Digital Imaging and Communications in Medicine (DICOM)

Supplement 94: Diagnostic X-Ray Radiation Dose Reporting (Dose SR)

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Table of Contents

Foreword

This supplement to the DICOM standard introduces a template for Diagnostic X-Ray Dose Reporting in DICOM. The concepts of Structured Reporting will be used in this context.

This document is a Supplement to the DICOM Standard. It is an extension to the following parts of the published DICOM Standard:

PS 3.3	Information Object Definitions
PS 3.4	Service Class Specifications
PS 3.6	Data Dictionary
PS 3.16	Content Mapping Resource
PS 3.17	Explanatory Information

This work was undertaken in liaison with International Electrotechnical Commission SubCommittee 62B (Diagnostic Imaging Equipment) Maintenance Team 38 (IEC SC62B MT38).

Scope and Field of Application

Many professional, public-health, and regulatory authorities recommend or require recording dosimetric information in the patient's medical records. X-ray imaging equipment is capable of measuring one or more relevant dosimetric quantities. Automatically transferring available information into standard formats will facilitate recording such information.

The DICOM Standard has since 1996 specified that patient radiation dose information can be carried in the Modality Performed Procedure Step (MPPS) object. However, it is problematic whether the MPPS, which goes to the RIS, is the proper place for this information. This would require the RIS to support processing and management of the radiation dose attributes, which is something current products generally do not do (certainly not to the level of detail required for CT). Implementation of MPPS dose reporting has not been widespread. Additionally, because the Exposure Dose Sequence is an optional attribute in an optional module of the MPPS, there is no DICOM mechanism to enforce its proper handling in applications.

It would be more appropriate to be able to send this information to a Radiation Safety Reporting System, an actor (in the IHE sense) that may or may not be combined with a RIS, a PACS, or may be a standalone system.

The approach taken here for Radiation Dose reporting is to define a new Structured Report (SR) object template and SOP Class. This SR object, independent of the images or the MPPS, could be routed to an appropriate Radiation Safety Reporting System. A system that claims conformance to such an SR object (either a modality as the creator, or the radiation reporting system as the receiver) would then be expected, as a concomitant of the conformance claim, to appropriately deal with such data items.

Such an SR dose object allows the data flow and data management of radiation dose reports to be disentangled from the data flow and data management of images, and may actually facilitate the evolution of a class of radiation safety information reporting systems that claim conformance to the DICOM SR dose object.

Recent activities from IEC SC62B MT38 have been started to define a common set of dose-related information and structure it to “levels of support” and for which entities it shall be recorded. This initiative provided valuable input for the Dose Recording activity in DICOM.

There is a strong need to differentiate between dose relevant data that has to be provided “per event” and those data that represent “accumulations”.

The herein defined Dose SR templates are not intended to cover Nuclear Medicine related reporting of applied nuclide doses nor does it affect the already defined SOP Classes for Radiation Therapy dose recording or treatment planning. The focus is X-Ray based imaging equipment, however not all modalities have been fully elaborated (CT, Dental X-Ray).

Irradiation Event

Each release of irradiation will create an irradiation event that includes dose related values. In order to understand the nature of these values a sufficient amount of “additional data” to describe the physical context of the irradiation exposure has to be recorded along with the dose values. An event resulting in creation of a DICOM Image SOP Instance shall include the reference to it. There are definitely irradiation events that will not result in any image storage but will create dose relevant data stored in the Radiation Dose Reporting Object.

The relevance of dose values will definitely change between the different types of equipment that are generating irradiation events – Radiography, Radio-fluoroscopy, General Angiography and Cardiology, Mammography, Dental and Computed Tomography. This will require individual templates when constructing the Radiation Dose Reporting Object.

The attributes contained in the different templates will typically include what can be practically reported by the device, although they will be influenced by regulatory requirements. In some cases, while it might be more desirable to report internal dose value presentations, devices might only practically be able to provide Entrance Dose.

Accumulated Values

One important part in understanding dose reporting is that storing individual irradiation events is not sufficient for documentation purposes. Several regulatory bodies in different countries postulate recording of accumulated dose values like the “Dose at the reference point” or the “Dose Area Product” per procedure. So to complete Dose reporting requirements, a distinct set of accumulated values has to be provided to fulfill dedicated legal requirements for “recording of accumulated values applied during a procedure”.

