

Reference Guide to the ATC DICOM File Set Reader Conformance Statement (v 2.3)

Advanced Technology QA Consortium
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This document is intended to provide a summary of the special requirements for institutions submitting protocol-compliant data sets using DICOM objects in advanced-technology, multi-institutional clinical trials involving radiation therapy. The information below is abstracted from the ATC DICOM File Set Reader Application Conformance Statement, which is part of the Advanced-Technology Consortium DICOM Conformance Statement.

The tables shown below list DICOM attributes for which the ATC imposes constraints beyond those specified in the DICOM standard. Such additional constraints arise from the need to perform QA and outcomes analysis of treatment planning and verification data submitted for these clinical trials, and generally reflect one (or two) of the following conditions:

- A constraint on the value of an attribute,
- A type 2 attribute whose value is required (non-NULL), indicated as type 2* or 2C* in the tables, or
- A type 3 attribute whose value is required.

Please note that the constraints expressed in this document may impose consequential requirements on the inclusion or value of other attributes in DICOM object IODs. E.g., the requirement that an attribute sequence be included, shown by the presence of an attribute with a value representation of SQ in these tables may require the presence of other attributes contained within the sequence as specified by the DICOM standard. Conditional attributes (those with type 1C or 2C) may also be required by the conditions specified in the tables below. For a complete list of a sufficient set of attributes for each of the supported IODs, please refer to the Conformance Statement.

3D Patient Geometry Imaging Study

- Spatially-related, transverse images
- Square pixels (except for ultrasound)

CT Image Storage IOD

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C.7.6.2	IMAGE PLANE	Pixel Spacing	(0028,0030)	1	DS	Only square pixels supported by ATC

MR Image Storage IOD

C.7.6.2	IMAGE PLANE	Pixel Spacing	(0028,0030)	1	DS	Only square pixels supported by ATC
C.8.3.1	MR IMAGE	Image Type	(0008,0008)	1	CS	See note on ATC recommended usage, below.
C.8.3.1	MR IMAGE	Scanning Sequence	(0018,0020)	1	CS	See note on ATC recommended usage, below
C.8.3.1	MR IMAGE	Sequence Variant	(0018,0021)	1	CS	See note on ATC recommended usage, below

MR images which are used as the basis of treatment planning, but whose acquisition parameters are not maintained by treatment planning systems may be given an Image Type (0008,0008) value of "DERIVED\SECONDARY\OTHER" to avoid confusion regarding their origin. In such cases, the Scanning Sequence (0018,0020) may be assigned the value "RM" (research mode) and the Sequence Variant (0018,0021) may be assigned "NONE" (no sequence variant).

Ultrasound Image Storage IOD

C.8.5.4	US FRAME OF REF.	Physical Units X Direction	(0018,6024)	1	US	Must be "0003H" meaning cm
C.8.5.4	US FRAME OF REF.	Physical Units Y Direction	(0018,6026)	1	US	Must be "0003H" meaning cm
C.8.5.4	US FRAME OF REF.	Physical Delta X	(0018,602C)	1	FD	X pixel size in cm Square pixels currently supported by ATC. Non-Square pixels will be supported.
C.8.5.4	US FRAME OF REF.	Physical Delta Y	(0018,602E)	1	FD	Y pixel size in cm Square pixels currently supported by ATC. Non-Square pixels will be supported.
C.8.5.4	US FRAME OF REF.	Reference Pixel x0	(0018,6020)	3	SL	Required by ATC x0 = 0 assumed if not present
C.8.5.4	US FRAME OF REF.	Reference Pixel y0	(0018,6022)	3	SL	Required by ATC y0 = 0 assumed if not present
C.8.5.6	US IMAGE	Image Transformation Matrix	(0018,5210)	3	DS	Required by ATC. [1, 0, 0] [0, -1, 0] for supine viewed from foot
C.8.5.6	US IMAGE	Image Translation Vector	(0018,5212)	3	DS	Required by ATC. [Xt, Yt, Zt] (in mm) translates the reference pixel to patient space. See (0018,6020) and (0018,6022)

Patient Anatomy and Target Defining Structure Set

- Protocol-required structures, with protocol-defined structure names
- **Only planar, transverse contours at the “Patient Geometry Imaging Study” axial positions**
- External contour (skin) on all axial positions (not required for TIPPB)
- Structures must reflect extent contoured by MD, i.e., structures must not interfere with each other
- It is preferred that non-protocol structures be filtered out

