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DICOM℠

Digital Imaging and Communications in Medicine

Deep dive into SR:

Key Object Selection and Radiation Dose Report

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Deep dive into SR

Basics of DICOM Structured Reporting

- External terminologies
- Data structures
- Concept relationships
- Post-coordination
- Templates and value sets

SR SOP Classes

Key Object Selection

Radiation Dose Report

Implementation considerations

DICOM Structured Reporting

The scope of DICOM SR is standardization of structured data and clinical observations in the imaging environment

SR objects record observations made for an imaging-based procedure

- **Particularly observations that describe or reference images, waveforms, or specific regions of interest**

Why DICOM SR?

To exchange structured data produced during image acquisition or post-processing, where:

- Leveraging the DICOM infrastructure is easy and desirable
- Results should be managed with other study evidence

Replaces legacy hacks

- Manually transcribed worksheets, screen scrapes from analysis apps, one-off integrations

Examples

- Sonographer measurements
- Computer-aided detection results
- QC notes about images
- Radiation dose reports
- Image exchange manifests

Key Aspects of DICOM SR

SR documents are encoded using DICOM standard data elements and leverage DICOM network services (storage, query/retrieve)

SR uses DICOM Patient/Study/Series information model (header), plus hierarchical tree of "Content Items"

Extensive use of coded concepts / vocabulary

Templates define content constraints for specific types of documents / reports

DICOM leverages other standards

Image compression – JPEG, MPEG

Character encoding – Unicode, ISO 8859 / 2022

Clinical terminology – SNOMED, LOINC, IEEE11073

Draw upon broader base of technical expertise

Reuse of technology beyond medical imaging

Data transportability to multiple contexts

Systematized Nomenclature of Medicine - Clinical Terms

Most comprehensive clinical healthcare terminology

- >357,000 concepts; 19 Hierarchies
- 1.2M English language descriptions or synonyms
- 900,000 defining semantic relationships

Since 1998 the primary external terminology system for DICOM

- Anatomy, disease, imaging methods and agents

Developed by College of American Pathologists, now managed by international consortium of health ministries (IHTSDO)

T-28000 Lung D3-13012 Angina C-B0317 Diatrizoate

Logical Observation Identifier Names and Codes

Coding system for laboratory and clinical observations

- > 70,000 codes
- > 300,000 relationships

Major DICOM external terminology for ultrasound and cardiovascular measurements

Managed by Regenstrief Institute, Indiana University

- Supported by U.S. National Library of Medicine
- Collaborative agreements with IHTSDO (SNOMED) and RSNA (RadLex)

59119-8 Filling Time 11820-8 Biparietal Diameter

Medical Device Communication Nomenclature

IEEE 11073

Universal nomenclature for ECG measurements and annotation

Designed for use in point of care device communication (ISO/IEEE 11073 MDC)

- **ECG, blood pressure, O_2 sensors connected to bedside monitor**

Nomenclature codes adopted for use in DICOM and HL7

Managed by IEEE Standards Association, work group meets jointly with HL7

2:16164 QTc interval global 10:11345 ECG lead system

SR is about *interoperable meaning*

SR must be interpreted through concepts and their grammar, not just text strings

- **E.g., a disease finding "tumor" does not mean "the location of the tumor"**
- **Pay careful attention to this grammar – dig into the semantics of the coded concepts**

Meaning arises from the combination of Terminology Model (coded vocabulary) and Information Model (message structure)

Code Sequence encodes concepts using external terminology

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Table 8.8-1 Common Attribute Set for Code Sequence Attributes (Invoked as "Code Sequence Macro")

Attribute Name	Tag	Type	Attribute Description
Code Value	(0008,0100)	1	See Section 8.1.
Coding Scheme Designator	(0008,0102)	1	See Section 8.2.
Code Meaning	(0008,0104)	1	See Section 8.3.