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Changes to NEMA Standards Publication PS 3.2-2004

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Digital Imaging and Communications in Medicine (DICOM)

Part 2: Conformance

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Item #01: Add new SOP Classes in Table A.1-2

Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.88.67	**X-Ray Radiation Dose SR**	**Transfer**
…		

Changes to NEMA Standards Publication PS 3.3-2004

Digital Imaging and Communications in Medicine (DICOM)

Part 3: Information Object Definitions

Item #02: Add PS3.3 Section A.35.X:

A.35.X X-Ray Radiation Dose SR Information Object Definition

A.35.X.1 X-Ray Radiation Dose SR Information Object Description

The X-Ray Radiation Dose SR IOD is used to convey the exposure characteristics and dose from X-rays generated by imaging devices.

Note: Therapeutic dose is reported in the RT Dose IOD.

A.35.X.2 X-Ray Radiation Dose SR IOD Entity-Relationship Model

The E-R Model in Section A.1.2 of this Part applies to the X-Ray Radiation Dose SR IOD. Table A.35.X-1 specifies the Modules of the X-Ray Radiation Dose SR IOD.

A.35.X.3 X-Ray Radiation Dose SR IOD Module Table

Table A.35.X-1
X-RAY RADIATION DOSE SR IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	SR Document Series	C.17.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Synchronization	C.7.4.2	C - shall be present if system time is synchronized to an external reference. May be present otherwise.
Equipment	General Equipment	C.7.5.1	M
Document	SR Document General	C.17.2	M
	SR Document Content	C.17.3	M
	SOP Common	C.12.1	M

A.35.X.3.1 X-Ray Radiation Dose SR IOD Content Constraints

A.35.X.3.1.1 Template

The document may be constructed from Baseline TID 10001 "Projection X-Ray Radiation Dose Report" (defined in PS3.16) invoked at the root node.

Note: This IOD maybe used with other Templates defined for Dose Reporting. Such other Templates maybe specialized for specific modalities or future dose measurement techniques.

A.35.X.3.1.2 Value Type

Value Type (0040,A040) in the Content Sequence (0040,A730) of the SR Document Content Module is constrained to the following Enumerated Values (see Table C.17-7 for Value Type definitions):

TEXT
CODE
NUM
DATETIME
UIDREF
PNAME
COMPOSITE
IMAGE
CONTAINER

A.35.X.3.1.3 Relationship Constraints

Relationships between content items in the content of this IOD may be conveyed by-value. Table A.35.X-2 specifies the relationship constraints of this IOD. See Table C.17.3-2 for Relationship Type definitions.

Table A.35.X-2
RELATIONSHIP CONTENT CONSTRAINTS FOR X-RAY RADIATION DOSE SR IOD

Source Value Type	Relationship Type (Enumerated Values)	Target Value Type
CONTAINER	CONTAINS	TEXT, CODE, NUM, DATETIME, UIDREF, PNAME, IMAGE, COMPOSITE, CONTAINER
TEXT, CODE, NUM	HAS OBS CONTEXT	TEXT, CODE, NUM, DATETIME, UIDREF, PNAME, COMPOSITE
CONTAINER, IMAGE, COMPOSITE	HAS ACQ CONTEXT	TEXT, CODE, NUM, DATETIME, UIDREF, PNAME, CONTAINER.
any type	HAS CONCEPT MOD	TEXT, CODE
TEXT, CODE, NUM	HAS PROPERTIES	TEXT, CODE, NUM, DATETIME, UIDREF, PNAME, IMAGE, COMPOSITE, CONTAINER.
TEXT, CODE, NUM	INFERRED FROM	TEXT, CODE, NUM, DATETIME, UIDREF, IMAGE, COMPOSITE, CONTAINER.

Note: The SOP Classes to which an IMAGE or COMPOSITE Value Type may refer, is documented in the Conformance Statement for an application (see PS 3.2 and PS 3.4).

Item #03: Add note to Section C.4.16

C.4.16 Radiation Dose

…

The scope of the attributes contained in this module covers the entire acquisition that comprises the Modality Performed Procedure Step. Attributes that relate to single images, such as mAs or kVP, may be included in the Image IODs. It is beyond the scope of DICOM to define what attributes may be required to calculate or estimate area dose product values.

Note: The X-Ray Radiation Dose SR SOP Class provides a more comprehensive means of reporting radiation dose. Such a dose report may be referenced in the Image Acquisition Results Module.

Item #04: Add attribute to Table C.7-9 GENERAL IMAGE MODULE ATTRIBUTES

Table C.7-9
GENERAL IMAGE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
….			
Irradiation Event UID	**(0008,3010)**	**3**	**Unique identification of the irradiation event(s) associated with the acquisition of this image. See C.7.6.1.1.x**
….			

