

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

### *Supplement 213: Second Generation Radiotherapy - Enhanced RT Image*

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**Open Issues**

#	Date	Item
1	2018-05-08	For continuous acquisition, not all frames may be recorded since the instance could get a huge size. Rather than frames may be sampled. For dosimetric purposes, the sampling needs to be annotated to know, how much frames are included in the exposed frame. Further on, an exposed frame may be calibrated for visualization, but the absolute dosimetric calibration is lost, esp. since the number of acquired frames included may differ across the set of samples frames. Certainly should be part of a frame-specific macro.
2	2018-05-14	Do we want to use Enhanced RT Image for Dose.
3	2018-05-15	WG-07: Annotations need to be supported (graphical and textual). For graphic annotations, Presentation state of Fiducials could be used. To address both projected contours and textual / symbolic overlays, presentation state is the first choice. To be explored.

**Closed Issues**

#	Date	Item

**Foreword**

This Supplement specifies the additional IOD representing projection images constructed for or acquired at Radiotherapy treatment sessions.

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**

The supplement adds new IOD called Enhanced RT Image to support projection images constructed for or acquired at Radiotherapy treatment sessions.

Such images represent projections of the patient geometry and potentially structures in relation to the treatment device equipment. They are used to guide the positioning of the patient on a patient support device to deliver therapeutic dose to the intended location.

In the current IOD to support such images is RT Image IOD. However, this IOD lacks various features needed for positioning in modern Radiotherapy, such as a string referencing scheme into control points, capturing of use-case-specific data related to monitoring and tracking, a proper representation of projected structures.

Further on some content has been added to partially address some of those issue, but the accumulation of such additions compromised cleanness and efficiency.

The IOD is part of the 2<sup>nd</sup> Generation RT Objects family and uses the concepts developed there.

Within this family it covers the positioning imaging sectors in line with other 2<sup>nd</sup> Generation Radiotherapy Objects and makes use of the strong concepts developed there. E.g. the generalizing to diverse types of devices, the systematic description of geometries and the annotation of devices used in the beam line will significantly streamline and tighten the semantic in the new IOD. Relations to other 2<sup>nd</sup> Generation Radiotherapy Objects can be not usefully included in the existing IOD.

This Supplement is based on the real-world model and specifications defined Supplements 147 and 175. References, definitions etc. not present in this supplement can be found in Supplement 147 and 175.

**Part 2 Addendum**

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

UID Value	UID Name	Category
<u>1.2.840.10008.5.1.4.1.1.481.XXX.1</u>	<u>Enhanced RT Image</u>	<u>Transfer</u>