"Triplet coding" : code value, scheme, meaning

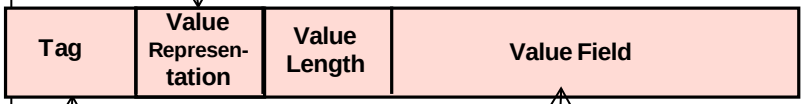
Table C.7-12
CONTRAST/BOLUS MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Contrast/Bolus Agent	(0018,0010)	2	Contrast or bolus agent
Contrast/Bolus Agent Sequence	(0018,0012)	3	Sequence that identifies the contrast agent. One or more Items may be present.
>Include 'Code Sequence Macro' Table 8.8-1		*Baseline Context ID is 12.*	
Contrast/Bolus Route	(0018,1040)	3	Administration route of contrast agent
Contrast/Bolus Administration Route Sequence	(0018,0014)	3	Sequence that identifies the route of administration of contrast agent. Only a single Item shall be permitted in this sequence.
>Include 'Code Sequence Macro' Table 8.8-1		*Baseline Context ID is 11.*	

Content Item encodes name-value pair similar to attribute

Table 10-2
Content Item Macro Attributes Description

Attribute Name	Tag	Type	Attribute Description
Value Type	(0040,A040)	1	The type of the value encoded in this name-value Item. Defined Terms: DATETIME DATE TIME PNAME UIDREF TEXT CODE NUMERIC
Concept Name Code Sequence	(0040,A043)	1	Coded concept name of this name-value Item. Only a single Item shall be permitted in this Sequence.
>Include 'Code Sequence Macro' Table 8.8-1			*No Baseline Context ID is defined.*
DateTime	(0040,A120)	1C	DateTime value for this name-value Item. Required if Value Type (0040,A040) is DATETIME.
…			
Text Value	(0040,A160)	1C	Text value for this name-value Item. Required if Value Type (0040,A040) is TEXT.
Concept Code Sequence	(0040,A168)	1C	Coded concept value of this name-value Item. Only a single Item shall be permitted in this Sequence. Required if Value Type (0040,A040) is CODE.
>Include 'Code Sequence Macro' Table 8.8-1			*No Baseline Context ID is defined.*
Numeric Value	(0040,A30A)	1C	Numeric value for this name-value Item. Required if Value Type (0040,A040) is NUMERIC.
Measurement Units Code Sequence	(0040,08EA)	1C	Units of measurement for a numeric value in this name-value Item. Only a single Item shall be permitted in this Sequence. Required if Value Type (0040,A040) is NUMERIC.



Content Items are like DICOM attributes, but at higher level of abstraction

- **In particular, concept name is triplet coded, not DICOM tag**

Content Items structured in **hierarchical tree**

Content Items are units of meaning …

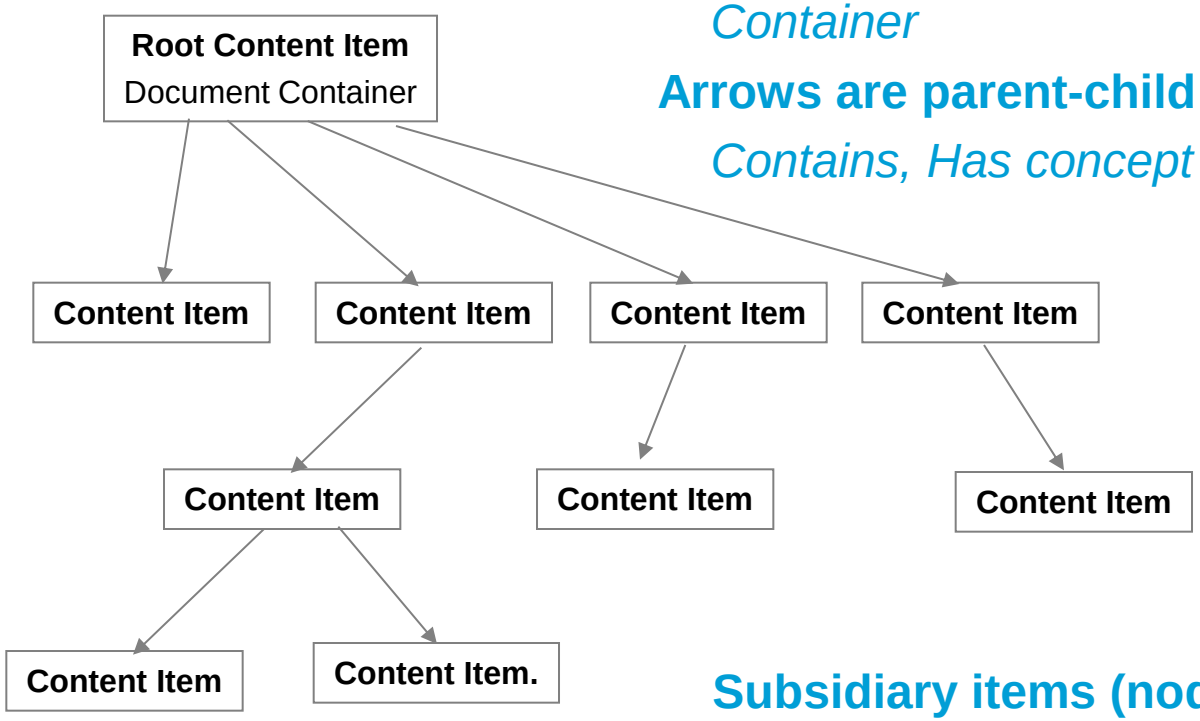
Text, Numeric, Code, Image, Spatial coordinates, etc.