C.7.6.1.1.x Irradiation Event UID

An irradiation event is the occurrence of radiation being applied to a patient in single continuous time-frame between the start (release) and the stop (cease) of the irradiation. Any on-off switching of the irradiation source during the event shall not be treated as separate events, rather the event includes the time between start and stop of irradiation as triggered by the user. E.g., a pulsed fluoro X-Ray acquisition shall be treated as a single irradiation event.

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Changes to NEMA Standards Publication PS 3.4-2004

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Part 4: Service Class Specifications

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Item #05: Add SOP Class to Table B.3-3

Table B.3-3
STANDARD AND RELATED GENERAL SOP CLASSES

SOP Class Name	Related General SOP Class Name
…	
X-Ray Radiation Dose SR	**Enhanced SR**
	Comprehensive SR

Item #06: Add SOP Class to Table B.5-1

B.5 STANDARD SOP CLASSES

Table B.5-1
STANDARD SOP CLASSES

SOP Class Name	SOP Class UID	IOD (See PS 3.3)
…		
X-Ray Radiation Dose SR	**1.2.840.10008.5.1.4.1.1.88.67**	**X-Ray Radiation Dose SR**

Item #07: Add Structured Reporting SOP Class to Section B.5.1.5

B.5.1.5 Structured Reporting Storage SOP Classes

The requirements of Annex O apply to the following SOP Classes:

- …
- **X-Ray Radiation Dose SR**

Item #08: Add SOP Class to Table I.4-1

I.4 MEDIA STORAGE SOP CLASSES

Table I.4-1
Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD (See PS 3.3)
…		
X-Ray Radiation Dose SR	**1.2.840.10008.5.1.4.1.1.88.67**	**X-Ray Radiation Dose SR**

Item #09: Add SOP Class to Section I.4.1.2

I.4.1.2 Structured Reporting Storage SOP Classes

The requirements of Annex O apply to the following SOP Classes:

- …
- **X-Ray Radiation Dose SR**

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282 **Changes to NEMA Standards Publication PS 3.6-2004**

Digital Imaging and Communications in Medicine (DICOM)

284 **Part 6: Data Dictionary**

Item #10: Add the following row to Table A-1

UID Value	UID Name	UID Type	Part
…			
1.2.840.10008.5.1.4.1.1.88.67	**X-Ray Radiation Dose SR**	**SOP Class**	**PS 3.4**
…			

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296 # Changes to NEMA Standards Publication PS 3.16-2004

Digital Imaging and Communications in Medicine (DICOM)

298 # Part 16: Content Mapping Resource

Item #11: Add new Section to Annex A

X-RAY RADIATION DOSE SR IOD TEMPLATES

The templates that comprise the X-Ray Radiation Dose SR are interconnected as in Figure A-x.

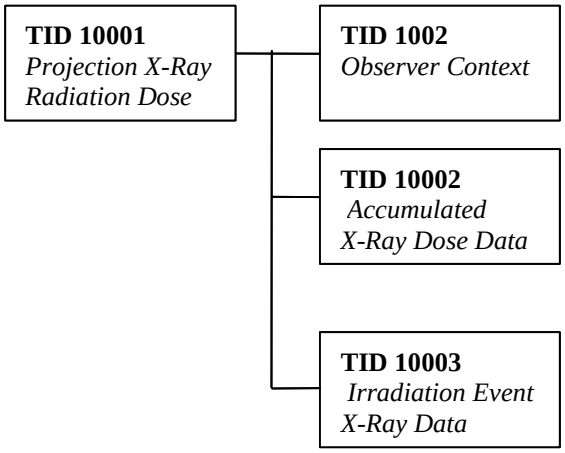

Figure A-x: X-Ray Radiation Dose SR IOD Template Structure

TID 10001 Projection X-Ray Radiation Dose

This template defines a container (the root) with subsidiary content items, each of which represents a single projection X-Ray irradiation event entry or plane-specific dose accumulations. There is a defined recording observer (the system or person responsible for recording the log, generally the system). A Biplane irradiation event will be recorded as two individual events, one for each plane. Accumulated values will be kept separate for each plane.