RT Structure Set Storage IOD

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C.8.8.5	STRUCTURE SET	Referenced Frame of Reference Sequence	(3006,0010)	3	SQ	Required for resolution of Referenced Frame of Reference UID (3006,0024) This sequence shall contain exactly one item.
C.8.8.5	STRUCTURE SET	Structure Set ROI Sequence	(3006,0020)	3	SQ	Required to provide structure set data
C.8.8.5	STRUCTURE SET	>Referenced Frame of Reference UID	(3006,0024)	1C	UI	Should be the same as Frame of Reference UID (0020,0052)
C.8.8.5	STRUCTURE SET	>ROI Name	(3006,0026)	2C*	LO	Required to identify ROI's as named by user.
C.8.8.6	ROI CONTOUR	>Contour Sequence	(3006,0040)	3	SQ	Introduces a Sequence of Contours for a given ROI
C.8.8.6	ROI CONTOUR	>>Contour Geometric Type	(3006,0042)	1C	CS	Must be CLOSED_PLANAR or POINT. CLOSED_PLANAR = closed contour (polygon) containing coplanar points. The first point of contour is not repeated (i.e., closing is implied). POINT = point of interest, e.g., isocenter, dose specification point.
C.8.8.8	ROI Observations	>ROI Observation Label	(3006,0085)	3	SH	If ROI Name (3006,0026) is NULL and this attribute is provided ATC will use it as the structure name
C.8.8.8	ROI Observations	>RT ROI Interpreted Type	(3006,00A4)	2	CS	Will be used by ATC to classify ROI, if provided.

Dose Arrays and DVHs

- Require separate dose array for each fraction group (beam dose and total plan dose are not required and will be ignored)
- Require absolute physical dose (in Gy)
- Extent must cover all meaningful dose (outside array, dose is assumed to be zero)
- DVH only for total plan dose. We prefer that this DVH is in a Dose IOD without a dose array.

RT Dose IOD

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C.7.6.2	IMAGE PLANE	Slice Thickness	(0018,0050)	2	DS	Ignored for Multi-frame information (0028, 0009) and (3004,000C)
C.7.6.6	MULTI-FRAME	Frame Increment Pointer	(0028,0009)	1	AT	Must contain the Grid Frame Offset Vector tag (3004, 000C)
C.8.8.3	RT DOSE	Dose Units	(3004,0002)	1	CS	Only GY supported by ATC.
C.8.8.3	RT DOSE	Dose Type	(3004,0004)	1	CS	ATC only supports physical dose and adds the following defined terms: PHYSICAL_HETERO = physical dose computed with heterogeneity correction (i.e., image-derived tissue density); PHYSICAL_HOMO = physical dose computed without heterogeneity correction (i.e., assuming water density)
C.8.8.3	RT DOSE	Dose Summation Type	(3004,000A)	1	CS	ATC supports FRACTION and PLAN and adds the terms TOTALHOMO and TOTALHETERO (see note below)
C.8.8.3	RT DOSE	Referenced RT Plan Sequence	(300C,0002)	1C	SQ	Dose must reference either FRACTION or PLAN. If Dose Summation Type (3004,000A) is TOTALHOMO or TOTALHETERO, this sequence is excluded. The sub-sequences for beam and brachy application setup should not be present.
C.8.8.3	RT DOSE	Grid Frame Offset Vector	(3004,000C)	1C	DS	Only monotonic offsets are supported. The values in the vector are considered relative to "Image Position (Patient)" (0020,0032); however, if "Image Orientation (Patient)" is [1,0,0, 0,1,0] (non-rotated) AND the first value in the vector is NOT zero (0.0), then the Z-values are considered to be Z coordinate values in patient space (for compatibility with prior implementations).
C.8.8.3	RT DOSE	Dose Grid Scaling	(3004,000E)	1	DS	Must convert to GY.
C.8.8.4	RT DVH	>Dose Units	(3004,0002)	1	CS	Must be GY.
C.8.8.4	RT DVH	>Dose Type	(3004,0004)	1	CS	Must be PHYSICAL, PHYSICAL_HETERO, or PHYSICAL_HOMO (see "Dose Type" in RT Dose module above)
C.8.8.4	RT DVH	>DVH Dose Scaling	(3004,0052)	1	DS	Must convert to GY.
C.8.8.4	RT DVH	>DVH Volume Units	(3004,0054)	1	CS	Must be CM3 (PERCENT not supported by ATC).
C.8.8.4	RT DVH	>DVH Data	(3004,0058)	1	DS	Note that the dose is specified as bin widths (which sum over each bin to yield the bin dose value) and not as the bin dose.