… or units of structure

Container

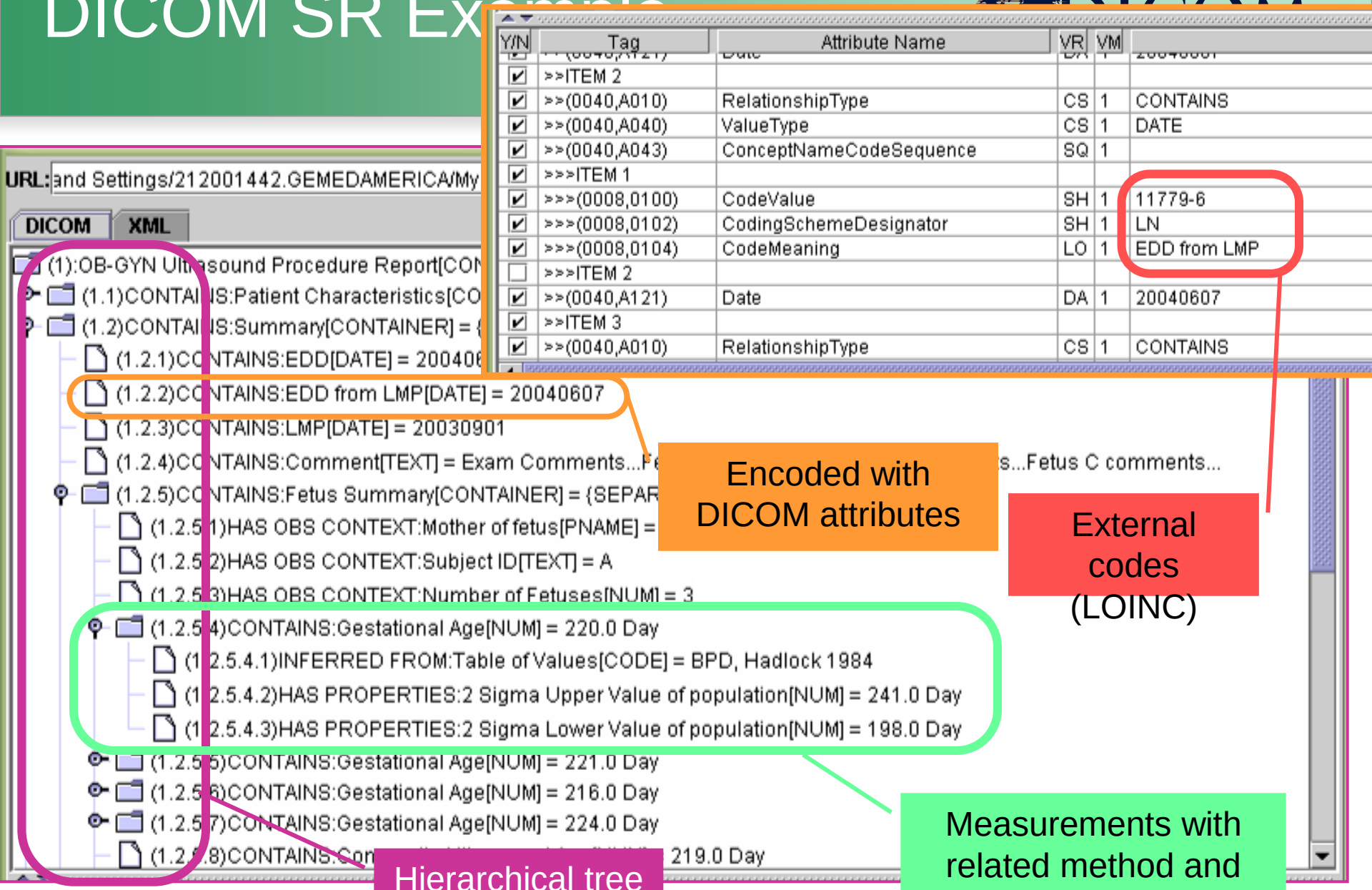
Arrows are parent-child relationships (grammar)

Contains, Has concept modifier, Inferred from, etc.



