	1C	Cartesian values (x,y,z) of the target of the beam in the equipment defined original (device) coordinate system. Required if Robotic Beam Sub-Control Point Sequence (30xx,0F42) is not present and the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.1.
>Robot Head Yaw Angle	(30xx,0F46)	1C	Robot Head Yaw Angle, i.e. the rotation of ROBOTIC COLLIMATOR coordinate system about the Z-axis of the ROBOTIC HEAD coordinate system (degrees). Required if Robotic Beam Sub-Control Point Sequence (30xx,0F42) is not present and if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.1.
>Include 'RT Beam Limiting Device Positions Macro' Table C.AA.2.21-1			
>Robotic Beam Sub-Control Point Sequence	(30xx,0F42)	1C	Specification of beam parameter changes within a Control Point. Required at all Control Points but the last. C.AA. Two or more Items shall be included in this sequence.
>>Include 'External Beam Sub-Control Point General Attributes Macro' Table C.AA.2.18-1			
>>RT Treatment Target Coordinate	(30xx,0F44)	1C	Cartesian values (x,y,z) of the target of the beam in the equipment defined original (device) coordinate system. Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1.

Attribute Name	Tag	Type	Description
>>Robot Head Yaw Angle	(30xx,0F46)	1C	Robot Head Yaw Angle, i.e. the rotation of ROBOTIC COLLIMATOR coordinate system about the Z-axis of the ROBOTIC HEAD coordinate system (degrees). Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1.

Note 1: The Robotic Path Node Number (30xx,0F33) may reference node positions being pre-defined in the device configuration. This attribute is distinct from the Control Point Index (30xx,0111), which simply indexes items within the Robotic Control Point Sequence (30xx,0F50).

C.AA.L1 Multi-Axial Delivery Device Module

The Multi-Axial Delivery Device Module contains specific information pertaining to the physical device used to deliver photon and electron treatments, including geometrical parameters of the collimation system. This information is constant for all possible beam deliveries with this equipment.

Table C.AA.L1-1
MULTI-AXIAL DELIVERY DEVICE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Source-Axis Distance	(300A,00B4)	1	Distance in (mm) from the Radiation source perpendicular to Gantry Roll rotation axis of the equipment that is to be used for beam delivery. See C.AA.L1.1.
Center of Rotation-Axis Distance	(30xx,1501)	1	Distance in (mm) from the Center of Rotation of the Multi-Axial Gantry Head perpendicular to Gantry Roll rotation axis of the equipment that is to be used for beam delivery (mm). See C.AA.L2.1.3.
Include 'Beam Mode Macro' Table C.AA.2.19-1			
Include 'RT Beam Limiting Device Definition Macro' Table C.AA.2.20-1			
Include 'Wedges Definition Macro' Table C.AA.2.22-1			
Include 'Accessory Holder Definition Macro' Table C.AA.2.26-1			
Include 'Boli Definition Macro' Table C.AA.2.28-1			

C.AA.L2.1 Multi Axial Delivery Device Attribute Description

C.AA.L1.1 Source-Axis Distance

For a Multi-Axial Delivery Device, the Source Axis Distance (300A,00B4) is defined with Gantry Head pitch and roll rotation angles at zero degree position (see figure C.AA.L2.1.3-1).