Dose matrices are required for each FRACTION GROUP (external or brachy), DVHs required for each total RT Plan. If the total dose DVHs refer to an RT Plan which is not provided, Dose Summation Type must be one of the following terms: TOTALHOMO = DVHs computed for total plan dose without heterogeneity correction, or TOTALHETERO = DVHs computed for total plan dose with heterogeneity correction.

Teletherapy Plans

External Beam 3DCRT

- Want beam description including energy, shaping, wedges, compensating filters
- Used for setup and beam weight QA (may allow dose recalculation in the future)

External Beam IMRT

- Not currently used for QA (may allow dose recalculation in the future)

RT Plan Storage IOD

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C8.8.9	RT GENERAL PLAN	RT Plan Geometry	(300A,000C)	1	CS	Must be PATIENT
C8.8.9	RT GENERAL PLAN	Referenced Structure Set Sequence	(300C,0060)	1C	SQ	Required since DICOM condition is forced
C.8.8.13	RT FRACTION SCHEME	>Number of Fractions Planned	(300A,0078)	2*	IS	Must be specified (non-null)
C.8.8.13	RT FRACTION SCHEME	>>Beam Dose Specification Point	(300A,0082)	3	DS	Requested by ATC
C.8.8.13	RT FRACTION SCHEME	>>Beam Dose	(300A,0084)	3	DS	Requested by ATC Beam Dose in Gy (per fraction).
C.8.8.13	RT FRACTION SCHEME	>>Beam Meterset	(300A,0086)	3	DS	Required by ATC
C.8.8.14	RT Beams	>Beam Name	(300A,00C2)	3	LO	Required if (300A,00C3) not present
C.8.8.14	RT Beams	>Beam Description	(300A,00C3)	3	ST	Required if (300A,00C2) not present
C.8.8.14	RT Beams	>Radiation Type	(300A,00C6)	2*	CS	Must be specified (non-null)
C.8.8.14	RT Beams	>Source-Axis Distance	(300A,00B4)	3	DS	Required by ATC
C.8.8.14	RT Beams	>>Leaf Position Boundaries	(300A,00BE)	2C*	DS	Must be specified (non-null) if condition met, i.e., if MLC
C.8.8.14	RT Beams	>>Wedge Angle	(300A,00D5)	2C*	IS	Must be specified (non-null) if condition met, i.e., if Wedge(s)
C.8.8.14	RT Beams	>>Wedge Orientation	(300A,00D8)	2C*	DS	Must be specified (non-null) if condition met, i.e., if Wedge(s)
C.8.8.14	RT Beams	>>Block Number of Points	(300A,0104)	2C*	IS	Must be specified (non-null) if condition met, i.e., if Block(s) and/or Port(s)
C.8.8.14	RT Beams	>>Block Data	(300A,0106)	2C*	DS	Must be specified (non-null) if condition met, i.e., if Block(s) and/or Port(s)
C.8.8.14	RT Beams	>>Cumulative Meterset Weight	(300A,0134)	2C*	DS	Must be specified (non-null)
C.8.8.14	RT Beams	>>Nominal Beam Energy	(300A,0114)	3	DS	Required by ATC
C.8.8.14	RT Beams	>>Isocenter Position	(300A,012C)	2C*	DS	Must be specified (non-null). Condition is ALWAYS met.

Brachytherapy Plans

TIPPB (Transperineal Interstitial Permanent Prostate Brachytherapy)

- We are expecting to implement dose recalculation
- Seed description including model and strength at implant
- Seed locations in patient space

HDR and LDR

- We are expecting to implement dose recalculation
- Source geometry and dwell positions (in patient space)
- Source strength
- Dwell times

RT Plan Storage IOD (cont'd)