Subsidiary items (nodes) support, or are qualified by, parent item

DICOM SR Example



Pre- and Post-coordination

Complex medical concepts must be constructed from more atomic terms

- **Pre-coordination = single code for multi-axial concept**
  - LOINC 18044-8 “Left ventricular Ejection fraction by Ultrasound using 2D single-plane ellipse method”
- **Post-coordination = composition from multiple terms with separate codes**

SR Post-coordination through **HAS CONCEPT MOD**ifier

(18148-7, LN, "Left Ventricular End Systolic Volume")
***NUM* 21.0 (ml, UCUM, "ml")**
> HAS CONCEPT MOD (G-C036, SRT, "Measurement Method") *CODE* (125209, DCM, "Teichholz")

Left Ventricular End Systolic Volume by Teichholz Method = 21.0 ml

Note the post-coordination of concept from four different vocabulary systems – LOINC (LN), SNOMED (SRT), DICOM (DCM), and SR relationship attribute (HAS CONCEPT MOD)

Post-coordination via message structure (context inheritance)

***Family History of* Breast Cancer**

***Family History of* Heart Disease**

***Family History of* Stroke**

Terminology Model

Equivalent content

Family History document section

- **Breast Cancer**
- **Heart Disease**
- **Stroke**

Information Model

SR Hierarchy imparts implicit post-coordination

CONTAINER **Echocardiography Report**

+ CONTAINER **Patient Characteristics**

+ CONTAINER **Findings** : **Finding Site = Left Ventricle**

+ CONTAINER **Findings** : **Finding Site = Right Ventricle**

− CONTAINER **Findings** : **Finding Site = Aortic Valve**

  − CONTAINER **Measurement Group** : **Mode = 2D**

    − NUM **Cardiovascular Orifice Diameter = 12.1 mm**

− CONTAINER **Findings** : **Finding Site = Mitral Valve**

  − CONTAINER **Measurement Group** : **Mode = 2D**

    − NUM **Cardiovascular Orifice Diameter = 11.7 mm**

HAS CONCEPT MOD

Implicit concept modifiers: Aortic Valve by 2D

Implicit concept modifiers: Mitral Valve by 2D

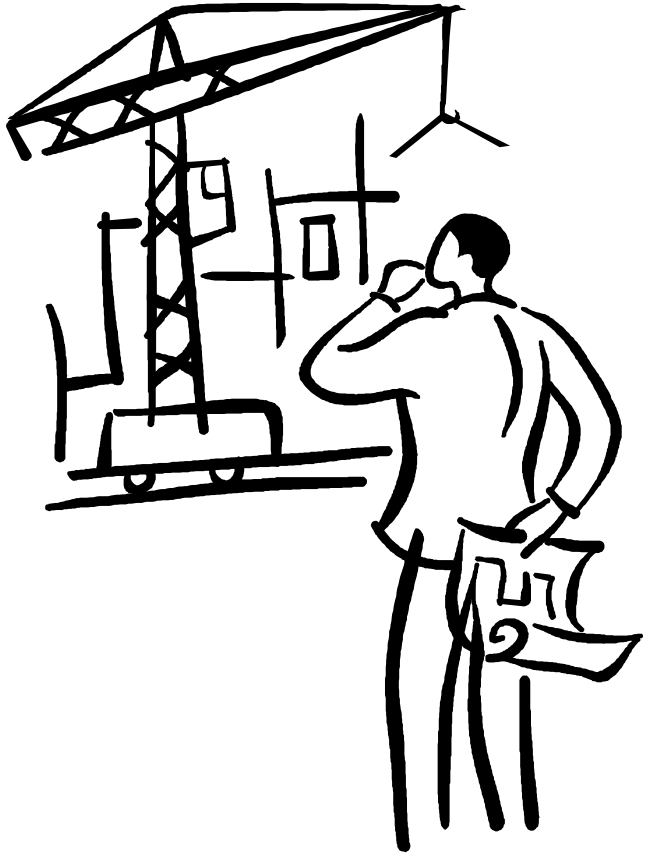
Why Templates?