C.AA.L2 Multi-Axial Beam Module

2 The Multi-Axial Beam Module specifies how a Multi-Axial treatment beam is to be delivered.

Table C.AA.L2-1

4 **MULTI-AXIAL BEAM MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Description
Radiation Particle	(30xx,5110)	1	Particle Type of Radiation. Enumerated Values: PHOTON ELECTRON
Gantry Head Mode	(30xx,1546)	1	The Gantry Head Mode. Defined Terms: STATIC = no Gantry Head movement is allowed DYNAMIC_TRACKING = Gantry Head movement is allowed except no detailed information is provided DYNAMIC = detailed Gantry Head movement information is provided
Multi-Axial Control Point Sequence	(30xx,1500)	1	Control points used to model the beam delivery. Two or more Items shall be included in this sequence.
>Include 'External Beam Control Point General Attributes Macro' Table C.AA.2.17-1			
>Beam Mode Index	(30xx,0113)	1	Uniquely references the Beam Mode identified by Beam Mode Index (30xx,0113) in Beam Mode Sequence (30xx,51C0).
>Include 'RT Beam Limiting Device Positions Macro' Table C.AA.2.21-1. See C.AA.L2.1.1.			
>Include 'Wedge Positions Macro' Table C.AA.2.23-1			
>Include 'Accessory Holder Definition Macro' Table C.AA.2.26-1			
>Gantry Pitch Continuous Angle	(30xx,51B7)	1C	Continuous gantry pitch angle at the Control Point, i.e. the rotation of the IEC GANTRY coordinate system about the x-axis of the system rotated by the Gantry Yaw Continuous Angle (30xx,51B3) in (degrees). See C.AA.G2.1.4 and C.AA.L2.1.3. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.

Attribute Name	Tag	Type	Description
>Gantry Roll Continuous Angle	(30xx,51B5)	1C	Continuous gantry angle of radiation source at the Control Point, i.e. the rotation of the IEC GANTRY coordinate system about the y-axis of the system rotated by the Gantry Yaw Continuous Angle (30xx,51B3) and rotated by the Gantry Pitch Continuous Angle (30xx,51B7) in (degrees). See C.AA.G2.1.4 and C.AA.L2.1.3. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.
>Gantry Yaw Continuous Angle	(30xx,51B3)	1C	Continuous gantry yaw angle at the Control Point, i.e. the rotation of the IEC GANTRY coordinate system about the z-axis of the IEC FIXED SYSTEM in (degrees). See C.AA.G2.1.4 and C.AA.L2.1.3. Required if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1.
>Gantry Head Pitch Angle	(30xx,1520)	1C	Gantry Head Pitch Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the X-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if Multi-Axial Sub-Control Point Sequence (30xx,1540) is not present and if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1 and C.AA.L2.1.2.
>Gantry Head Roll Angle	(30xx,1521)	1C	Gantry Head Roll Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the Y-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if Multi-Axial Sub-Control Point Sequence (30xx,1540) is not present and if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1 and C.AA.L2.1.2.

Attribute Name	Tag	Type	Description
>Gantry Head Yaw Angle	(30xx,1522)	1C	Gantry Head Yaw Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the Z-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if Multi-Axial Sub-Control Point Sequence (30xx,1540) is not present and if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1 and C.AA.L2.1.2.
>Multi-Axial Target Coordinate	(30xx,1525)	2C	Target coordinates (x,y,z) in the patient based coordinate system described in C.7.6.2.1.1 (mm) at Source-Axis Distance. Required if Multi-Axial Sub-Control Point Sequence (30xx,1540) is not present and if the Control Point Index (30xx,0111) equals 1 or attribute value changes at any Control Point. See C.AA.2.16.1 and C.AA.L2.1.2.
>Surface Entry Point	(300A,012E)	2	Patient surface entry point coordinates (x,y,z), along the central axis of the beam, in the patient based coordinate system described in C.7.6.2.1.1 (mm).
>Source to Surface Distance	(300A,0130)	2	Source to Patient Surface distance (mm).
>Multi-Axial Sub-Control Point Sequence	(30xx,1540)	1C	Sub-Control Points. Required at every Control Point except the last if Gantry Head Mode (30xx,1546) is DYNAMIC. May be present at every Control Point except the last if Gantry Head Mode is DYNAMIC_TRACKING. Two or more Items shall be included in this sequence.
>>Include 'External Beam Sub-Control Point General Attributes Macro' Table C.AA.2.18-1			
>>Gantry Head Pitch Angle	(30xx,1520)	1C	Gantry Head Pitch Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the X-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1.and C.AA.L2.1.2.