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C.8.8.15	RT BRACHY APP SETUP	Brachy Treatment Technique	(300A,0200)	1	CS	"PERMANENT" for TIPPB
C.8.8.15	RT BRACHY APP SETUP	Brachy Treatment Type	(300A,02202)	1	CS	"HDR" for HDR, "LDR" for LDR
C.8.8.15	RT BRACHY APP SETUP	>Source Type	(300A,0214)	1	CS	Note: POINT is the expected type for TIPPB
C.8.8.15	RT BRACHY APP SETUP	>Air Kerma Rate Reference Date	(300A,022C)	1	DA	Must be date of Implant for TIPPB
C.8.8.15	RT BRACHY APP SETUP	>Air Kerma Rate Reference Time	(300A,022E)	1	TM	Must be time of Implant for TIPPB
C.8.8.15	RT BRACHY APP SETUP	Application Setup Sequence	(300A,0230)	1	SQ	One per seed for TIPPB
C.8.8.15	RT BRACHY APP SETUP	>Channel Sequence	(300A,0280)	1	SQ	Note: Exactly one per application setup for TIPPB
C.8.8.15	RT BRACHY APP SETUP	>>Channel Total Time	(300A,0286)	1	DS	See note C.8.8.15.1 (Mean Lifetime of isotope for TIPPB).
C.8.8.15	RT BRACHY APP SETUP	>>Source Movement Type	(300A,0288)	1	CS	FIXED for TIPPB
C.8.8.15	RT BRACHY APP SETUP	>>>Cumulative Time Weight	(300A,02D6)	2*	DS	Must be specified (non-null)
C.8.8.15	RT BRACHY APP SETUP	>>>Control Point 3D Position	(300A,02D4)	3	DS	Required by ATC. This is the (x,y,z) location of the seed or dwell point in patient coordinates.

Images Other Than for 3D Patient Geometry

- Requirements are protocol specific
- Can be used for DRRs, digitized port films, digitized simulator films, EPIs
- RT Image is preferred to SC or CR when relationship to beam is known

RT Image Storage IOD

Ref #	DICOM Module	Attribute Name	Tag	Type	VR	Comments
C8.8.2	RT IMAGE (IMAGE PIXEL)	Samples per Pixel	(0028,0002)	1	US	Must be 1 for RT Image.
C8.8.2	RT IMAGE (IMAGE PIXEL)	Photometric Interpretation	(0028,0004)	1	CS	Must be MONOCHROME2 for RT Image.
C8.8.2	RT IMAGE (IMAGE PIXEL)	Bits Allocated	(0028,0100)	1	US	Must be 8 or 16 for RT Image.
C8.8.2	RT IMAGE (IMAGE PIXEL)	Bits Stored	(0028,0101)	1	US	Must be 8 or 12 through 16 for RT Image.
C8.8.2	RT IMAGE (IMAGE PIXEL)	High Bit	(0028,0102)	1	US	One less than Bits Stored (0028,0101)
C8.8.2	RT IMAGE (IMAGE PIXEL)	Pixel Representation	(0028,0103)	1	US	Must be unsigned for RT Image.
C8.8.2	RT IMAGE	RT Image Plane	(3002,000C)	1	CS	Must be NORMAL for DRRs.
C8.8.2	RT IMAGE	X-Ray Image Receptor Angle	(3002,000E)	2*	DS	For DRRs this is normally equal to zero (0) unless the image rotates with the collimators (i.e., beam limiting device) in which case this should be identical to the collimator angle.
C8.8.2	RT IMAGE	Image Plane Pixel Spacing	(3002,0011)	2*	DS	See note below for DRRs
C8.8.2	RT IMAGE	RT Image Position	(3002,0012)	2*	DS	Value required if Image Type (0008,0008) is DRR and image is not centered on central ray.
C8.8.2	RT IMAGE	RT Image SID	(3002,0026)	2*	DS	See note below for DRRs
C8.8.2	RT IMAGE	Referenced RT Plan Sequence	(300C,0002)	3	SQ	Required if Image Type (0008,0008) is DRR or PORTAL.
C8.8.2	RT IMAGE	Referenced Beam Number	(300C,0006)	3	IS	Required if Image Type (0008,0008) is DRR or PORTAL.

In order to determine the scale of DRR images either (preferably) the Image Plane Pixel Spacing (3002,0011) and RT Image SID (3002,0026) attributes must both be specified, or some scale must be "burned in" to the image (e.g. the port shape or graticule).

Secondary Capture (SC)

- Can be used for digitized films

Computed Radiography (CR)

- EPIs

Diagnostic CT, MR, PET, US

- Images not used in patient geometry definition