SR is the "bricks and mortar"

Terminologies are the "furniture and lights"

Need a "blueprint" to put them together for real world use!

- **Everybody's house needs are different**



SR Templates

Like IODs, but for SR content

- Define attributes (concepts), required/optional, and allowed values
- Specify hierarchical structure of sections and subsections (containers)

Specified for a variety of uses, often in conjunction with specialty societies

- OB/GYN, vascular, echo, and IVUS ultrasound
- X-ray, CT, and MR angiography
- Mammo, chest, and colon computer-aided detection
- Radiation dose

DICOM Part 16 has over 250 defined Templates, and over 800 associated Context Groups (value sets)

Context Groups (value sets)

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CID 5001 Countries

Context Group ID 5001 comprises the two letter country code scheme of ISO 3166. The Coding Scheme Designator (0008,0102) shall be ISO3166_1.

Note: The two letter country codes of ISO 3166 may be obtained at http://www.iso.ch/iso/en/prods-services/iso3166ma/02iso-3166-code-lists/index.html

Context ID 6210
Location in Intestinal Tract
Type: Extensible Version: 20090402

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SRT	T-59600	Rectum
SRT	T-59470	Sigmoid colon
SRT	T-59460	Descending colon
SRT	T-59440	Transverse colon
SRT	T-59420	Ascending colon
SRT	T-59100	Cecum
SRT	T-59442	Splenic flexure of colon

Intensional – by definition

Extensional – by enumeration

Context ID 7210
Related Series Purposes of Reference
Type: Extensible Version: 20030619

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	122400	Simultaneously Acquired
DCM	122401	Same Anatomy
DCM	122402	Same Indication
DCM	122403	For Attenuation Correction

Quick summary of terms

SNOMED, LOINC, IEEE 11073

Terminology model, Information model

Code Sequence, Content Item, Content Tree

Pre-coordination, Post-coordination

Templates, Context Groups

Intensional, Extensional

DICOM SR Object Classes

Basic Text - Free text / dictation only

Enhanced, Comprehensive and Comprehensive 3D - General use text, coded content, numeric measurements, spatial and temporal ROI references

CAD - Automated analysis results (SOP Class per CAD template)

Key Object Selection (KOS) - Flags set of referenced objects (images) with a purpose of reference and a text note

Procedure Log – Events and observations during extended duration procedures (e.g., cath)

Radiation Dose Report - Projection X-ray; CT

- Aligned with international dose standards

Key Object Selection (KOS)

Template 2010

- Purpose (“for referring physician”, “for report”, …) in root container Concept Code
- Single text note applies to entire set of referenced objects

Uses in DICOM Part 17

- Annex K: Ultrasound best image selection
- Annex W: Digital signature for referenced objects
- Annex X: Key images for attachment to report

Specific uses are in addition to SOP Class conformance

- How application handles specific root Concept Codes

IHE KOS-related Profiles

Key Image Notes Profile uses KOS tagging of images for subsequent use

Cross-enterprise Document Sharing for Imaging (XDS-I) and Teaching File and Clinical Trial Export use KOS for a "manifest"

- List of images in a study shared through a Health Information Exchange or exported for secondary use

Imaging Object Change Management and Mammography Acquisition Workflow use KOS to identify images to be removed from clinical use

- Mislabeled images (wrong patient, wrong body part laterality)
- Images past retention period