Attribute Name	Tag	Type	Description
>>Gantry Head Roll Angle	(30xx,1521)	1C	Gantry Head Roll Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the Y-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1.and C.AA.L2.1.2.
>>Gantry Head Yaw Angle	(30xx,1522)	1C	Gantry Head Yaw Angle, i.e. the rotation of the MULTI-AXIAL GANTRY HEAD coordinate system about the Z-axis of the MULTI-AXIAL GANTRY HEAD coordinate system (degrees). Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1. and C.AA.L2.1.2.
>>Multi-Axial Target Coordinate	(30xx,1525)	2C	Target coordinates (x,y,z) in the patient based coordinate system described in C.7.6.2.1.1 (mm) at Source-Axis Distance. Required if the Sub-Control Point Index (30xx,0115) equals 1 or attribute value changes at any Sub-Control Point. See C.AA.2.18.1.1.
>>Surface Entry Point	(300A,012E)	2	Patient surface entry point coordinates (x,y,z), along the central axis of the beam, in the patient based coordinate system described in C.7.6.2.1.1 (mm).
>>Source to Surface Distance	(300A,0130)	2	Source to Patient Surface distance (mm).

C.AA.L2.1 Multi Axial Beam Attribute Description

C.AA.L2.1.1 Multi-Axial Gantry Angles

For a Multi-Axial treatment machine, the Gantry Pitch Continuous Angle (30xx,51B7), Gantry Roll Continuous Angle (30xx,51B5) and Gantry Yaw Continuous Angle (30xx,51B3) shall be applied in the order z, x, y: first the yaw angle about the z-axis, then the pitch angle about the x-axis and then the roll angle about the y-axis.

C.AA.L2.1.2 Gantry Head Angles

Gantry Head Pitch Angle (30xx,1520), Gantry Head Roll Angle (30xx,1521) and Gantry Head Yaw Angle (30xx,1522) shall be applied in the order z, x, y: first the angle about the Z_h-axis, then the angle about the X_h-axis and then the angle about the Y_h-axis. These angles are the authoritative definition of the Gantry Head. The coordinate defined in Multi-Axial Target Coordinate (30xx,1525) shall only serve the purpose of annotation.

C.AA.L2.1.3 Multi Axial Beam Delimiter Positions

For the Multi-Axial Delivery Device, there is an "h" coordinate system which is fixed with respect to the MULTI-AXIAL GANTRY HEAD and its mother system is the IEC GANTRY coordinate system. Its origin I_h is the MULTI-AXIAL GANTRY HEAD center of rotation.

Its daughter system is the IEC BEAM LIMITING DEVICE or DELINEATOR coordinate system ("b").