TID 10001
PROJECTION X-RAY RADIATION DOSE
Type: Extensible

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (113701, DCM, “X-Ray Radiation Dose Report”)	1	M		
2	>	HAS CONCEPT MOD	CODE	EV (121058, DCM, ”Procedure reported”)	1	M		DT (113704, DCM, “Projection X-Ray”)
3	>		INCLUDE	DTID (1002) Observer Context	1-n	M		
4	>	HAS OBS CONTEXT	CODE	EV (113705, DCM, “Scope of Accumulation”)	1	M		DCID (10000) Scope of Accumulation

5	>>	HAS PROPERTIES	UIDREF	DCID (10001) UID Types	1	M		
6	>	CONTAINS	TEXT	EV (113780, DCM, “Reference Point Definition”)	1	U		
7	>	CONTAINS	INCLUDE	DTID (10002) Accumulated X-Ray Dose	1	MC	IFF Single Plane system	$Plane = EV (113622, DCM, ”Single Plane”
8	>	CONTAINS	INCLUDE	DTID (10002) Accumulated X-Ray Dose	1	MC	IFF Biplane system	$Plane = EV (113620, DCM, ”Plane A”)
9	>	CONTAINS	INCLUDE	DTID (10002) Accumulated X-Ray Dose	1	MC	IFF Biplane system	$Plane = EV (113621, DCM, ”Plane B”)
10	>	CONTAINS	INCLUDE	DTID (10003) Irradiation Event X-Ray Data	1-n	M		
11	>	CONTAINS	TEXT	EV (121106, DCM, “Comment”)	1	U		

316 **Content Item Descriptions**

Row 3	The observer context may include both a Person Observer identification, as well as the identity of the equipment providing the values for the irradiation event (Device Observer identification), if not inherited.
Row 6	This item defines the Reference Point (RP) used for RP-related dose values. The RP may be defined according to IEC 60601-2-43, or may use an implementation-specific definition.

318 **TID 10002 Accumulated X-Ray Dose**

This general template provides detailed information on projection X-Ray dose value accumulations over
320 several irradiation events from the same equipment (typically a study or a performed procedure step).

Parameter Name	Parameter Usage
$Plane	Coded term identifying to which acquisition plane the encoded information belongs.

322 **TID 10002**
ACCUMULATED X-RAY DOSE
324 **Type: Extensible**

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (113702, DCM, ”Accumulated X-Ray Dose Data”)	1	M		
2	>	HAS CONCEPT MOD	CODE	EV (113764, DCM, “Acquisition Plane”	1	M		$Plane
3	>	CONTAINS	TEXT	EV (113780, DCM, “Reference Point Definition”)	1	U		
4	>	CONTAINS	CONTAINER	EV (122505, DCM, “Calibration”)	1	M		

5	>>	HAS CONCEPT MOD	CODE	EV (113794, DCM, “Dose Measurement Device”)	1-n	M		DCID (10010) Dose Measurement Devices
6	>>	CONTAINS	DATETIME	EV (113723, DCM, “Calibration Date”)	1	M		
7	>>	CONTAINS	NUM	EV (122322, DCM, “Calibration Factor”)	1	M		Units = EV (1, UCUM, “no units”)
8	>>	CONTAINS	NUM	EV (113763, DCM, “Calibration Uncertainty”)	1	M		Units = EV (%, UCUM, “Percent”)
9	>>	CONTAINS	TEXT	EV (113724, DCM, “Calibration Responsible Party”)	1	M		
10	>	CONTAINS	NUM	EV (113722, DCM, “Dose Area Product Total”)	1	M		Units = EV (Gym2, UCUM, “Gym2”)
11	>	CONTAINS	NUM	EV (113725, DCM, “Dose (RP) Total”)	1	M		Units = EV (Gy, UCUM, “Gy”)
12	>	CONTAINS	NUM	EV (113726, DCM, “Fluoro Dose Area Product Total”)	1	MC	IFF TID(10003) Row 3 value = (P5-06000, SRT, “Fluoroscopy”) for at least one irradiation event	Units = EV (Gym2, UCUM, “Gym2”)
13	>	CONTAINS	NUM	EV (113728, DCM, “Fluoro Dose (RP) Total”)	1	MC	IFF TID(10003) Row 3 value = (P5-06000, SRT, “Fluoroscopy”) for at least one irradiation event	Units = EV (Gy, UCUM, “Gy”)
14	>	CONTAINS	NUM	EV (113730, DCM, “Total Fluoro Time”)	1	MC	IFF TID(10003) Row 3 value = (P5-06000, SRT, “Fluoroscopy”) for at least one irradiation event.	Units = EV (s, UCUM, “s”)
15	>	CONTAINS	NUM	EV (113727, DCM, “Acquisition Dose Area Product Total”)	1	M		Units = EV (Gym2, UCUM, “Gym2”)
16	>	CONTAINS	NUM	EV (113729, DCM, “Acquisition Dose (RP) Total”)	1	M		Units = EV (Gy, UCUM, “Gy”)
17	>	CONTAINS	NUM	EV (113731, DCM, “Total Number of Radiographic Frames”)	1	U		Units = EV (1, UCUM, “no units”)