Key Object Selection – Template 2010

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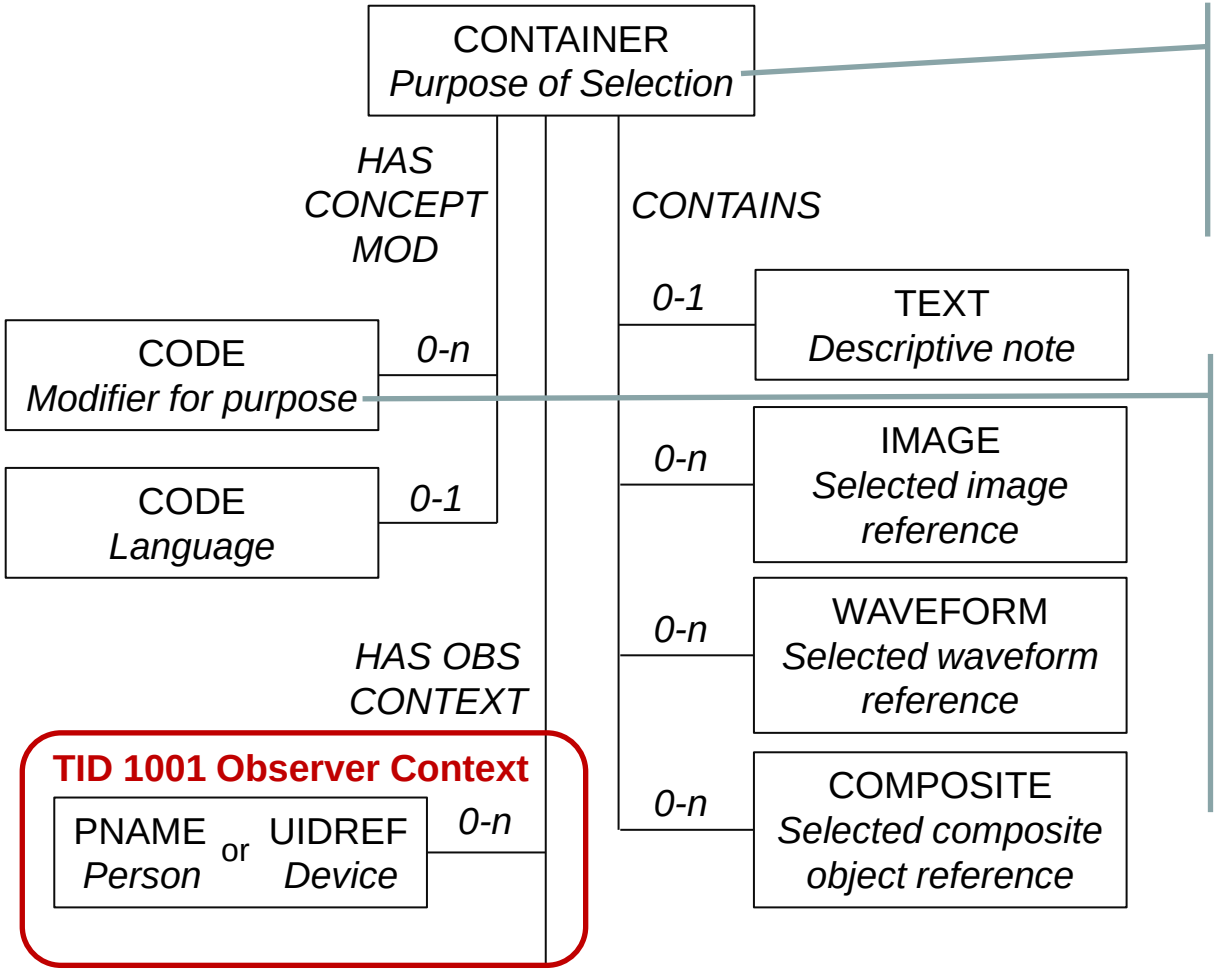
TID 2010
KEY OBJECT SELECTION
Type: Non-Extensible Order: Non-Significant

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	DCID(7010) Key Object Selection Document Titles	1	M		Root node
2	>	HAS CONCEPT MOD	CODE	EV (113011, DCM, "Document Title Modifier")	1-n	U		
3	>	HAS CONCEPT MOD	CODE	EV (113011, DCM, "Document Title Modifier")	1	UC	IF Row 1 Concept Name = (113001, DCM, "Rejected for Quality Reasons") or (113010, DCM," Quality Issue")	DCID (7011)
4	>	HAS CONCEPT MOD	CODE	EV (113011, DCM, "Document Title Modifier")	1	MC	IF Row 1 Concept Name = (113013, DCM, "Best In Set")	DCID (7012)
5	>	HAS CONCEPT MOD	INCLUDE	DTID(1204) Language of Content Item and Descendants	1	U		
6	>	HAS OBS CONTEXT	INCLUDE	DTID(1002) Observer Context	1-n	U		
7	>	CONTAINS	TEXT	EV(113012, DCM, "Key Object Description")	1	U		
8	>	CONTAINS	IMAGE	Purpose of Reference shall not be present	1-n	MC	At least one of Rows 8, 9 and 10 shall be present	
9	>	CONTAINS	WAVEFORM	Purpose of Reference shall not be present	1-n	MC	At least one of Rows 8, 9 and 10 shall be present	
10	>	CONTAINS	COMPOSITE	Purpose of Reference shall not be present	1-n	MC	At least one of Rows 8, 9 and 10 shall be present	

