DICOM
Digital Imaging and Communications in Medicine

DICOM
Second Generation Radiotherapy

Supplement 213

Enhanced RT Image
and
RT Patient Position Acquisition Instruction

DICOM Working Group 07

Radiotherapy

Scope of Supplement

- **Radiotherapy Imaging for Patient Position Detection: Various imaging technologies result in various IODs**
- **Advice to Procedure Execution: Acquisition Devices are instructed about details of Acquisition**

Scope of Supplement 213: Red parts:

Technology	Result IODs	Acquisition Instruction IOD
Projection / RT Image	Enhanced RT Image -> Sup 213	Included -> Sup 213
CT	CT	Included -> Sup 213
MR	MR	Future Extension
Ultrasound	US	Future Extension
Surface Scanning	Surface	Future Extension
Transponder Marker	Segmentation, Fiducials	Future Extension
…others	…others	Future Extension

Supplement Content

2 IODs for RT Image

- Enhanced RT Image
- Enhanced Continuous RT Image

1 Instruction IOD

- RT Patient Position Acquisition Instruction

Several Macros

- Applicability (to RT Radiation Sets, RT Radiations…)
- Geometry (Image Source and Receptor in respect to Equipment)
- Signal Generation (KV, MV, potentially in future: other modalities)

Macro usage across all 3 IODs:

- RT Image IODs: Recording parameters used during acquisition
- Instruction IOD: Specifying parameters to be used during acquisition

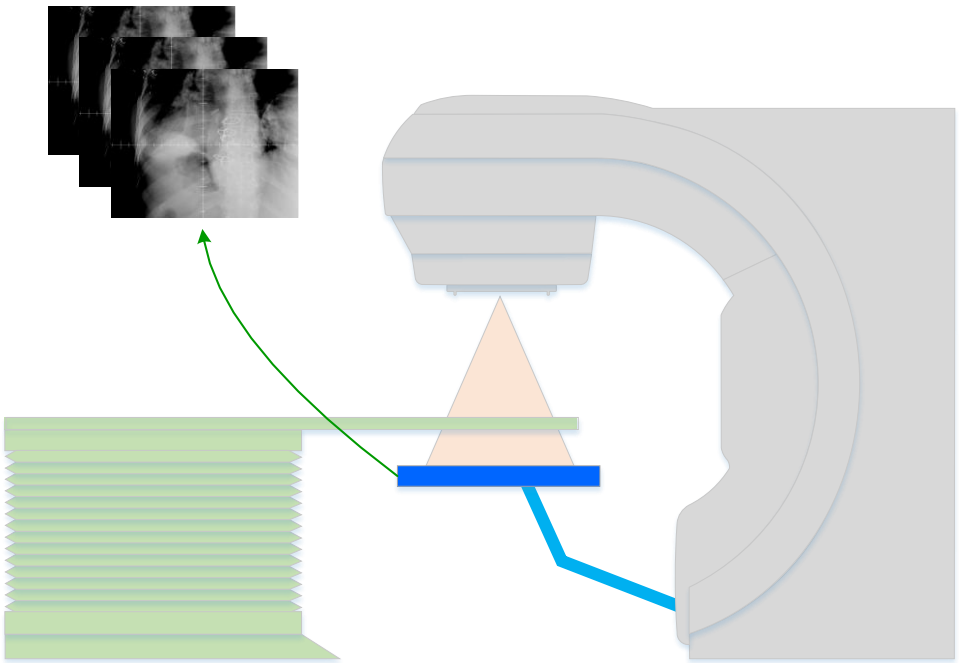
RT Image Functional Scope

(substantially same scope of content as in 1st Generation)

Image Characteristics

- Projection Image
- May be:
  - Single Frame
  - Couple of Frames
  - Continuous acquisition (MPEG) (*)

(*) Supported by annotation of selected Image Frames only (instead of annotation all Frames -> huge, but unnecessary size)