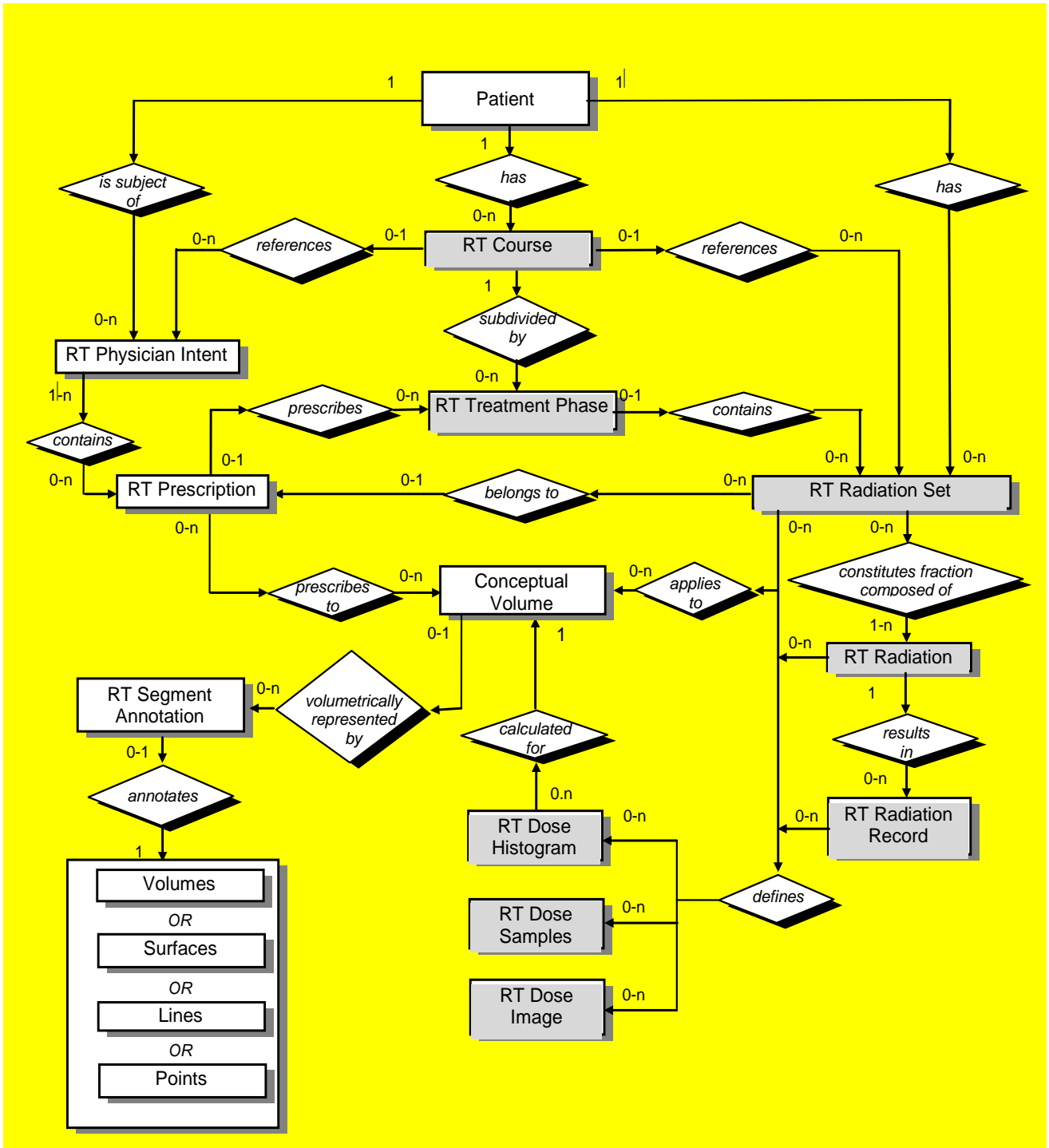
**Part 3 Addendum**

**Add the following in PS3.3 Chapter 7 DICOM model of the real-world**

**7.14 EXTENSION OF THE DICOM MODEL OF THE REAL-WORLD FOR RADIOTHERAPY SECOND GENERATION INFORMATION OBJECTS**

For the purpose of RT Second Generation SOP Classes the DICOM Model of the Real-World is described in this section. This subset of the real-world model covers the requirements for transferring information about planned and performed radiotherapeutic treatments and associated data.

Figure 7.14-1 describes the most important elements involved in the radiotherapy domain in DICOM.



Note 1: IODs which contain a representation of Volumes, Surfaces, Lines, Points can be annotated by an RT Segment Annotation.

Note 2: For better readability the diagram only contains the most important relationships, e.g. all objects have a relation to the Patient, but not all of these relationships are part of this diagram.

**Figure 7.14-1 DICOM MODEL OF THE REAL WORLD – RADIOTHERAPY**

<p><b>Add the following columns in PS3.3 Section A.1.4, Table A.1-1 COMPOSITE INFORMATION OBJECT MODULES OVERVIEW – RADIOTHERAPY</b></p>
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**A.1.4 Overview of the Composite IOD Module Content**

...