TID 2010 – Key Object Selection



DCM	113000	Of Interest
DCM	113001	Rejected for Quality Reasons
DCM	113002	For Referring Provider
DCM	113003	For Surgery
DCM	113013	Best In Set
…	…	…

CID 7010

DCM	111207	Image artifact(s)
DCM	111208	Grid artifact(s)
DCM	111209	Positioning
DCM	111210	Motion blur
…	…	…

CID 7011

DCM	113014	Study
DCM	113015	Series
DCM	113016	Performed Procedure Step
DCM	113017	Stage-view

CID 7012

Radiation Dose Report (RDR)

TID 10001 Projection X-Ray Radiation Dose

TID 10011 CT Radiation Dose

(Sup 159 in process) Radiopharmaceutical Dose

Critical part of patient safety improvement efforts

- **Developed in conjunction with IEC and AAPM**
- **Aligned with NEMA XR-25 CT Dose Check Standard, capturing check parameters and authorizations**

Use case workflow described in IHE Radiation Exposure Monitoring Profile

- **Objects can be forwarded to dose analysis/management systems**

RDR principles

More robust than MPPS Radiation Dose Module

- **New implementations should use RDR, not MPPS**

Report is created for specific “scope of accumulation”

- **Typically a Study or a Performed Procedure Step**

Each exposure event has a Unique ID

Report includes dose parameters for each event, and total for scope of accumulation

Allows data aggregation and mining by type of equipment, type of procedure, target anatomy, operator, radiologist, patient

DICOM SR
Implementation Considerations

SR requires SW flexibility

Coded terminology is less stable than IOD attribute definition – vocabulary evolves!

- Codes replaced due to mistakes/ambiguities
- Changes common with large nomenclatures

Context Groups revised with additional terms

- Support extended use cases

Templates change

- New analysis techniques / protocols / user requirements

Context Group Evolution – CID 7010 KOS Document Title

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Coding Scheme Designator	Code Value	Code Meaning	When added
DCM	113000	Of Interest	2002
DCM	113001	Rejected for Quality Reasons	2002
DCM	113002	For Referring Provider	2002
DCM	113003	For Surgery	2002
DCM	113004	For Teaching	2002
DCM	113005	For Conference	2002
DCM	113006	For Therapy	2002
DCM	113007	For Patient	2002
DCM	113008	For Peer Review	2002
DCM	113009	For Research	2002
DCM	113010	Quality Issue	2002
DCM	113013	Best In Set	2002
DCM	113018	For Printing	2002
DCM	113020	For Report Attachment	2004
DCM	113030	Manifest	2005
DCM	113031	Signed Manifest	2005
DCM	113032	Complete Study Content	2005
DCM	113033	Signed Complete Study Content	2005
DCM	113034	Complete Acquisition Content	2005
DCM	113035	Signed Complete Acquisition Content	2005
DCM	113036	Group of Frames for Display	2006
DCM	113037	Rejected for Patient Safety Reasons	2008

Support for Evolving Context Groups

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Run-time binding of Context Group content (*for vocabulary intended for user pick list*)

- **E.g., in configuration file**
- **Allows update without recompilation**
- **May allow customer update (additions/deletions)**

Update methods

- **Service engineering interface**
- **Authorized user**
- **IHE Shared Value Set retrieve**

Coded value replacement

Need to easily identify whether a particular code is used by an application, and easily update to a new code

- **E.g., use separate configuration file**

Private codes

Private coding scheme designators begin with "99" – e.g., "99SMS"

Private coded concepts must still be rigorously defined

- **Measurements must define the quality being measured and the class of metric (length, volume, pressure, etc.)**
- **Beware of "type mismatch" – diseases vs. anatomic location of disease; clinical finding vs. measurement of an anatomic feature**
  - Compare private concepts with SNOMED and LOINC information models

The purpose of private codes is still semantic interoperability – with receivers whom you may not know!

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Thank you for your attention !