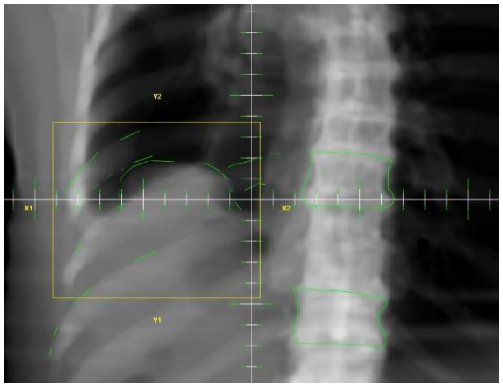


RT Image Clinical Role

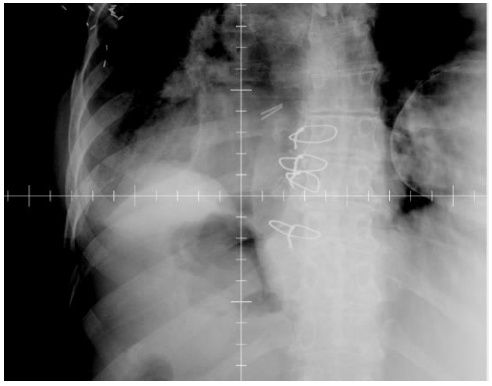
Image Object may represent

- **Images acquired**
  before / during / after therapeutic Radiation
- **Images re-constructed from 3D Images prior to Treatment**
  'DRRs', 'Reference Images', constructed in Treatment Planning phase
  - Used for verification:
    Comparison against acquired Images

DRR



Acquired



RT Image Clinical Role

Patient Position Detection and Correction

- Acquire RT Image with patient on table.
- Relate current Patient Position in respect to treatment device
- Determine correction of Patient Position:
  - Determine current beam geometry in respect to patient
  - Relate current beam geometry to planned beam geometry (in respect to patient)
  - - as needed - Align position and orientation of patient to match planned beam geometry

⇒ **RT Image provides well-defined path of geometric calculation:**

- From: treatment beam in device coordinates
- To: Patient FOR
- For various type of treatment devices
- Crucial for correct placement of therapeutic radiation

RT Image Clinical Role

Patient Position Monitoring

- RT Images acquired during Therapeutic Radiation Delivery
- Using various acquisition frequencies / trigger points
- Various Modes of Use, namely
  - Pre-Treatment verification
    To verify, that the position is within limits
  - During-treatment observation
    Ensure that position stays within certain limits
  - Post-Treatment Monitoring
    To verify, that the position was within limits
    Assess amount of motion

Functional Requirements

Geometric Content

- Generalized description of geometric relation of Image
  - to Treatment device
  - to Patient positioning device

Therapeutic Beam-related Content

- State of Device where the Image relates to:
  - Meterset / Time
  - Related to device states (e.g. gantry rotation, collimation etc.)
  - Description of Beam Modifiers in generalized approach of 2nd Gen

Therapeutic Context

- RT Radiation, RT Radiation Set, RT Plan
- Treatment Session and Treatment Fraction

Why 2nd Generation?

Use of 2nd Gen concepts

- RT Image Context to RT Radiation Sets, RT Radiations
- Using Equipment Coordinate System
- Generalizing geometry specification to handle variety of Imaging devices and Treatment Device geometries – re-use Macros
- Using 2nd generation macros to describe Patient Position, Beam Modifiers, Radiation – re-use Macros