<b>IODs Modules</b>	<b>Enhanced RT Image</b>
Patient	<u><b>M</b></u>
Clinical Trial Subject	<u><b>U</b></u>
General Study	<u><b>M</b></u>
Patient Study	<u><b>U</b></u>
Clinical Trial Study	<u><b>U</b></u>
General Series	<u><b>M</b></u>
Clinical Trial Series	<u><b>U</b></u>
Enhanced RT Series	<u><b>M</b></u>
General Equipment	<u><b>M</b></u>
Enhanced General Equipment	<u><b>M</b></u>
Radiotherapy Common Instance	<u><b>M</b></u>
Frame Of Reference	<u><b>M</b></u>
Synchronization	<u><b>C</b></u>
<b><u>Enhanced RT Image</u></b>	<u><b>M</b></u>
<b><u>m2</u></b>	
<b>Multi-frame Functional Groups</b>	<u><b>M</b></u>
<b>Multi-frame Dimension</b>	<u><b>M</b></u>
<b>Respiratory Synchronization</b>	<u><b>C</b></u>
General Reference Module	<u><b>M</b></u>
Common Instance Reference Module	<u><b>M</b></u>
SOP Common	<u><b>M</b></u>



**Add the following to PS3.3 Annex A:**

**A.86 RT SECOND GENERATION**

**A.86.1 RT Second Generation Objects**

This section provides a brief description of the IODs of RT Second Generation. Specifically, this description includes:

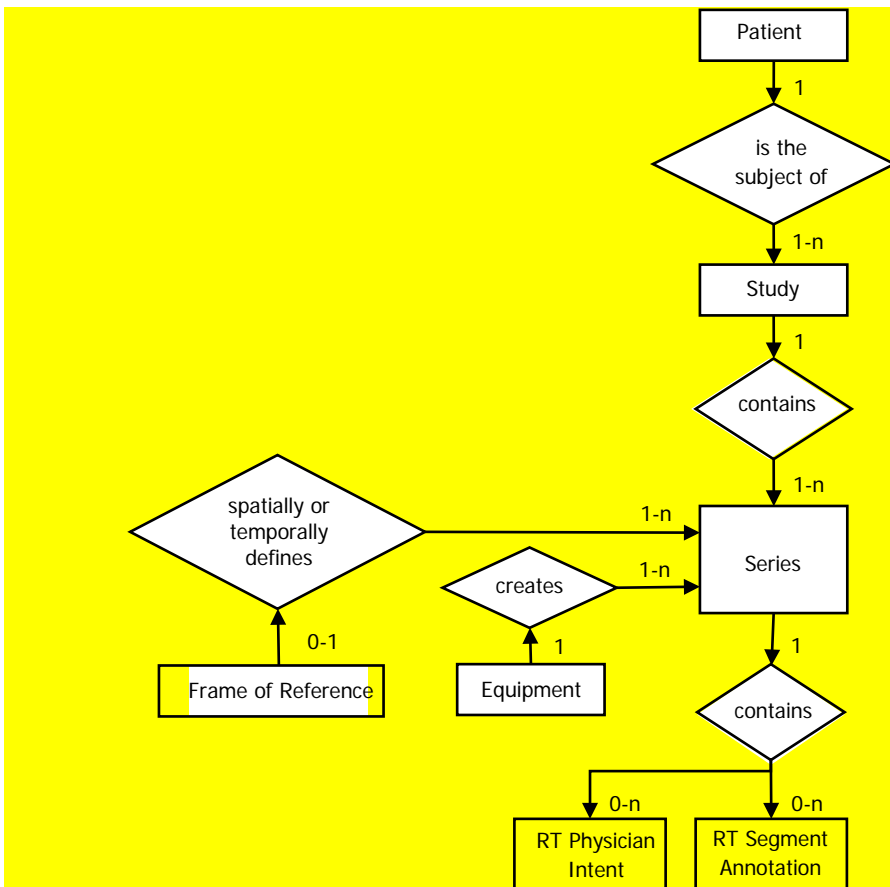
- The Real-World Object which is represented by the IOD
- Information as to the scope of the represented object if appropriate

**A.86.1.1 RT Second Generation Common Information**

This section provides a description of the Module structure which is shared by the RT Second Generation IODs.