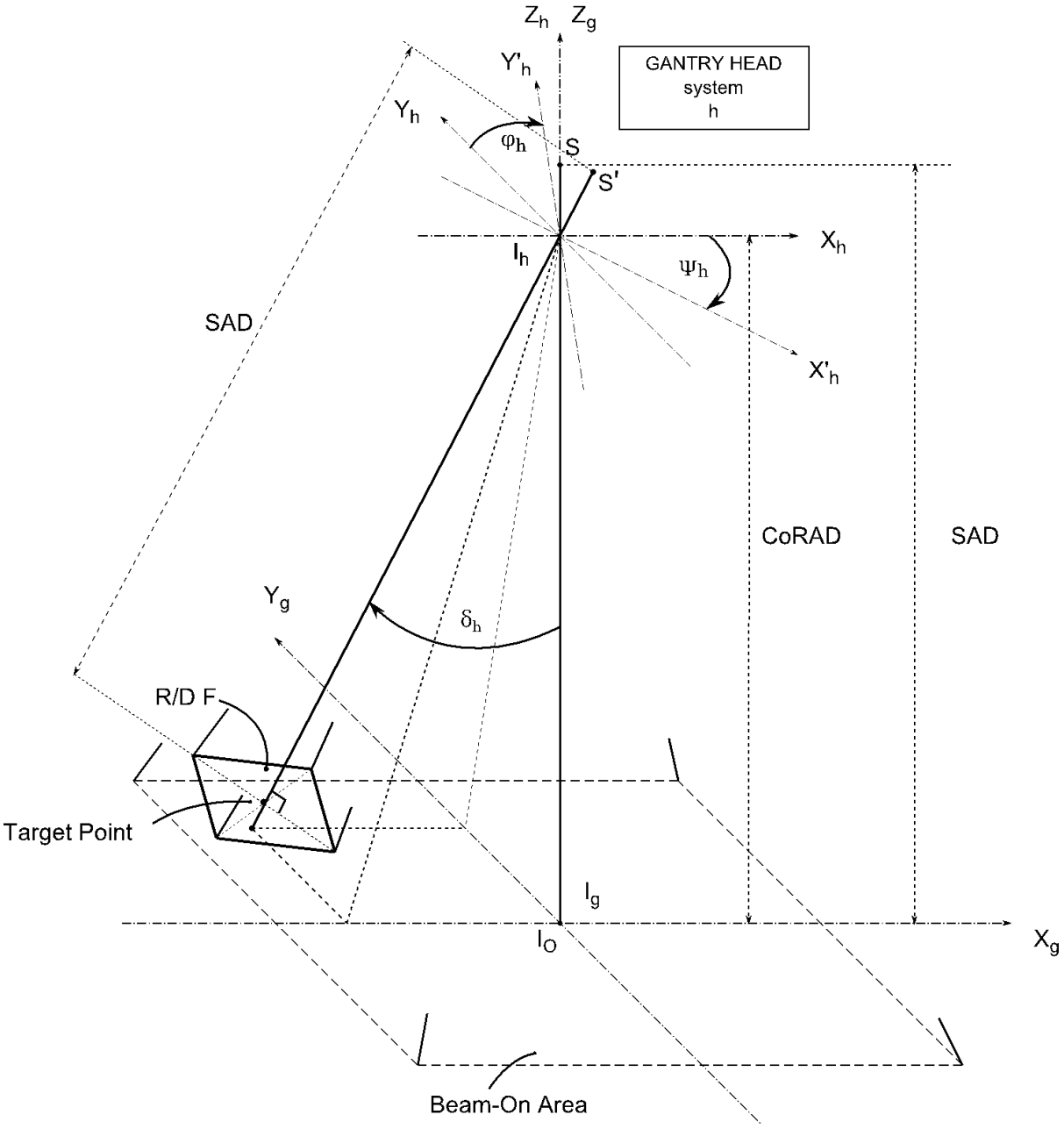

Figure C.AA.L2.1.3-1
Multi-Axial treatment machine GANTRY HEAD system

Thus, the RT Beam Delimiter Element Positions (30xx,504A) within RT Beam Limiting Device Positions Macro are always defined at Source-Axis Distance (300A,00B4) as defined in the Multi-

Axial Delivery Device Module. This is true even if the Gantry Head Pitch Angle (30xx,1520) or the Gantry Head Roll Angle (30xx,1521) are not at a zero degree position. The distance from the Center of Rotation of the Gantry Head to the Axis, is called the Center of Rotation-Axis Distance (CoRAD).

The RADIATION FIELD or DELINEATED RADIATION FIELD (R/D F) is always normal to the beam axis. Therefore, if the Gantry Head Pitch Angle and/or Gantry Head Roll Angle are not at a zero degree position, the R/D F is not within the Treatment Position x-y-plane (respectively the X/Y plane of the IEC Gantry System at the isocenter).

Part 4 Addendum

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.XN.5.1	
Multiple Fixed Source Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.4	
Robotic Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.5	
Multi-Axial Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.7	
Tomotherapeutic Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.1	
Multiple Fixed Source Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.4	
Robotic Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.5	
Multi-Axial Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.7	

Add the following to PS3.4, Table I.4-1

2

Table I.4-1 Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification
Tomotherapeutic Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.1	Tomotherapeutic Radiation
C-Arm Photon Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.2	C-Arm Photon Radiation
C-Arm Electron Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.3	C-Arm Electron Radiation
Multiple Fixed Source Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.4	Multiple Fixed Source Radiation
Robotic Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.5	Robotic Radiation
Multi-Axial Radiation Storage	1.2.840.10008.5.1.4.1.1.481.XN.5.7	Multi-Axial Radiation
Tomotherapeutic Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.1	Tomotherapeutic Radiation Record
Multiple Fixed Source Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.4	Multiple Fixed Source Radiation Record
Robotic Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.5	Robotic Radiation Record
Multi-Axial Radiation Record Storage	1.2.840.10008.5.1.4.1.1.481.XN.6.7	Multi-Axial Radiation Record

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Part 6 Addendum

Add the following data elements to PS3.6:

6 REGISTRY OF DICOM DATA ELEMENTS

[Editorial Note: The content of this chapter is currently only part of Supplement 147, rev. 43, where the table of attributes is already separted between those attributes that will be part of Supplement 147 and those that will be moved over to this document, once Supplement 147 is ready for Public comment.]