Use of Enhanced Multi-Frame Approach

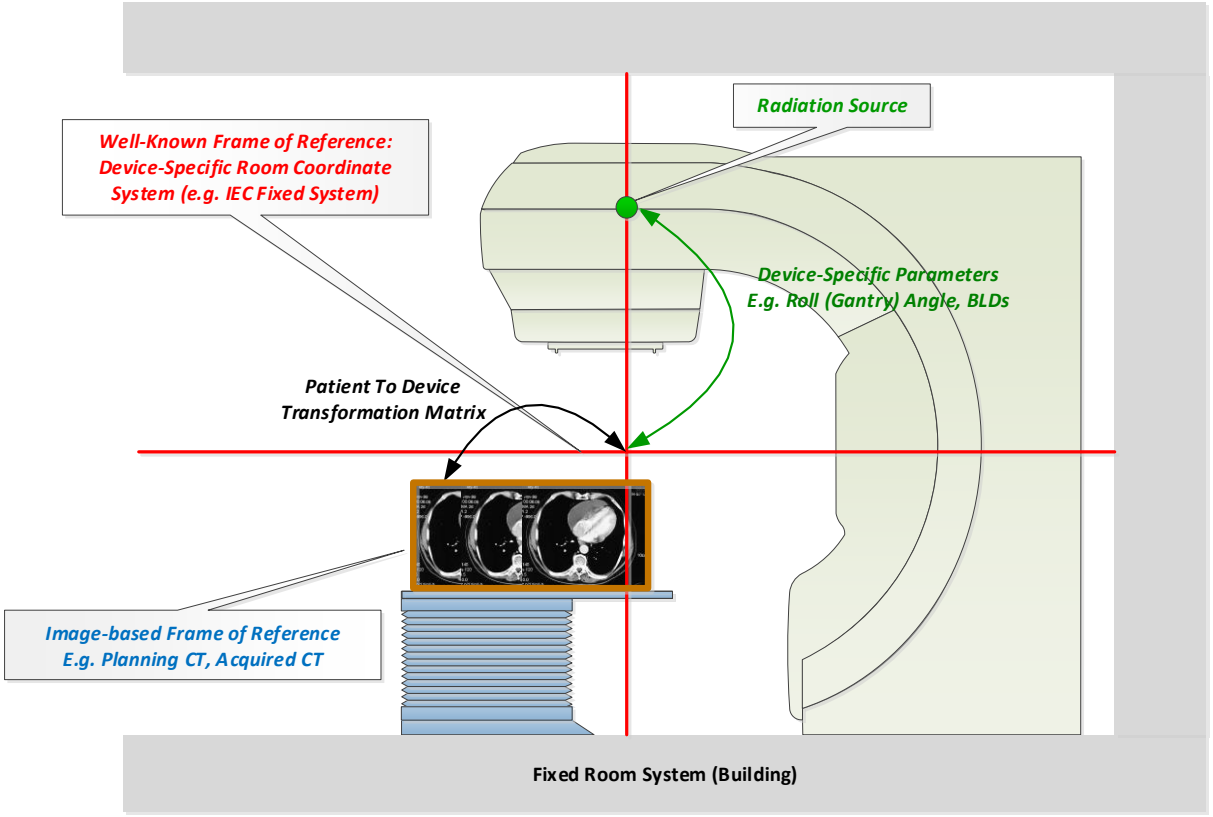
- Benefit from Multi-Frame Functional Groups formalism
- Stay in line with current Multi-Frame of other IODs

Cleaning up / strengthening / expanding…

- the historically grown patchy structure and representation of 1st Gen RT Image IOD

Part of 2nd Generation RT

2nd Gen Use of application of Equipment FOR and Patient FOR



Acquisition Instruction

RT Patient Position Acquisition Instruction IOD

Contains specification for (as applicable):

- **RT Patient Support Device Position**

Specified Position in respect to Equipment Coordinate System at which acquisition shall be performed

- **Acquisition Device Position**

Positions of Acquisition Devices in respect to Equipment Coordinate System when artifacts are acquired

- **Acquisition Execution Parameters**

Parameters to be used when artifacts are acquired

- **Acquisition Triggers**

Specifies when devices should perform the acquisition

Current Coverage in Supplement 213:

MV / KV, Projection and Volumetric Image Acquisition

Other modalities / technologies may be added to this IOD by future supplements

IOD designed for extensibility

RT Pat. Position Instruction

Task

- **Index / Workitem Code**
- **Applicability Scope**
  References to Radiation Instances / Treatment Groups

Subtask
(1-n)

- **Index / Specialized Workitem Code**
- **Acquisition Template Identifier**
- **Baseline Radiation Reference**
- **RT Device Distance Reference**
- **Acquisition Initiation**
- **Source Signal Generation**
  - kV Generation
  - MV Generation
- **RT Device to Patient Geometry**
  - Projection Imaging Geometry
  - 3D Imaging Geometry
- **Device-Specific Parameters**
- **Additional Devices / Parameters**
- **Position Reference Instances**

One Subtask Example

Task	Workitem Code = (121702, DCM, “RT Patient Position Acquisition, single plane MV“) Applicability Scope = RT Radiation “AP”	
	Subtask 1	Index = 1 Workitem Code = (121702, DCM, “RT Patient Position Acquisition, single plane MV“) Acquisition Initiation = (S213504, 99SUP213 “Acquisition Initiation at specified value”) (Start Paramater) = (S213520, DCM, "Meterset") = 10 MU MV Generation = 6 MV Projection Geometry = Gantry Angle 0 Position Reference Instance = RT Image “AP”