**A.86.1.1.1 RT Second Generation Entity-Relationship Model**

The E-R Model in Figure A.86.1.1.1-1 depicts those components of the DICOM Information Model that are relevant to RT Second Generation IODs.



**Figure A.86.1.1.1-1. RT Second Generation IOD information model**

**A.86.1.a1 Enhanced RT Image Information Object Definition**

**A.86.1.a1.1 Enhanced RT Image IOD Description**

The Enhance RT IOD represents projection images constructed for or acquired at Radiotherapy treatment sessions. Such images represent a projection of the patient geometry and potentially structures to guide the positioning of the patient on a patient support device to deliver therapeutic dose to the intended location.

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

#### A.86.1.a1.2 Enhanced RT Image IOD Entity-Relationship Model

See Figure A.86.1.1.1-1.

#### A.86.1.a1.3 Enhanced RT Image IOD Module Table

**Table A.86.1.x1-1  
Enhanced RT Image IOD Modules**

IE	Module	Reference	Usage
<i>Include Table A.86.1.1.1-1 'RT Second Generation IOD Modules Macro'</i>			
Frame of Reference	Frame of Reference	C.7.4.1	M
	Synchronization	C.7.4.2	C – Required if time synchronization was applied.
RT Image	Floating Point Image Pixel	C.7.6.24	M (TBD: Certainly we want to user integer for imaging content and float for integrated dose content See also Issue #2
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Respiratory Synchronization	C.7.6.18.2	C – Required if respiratory synchronization was applied.
	Enhanced RT Image	C.36.S1	M
	S2	C.36.S2	M
	General Reference Module	C.12.4	M

#### A.86.1.a1.4 Enhanced RT Image Constraints

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

#### A.86.1.a1.5 Enhanced RT Image Functional Group Macros

**Table A.86.1.x1-2  
ENHANCED RT IMAGE FUNCTIONAL GROUP MACROS**

Function Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Frame Content	C.7.6.16.2.2	M
Plane Position (Patient)	C.7.6.16.2.3	M
Plane Orientation (Patient)	C.7.6.16.2.4	M
Referenced Image	C.7.6.16.2.5	TBD
Derivation Image	C.7.6.16.2.6	C - Required if the image has been derived from other images.

Respiratory Synchronization	C.7.6.16.2.17	U
Cardiac Synchronization	C.7.6.16.2.7	U
RT Treatment Position Macro	C.36.2.32	M TODO: Move to RT Image Module Replaced by Treatment Position Reference Shared or per frame
Image Source Position Parameter Macro	C.36.2.x1	M Shared or per frame
RT Radiation Context Macro	C.36.2.x2	M
Real World Value Mapping	C.7.6.16.2.11	M

**A.86.1.a1.5.1 Enhanced RT Image Functional Group Macros Content Constraints**

At least one dimension shall be present which is positional.

This dimension shall be defined as:

(TODO after the scopes and divisions of functional groups are clarified)

- Functional Group Pointer (0020,9167) shall have the value Plane Position Sequence (0020,9113)
- Dimension Index Pointer (0020,9165) shall have the value Image Position (Patient) (0020,0032).

**Add the following to PS3.3 Annex C, Section C.7.6.16.2.1 Pixel Measures Macro:**

**C.7.6.16.2.1 Pixel Measures Macro**

Table C.7.6.16-2 specifies the attributes of the Pixel Measures Functional Group Macro.

**Table C.7.6.16-2. Pixel Measures Macro Attributes**

Attribute Name	Tag	Type	Attribute Description
Pixel Measures Sequence	(0028,9110)	1	Identifies the physical characteristics of the pixels of this frame. Only a single Item shall be included in this Sequence.
>Pixel Spacing	(0028,0030)	1C	Physical distance in the imaging target (patient, specimen, or phantom) between the centers of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. See Section 10.7.1.3 for further explanation of the value order.  Note In the case of CT images with an Acquisition Type (0018,9302) of CONSTANT_ANGLE, the pixel spacing is that in a plane normal to the central ray of the diverging X-Ray beam as it passes through the data collection center.  Required if: Volumetric Properties (0008,9206) is other than DISTORTED or SAMPLED, or SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of