Add the following to PS3.6 Annex A:

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.XN.5.1	Tomotherapeutic Radiation Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.5.4	Multiple Fixed Source Radiation Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.5.5	Robotic Radiation Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.5.7	Multi-Axial Radiation Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.6.1	Tomotherapeutic Radiation Record Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.6.4	Multiple Fixed Source Radiation Record Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.6.5	Robotic Radiation Record Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.481.XN.6.7	Multi-Axial Radiation Record Storage	SOP Class	PS 3.4

Add the following data elements to PS3.6, Annex A:

Table A-3
CONTEXT GROUP UID VALUES

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.FFF.10	SUP147010	Beam Limiting Device Types
1.2.840.10008.6.1.FFF.11	SUP147011	Radiotherapy Robotic Paths
1.2.840.10008.6.1.FFF.14	SUP147014	Treatment RT Radiation Set Alteration Types
1.2.840.10008.6.1.FFF.15	SUP147015	Treatment Termination Reasons
1.2.840.10008.6.1.FFF.16	SUP147016	Compensator Device Types

1.2.840.10008.6.1.FFF.17	SUP147017	Radiotherapy Treatment Machine Modes
1.2.840.10008.6.1.FFF.18	SUP147018	Pre-Treatment RT Radiation Set Purpose
1.2.840.10008.6.1.FFF.20	SUP147020	Instance Reference Purposes
1.2.840.10008.6.1.FFF.21	SUP147021	Patient Setup Techniques
1.2.840.10008.6.1.FFF.23	SUP147023	Shielding Device Types
1.2.840.10008.6.1.FFF.24	SUP147024	Setup Devices
1.2.840.10008.6.1.FFF.26	SUP147026	Dose Statistics
1.2.840.10008.6.1.FFF.27	SUP147027	Fixed Beam Limiting Device Types
1.2.840.10008.6.1.FFF.28	SUP147028	Radiotherapy Wedge Types
1.2.840.10008.6.1.FFF.30	SUP147030	General Accessory Device Types
1.2.840.10008.6.1.FFF.35	SUP147035	Effective Dose Method Code Definition
1.2.840.10008.6.1.FFF.36	SUP147036	Purpose of Referenced Dose Calculation Annotation Object
1.2.840.10008.6.1.FFF.37	SUP147037	Dose Data Source Measurement Definition
1.2.840.10008.6.1.FFF.39	SUP147039	Dose Histogram Spatial Unit Definition
1.2.840.10008.6.1.FFF.41	SUP147041	Dose Algorithm Class
1.2.840.10008.6.1.FFF.43	SUP147043	RT Item States
1.2.840.10008.6.1.FFF.44	SUP147044	RT Operation States
1.2.840.10008.6.1.FFF.48	SUP147048	Revised value
1.2.840.10008.6.1.FFF.49	SUP147049	Radiotherapy General Workitem Definition
1.2.840.10008.6.1.FFF.50	SUP147050	Beam Mode Type Definition
1.2.840.10008.6.1.FFF.51	SUP147051	Delivery Rate Unit Definition
1.2.840.10008.6.1.FFF.54	SUP147054	Treatment Delivery Device Type

1.2.840.10008.6.1.FFF.55	SUP147055	Dosimeter Unit Definition
1.2.840.10008.6.1.FFF.56	SUP147056	Treatment Session Sign-Off
1.2.840.10008.6.1.FFF.65	SUP147065	Radiotherapy Dose Real World Units

Part 16 Addendum

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

[Editorial Note: The content of this chapter is currently only part of Supplement 147, rev. 43, where the CID tables are already separted between those that will be part of Supplement 147 and those that will be moved over to this document, once Supplement 147 is ready for Public comment.]

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

ANNEX D DICOM CONTROLLED TERMINOLOGY DEFINITIONS (NORMATIVE)

[Editorial Note: The content of this chapter is currently only part of Supplement 147, rev. 43, where the definitions are already separted between those that will be part of Supplement 147 and those that will be moved over to this document, once Supplement 147 is ready for Public comment.]