Two Subtask Example kV/kV

Task	Workitem Code = (121705, DCM, “RT Patient Position Acquisition, dual plane kV“) Applicability Scope = RT Radiation “AP”	
	Subtask 1	Index = 1 Workitem Code = (121704, DCM, “RT Patient Position Acquisition, single plane kV“) Acquisition Initiation = (S213502, 99SUP213 “Acquisition Initiation before start of Radiation”) kV Generation = 80 kV Projection Geometry = Source Angle 0 Position Reference Instance = RT Image “AP”
	Subtask 2	Index = 2 Workitem Code = (121704, DCM, “RT Patient Position Acquisition, single plane kV“) Acquisition Initiation = (S213502, 99SUP213 “Acquisition Initiation before start of Radiation”) kV Generation = 80 kV Projection Geometry = Source Angle 90 Position Reference Instance = RT Image “LATR”

Two Subtask Example kV/MV

Task	Workitem Code = (121706, DCM, “RT Patient Position Acquisition, dual plane kV/MV“) Applicability Scope = RT Radiation “AP”	
	Subtask 1	Index = 1 Workitem Code = (121704, DCM, “RT Patient Position Acquisition, single plane kV“) Acquisition Initiation = (S213502, 99SUP213 “Acquisition Initiation before start of Radiation”) kV Generation = 80 kV Projection Geometry = Source Angle 90 Position Reference Instance = RT Image “LATR”
	Subtask 2	Index = 2 Workitem Code = (121702, DCM, “RT Patient Position Acquisition, single plane MV“) Acquisition Initiation = (S213502, 99SUP213 “Acquisition Initiation before start of Radiation”) MV Generation = 6 MV Projection Geometry = Source Angle 0 Position Reference Instance = RT Image “AP”

Acq Instr.: Tasks to perform

One or more Acquisition Tasks

For example:

- Task 1: One KV/MV Image pair prior to therapeutic beam
- Task 2: 5 MV Images during beam
- Task 3: One KV Image after beam

A task applies to:

- a set of RT Radiation Sets
- or a set RT Radiations
- or a Treatment Position group.

One or more Subtasks per Task.

Per example of above:

- Task 1: 2 subtasks: one for KV, one for MV
- Task 2: 1 subtask for MV, with 5 trigger values defined
- Task 3: 1 subtask for MV

Acq Instr.: Specification Approaches

Parameters are specified by:

Indirectly by Protocol

- Refer to a protocols knows to the acquisition device
  - by Code, or
  - by ID
- User may fine-tune this protocol at the acquisition device any time
  - Protocol identification stays the same
  - Protocol Version tracking out of scope
  - Device – based settings may be traced locally at the device

Directly by explicit Parameters:

- As indicated in the following slides

Any combination of Protocol-inferred and explicit Parameters supported

Addresses variability of devices in terms of

- Technology
- Generation

Acq Instr.: Geometry

Basis: Equipment FOR

- Same approach as used for RT Radiation IODs as well

Device Geometries

Transformation Matrix from Equipment FOR to

- Imaging Source Coordinate System
- Image Receptor Coordinate System

User-readable decomposition optionally supported for applications, which can´t do this

- concept as used in RT Radiations as well

Patient Positioner Geometry

Use of existing 2nd Generation Approach

- Relate Patient FOR to Equipment FOR
- Library Approach
  - Specify Patient Position once
  - Apply many times by reference, since most treatments have static positions, but some do not

Acq Instr.: Signal Generation

Generation of MV (therapeutic) Beam for Imaging

- Use of 2nd Gen Radiation Generation Macro
- Covers MV Photons and Particles
- Incl. all beam generation specifics for the therapeutic beam devices

Generation of KV (therapeutic) Beam for Imaging

- Use of existing (KV) X-Ray Attributes
- Covers KV Photons

(future outlook: Addition of other technologies as needed)

Main Editor

Ulrich Busch
Member WG-07
Individual
ulrich.busch@bluewin.ch