Attribute Name	Tag	Type	Attribute Description
			<p>Reference UID (0020,0052) is present, or                      SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or                      SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8") <b>or Enhanced RT Image ("1.2.840.10008.5.1.4.1.1.481.XN.8.1")</b></p> <p>May be present otherwise.</p>
>Slice Thickness	(0018,0050)	1C	<p>Nominal reconstructed slice thickness (for tomographic imaging) or depth of field (for optical non-tomographic imaging), in mm.</p> <p>See Section C.7.6.16.2.3.1 for further explanation.</p> <p>Note                      Depth of field may be an extended depth of field created by focus stacking (see Section C.8.12.4).</p> <p>Required if:                      Volumetric Properties (0008,9206) is VOLUME or SAMPLED, or                      SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present, or                      SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or                      SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8").</p> <p>May be present otherwise, <u>if</u>  <b><u>SOP Class UID is not Enhanced RT Image ("1.2.840.10008.5.1.4.1.1.481.XN.8.1").</u></b></p>
>Spacing Between Slices	(0018,0088)	3	<p>Spacing between adjacent slices, in mm. The spacing is measured from the center-to-center of each slice, and if present shall not be negative.</p>

**C.7.6.16.2.4 Plane Orientation (Patient) Macro**

Table C.7.6.16-5 specifies the attributes of the Plane Orientation (Patient) Functional Group Macro.

**Table C.7.6.16-5. Plane Orientation (Patient) Macro Attributes**

Attribute Name	Tag	Type	Attribute Description
Plane Orientation Sequence	(0020,9116)	1	<p>Identifies orientation of the plane of this frame.</p> <p>Only a single Item shall be included in this Sequence.</p>
>Image Orientation (Patient)	(0020,0037)	1C	<p>The direction cosines of the first row and the first column with respect to the patient. See Section C.7.6.2.1.1 and Section C.7.6.16.2.3.1 for further explanation.</p>

Attribute Name	Tag	Type	Attribute Description
			Required if: Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Volumetric Properties (0008,9206) of this frame is other than DISTORTED, or SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present, or SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8") <b>or Enhanced RT Image ("1.2.840.10008.5.1.4.1.1.481.XN.8.1")</b> . May be present otherwise.

**Add the following to PS3.3 Annex C, Section C.36.2 RT Second Generation General -Purpose Macros:**

**C.36.2 RT Second Generation Macros**

**C.36.2.1 RT Second Generation General Purpose Macros**

*EDITORIAL: Placeholder only. Currently not used by this supplement.*

**C.36.2.2 RT Second Generation Radiation Macros**

**C.36.2.x1 Image Source Position Parameter Macro**

This macro provides the device-specific geometric settings for the device carrying the image radiation source used to acquire the image or a virtual source when the image is reconstructed.

**Table C.36.2.x1-1  
Image Source Position Parameter Macro Attributes**

Attribute Name	Tag	Type	Description
Source Position	(4010,1061)	1	Position if the Source with respect to the Patient Frame of Reference.
Image Source Position Parameter Sequence	(gggg,7100)	2	Translational and rotational parameters to (TBD). Zero or more Items shall be included in this Sequence.
>Include Content Item Macro Table 10-2			Baseline TID is TID SUPnnn001.

**C.36.2.x1.1 Image Source Position Parameter Attribute Descriptions**

**C.36.2.x1.1.1 TBD**

**C.36.2.x2 RT Radiation Context Macro Macro**

This macro provides the device-specific geometric settings for the device carrying the image radiation source used to acquire the image or a virtual source when the image is reconstructed.

**Table C.36.2.x2-1  
RT Radiation Context Macro Macro Attributes**

Attribute Name	Tag	Type	Description
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Attribute Name	Tag	Type	Description
Referenced RT Control Point Index	(gggg,0115,)	1C	The value of RT Control Point Index (gggg,0111) in the TBD Ref CP Seq of the ref Radiation Inst.

**C.36.2.x2.1 RT Radiation Context Attribute Descriptions**

**C.36.2.x2.1.1 TBD**

**C.36.m1 Enhanced RT Image Module**

The Enhanced RT Image Module contains information about the overall content of the image.

**Table C.36.m1-1  
Enhanced RT Image Module Attributes**

Attribute Name	Tag	Type	Description
<i>Include Table C.36.2.2-1 'Entity Long Labeling Macro'</i>			
Equipment Frame of Reference UID	(gggg,51A0)	1	Frame of Reference identifier for the Treatment Delivery Device delivering the treatment for which the current instance is used. See C.36.E1.1.1.
<i>Include 'RT Patient Support Devices Macro' Table C.36.2.12-1</i>			

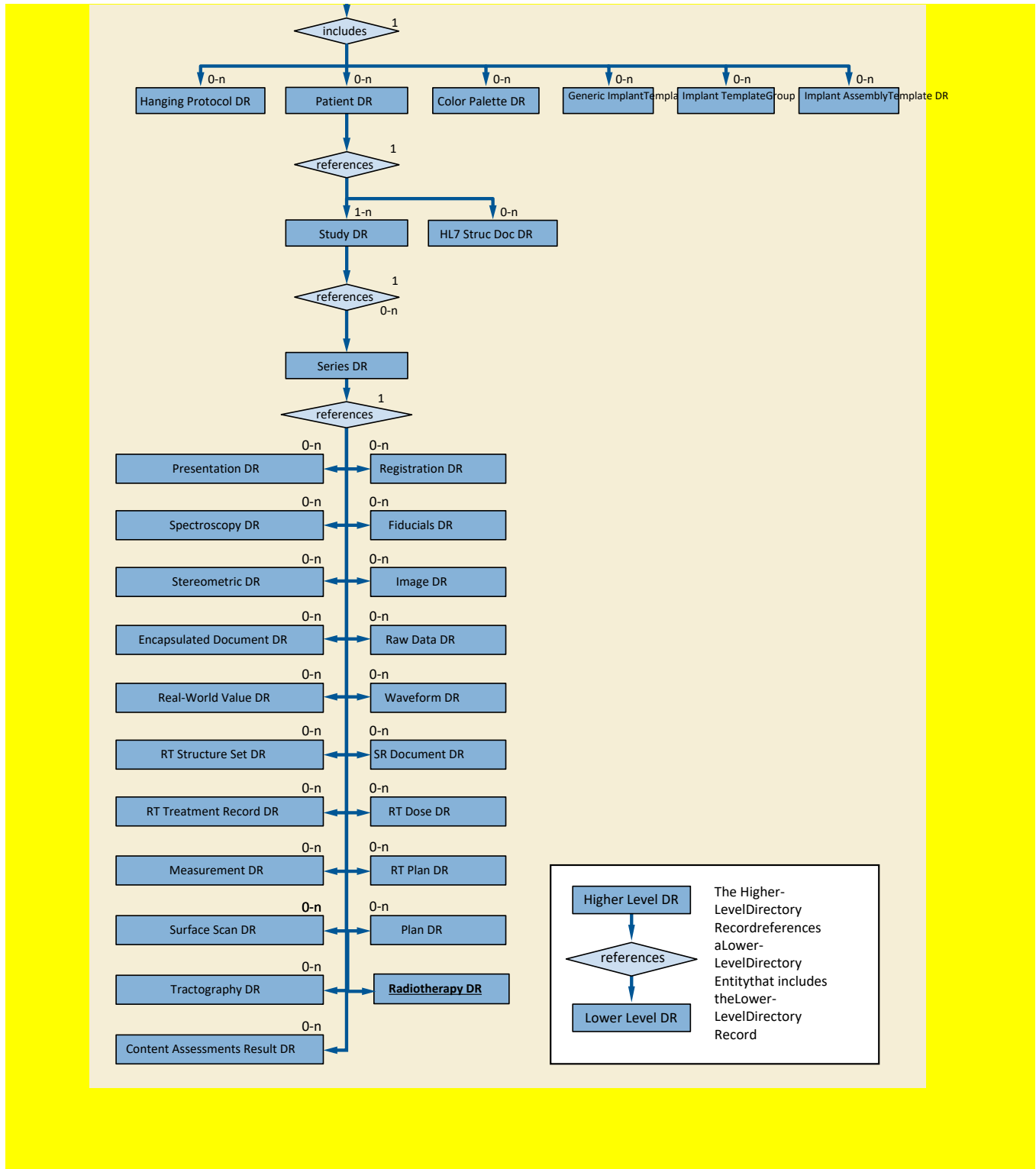
**C.36.m1.1 Enhanced RT Image Attribute Descriptions**

**C.36.m1.1.1 TBD**

**C.36.m2 m2 Module**

Add the “RADIOTHERAPY DR” box at the bottom of PS3.3, Annex F, Figure F.4-1:

**F.5 DEFINITION OF SPECIFIC DIRECTORY RECORDS**







**Part 4 Addendum**

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

<b>SOP Class Name</b>	<b>SOP Class UID</b>	<b>IOD Spec (defined in PS 3.3)</b>
<b><u>Enhanced RT Image</u></b>	<b><u>1.2.840.10008.5.1.4.1.1.481.XXX.1</u></b>	<b><u>Enhanced RT Image IOD</u></b>

**Part 6 Addendum**

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

**6 REGISTRY OF DICOM DATA ELEMENTS**

*Editorial Note:*  
 Use Range (gggg,7000) – (gggg,7FFF).

(gggg,7100)	Image Source Position Parameter Sequence	ImageSourcePositionParameterSequen ce	SQ	1
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**Add the following to PS3.6 Annex A:**

**ANNEX A REGISTRY OF DICOM UNIQUE IDENTIFIERS (UIDS) (NORMATIVE)**

**Table A-1 UID Values**

UID Value	UID Name	UID Type	Part
<u>1.2.840.10008.5.1.4.1.1.481.XXX.1</u>	<u>Enhanced RT Image Storage</u>	<u>SOP Class</u>	<u>PS3.4</u>

**Table A-3 Context Group UID Values**

Context UID	Context Identifier	Context Group Name
<u>1.2.840.10008.6.1.S213.001</u>	<u>SUP213001</u>	<u>cid1title</u>

**Part 16 Addendum**

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

**ANNEX B DCMR CONTEXT GROUPS (NORMATIVE)**

**CID SUP213001      CID1TITLE**

**Context ID SUP213001**

**cid1title**

**Resources: HTML | FHIR JSON | FHIR XML | IHE SVS XML**

**Type: Extensible**

**Version: yyyyymmdd**

**UID: 1.2.840.10008.6.1.Snnn.001**

<b>Coding Scheme Designator (0008,0102)</b>	<b>Code Value (0008,0100)</b>	<b>Code Meaning (0008,0104)</b>
<i>Include CID 9531 Volume and Dose Dosimetric Objectives</i>		
99SUP147	S213001	

**Add the following templates to PS3.16, Annex C:**

**ANNEX C ACQUISITION AND PROTOCOL CONTEXT TEMPLATES (NORMATIVE)**

**TID SUP213001 IMAGE SOURCE GEOMETRY PARAMETERS**

((Annotating the native source parameter))

**TID SUP213001**

**Image Source Geometry Parameters**

**Type: Extensible Order: Non-Significant**

	Value Type	Concept Name	VM	Req Type	Condition	Value Set Constraint
1	NUMERIC		1	U		

**Content Item Descriptions**

Row 1	The particle to be used for this RT treatment. More than one particle indicates that the RT treatment may use any combination of those particles for treatment. There is no defined relationship between the entries in Row 11, 12, 13 and entries in the Rows 14 and 15.
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**Add the following to the table in PS3.16, Annex D:**

**ANNEX D DICOM CONTROLLED TERMINOLOGY DEFINITIONS (NORMATIVE)**

<b>Code Value</b>	<b>Code Meaning</b>	<b>Definition</b>	<b>Notes</b>
S213001			