Content Item Descriptions

Row 3	Reference Point definition if not provided in TID 10001
Row 4	Date that the calibration of the equipment’s dose indicators was performed
Row 7	Factor by which the measured dose area product total was multiplied to obtain the Dose Area Product Total (Row 10).
Row 8	Value range from 0 to 100 percent. Uncertainty of the ‘actual’ value expressed as +/- of the mean.
Row 9	Identifies Individual or organization responsible for calibration
Row 10	Sum of acquisition and fluoroscopy
Row 11	Sum of acquisition and fluoroscopy, relative to reference point.
Rows 12-14	Fluoroscopic component only
Rows 15-16	Acquisition component only

330 **TID 10003 Irradiation Event X-Ray Data**

This template conveys the dose and equipment parameters of a single irradiation event.

332 An irradiation event is the occurrence of radiation being applied to a patient in single continuous time-frame between the start (release) and the stop (cease) of the irradiation. The irradiation event is the
334 "smallest" information entity to be recorded in the realm of Radiation Dose reporting. Individual Irradiation Events are described by a set of accompanying physical parameters that are sufficient to understand the
336 "quality" of irradiation that is being applied. This set of parameters may be different for the various types of equipment that are able to create irradiation events. Any on-off switching of the irradiation source during
338 the event shall not be treated as separate events, rather the event includes the time between start and stop of irradiation as triggered by the user. E.g., a pulsed fluoro X-Ray acquisition shall be treated as a
340 single irradiation event.

As described in Section 6.2.4, measurement concepts may be post-coordinated, even though not explicitly
342 specified in the Template. In particular, post-coordination using modifier concept (121401, DCM, "Derivation"), with modifier values drawn from CID 10009 Measured/Calculated would be appropriate to
344 encode indications of measured or of calculated values.

346 **TID 10003**
IRRADIATION EVENT X-RAY DATA
348 **Type: Extensible**

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (113706, DCM, "Irradiation Event X-Ray Data")	1	M		
2	>	HAS CONCEPT MOD	CODE	EV (113764, DCM, "Acquisition Plane"	1	M		DCID (10003) Equipment Plane Identification
3	>	CONTAINS	CODE	EV (113721, DCM, "Irradiation Event Type")	1	M		DCID (10002) Irradiation Event Types
4	>	CONTAINS	TEXT	EV (125203, DCM, "Acquisition Protocol")	1	U		
5	>	CONTAINS	TEXT	EV (113780, DCM, "Reference Point Definition")	1	U		
6	>	CONTAINS	IMAGE	EV (113795, DCM, "Acquired Image")	1-n	MC	IFF Image Object is created for this irradiation event	
7	>	CONTAINS	UIDREF	EV (113769, DCM, "Irradiation Event UID")	1	M		
8	>	CONTAINS	NUM	EV (122130, DCM, "Dose Area Product"	1	M		Units = EV (Gym2, UCUM, "Gym2")
9	>	CONTAINS	NUM	EV (113738, DCM, "Dose (RP)")	1	M		Units = EV (Gy, UCUM, "Gy")
10	>	CONTAINS	NUM	EV (112011, DCM, "Positioner Primary Angle")	1	UC	XOR Row 14	Units = EV (deg, UCUM, "º")

11	>	CONTAINS	NUM	EV (112012, DCM, “Positioner Secondary Angle”)	1	UC	XOR Row 14	Units = EV (deg, UCUM, “º”)
12	>	CONTAINS	NUM	EV (113739, DCM, “Positioner Primary End Angle”	1	UC	IFF Row 3 value = (113613, DCM, “Rotational Acquisition”)	Units = EV (deg, UCUM, “º”)
13	>	CONTAINS	NUM	EV (113740, DCM, “Positioner Secondary End Angle”	1	UC	IFF Row 3 value = (113613, DCM, “Rotational Acquisition”)	Units = EV (deg, UCUM, “º”)
14	>	CONTAINS	NUM	EV (113770, DCM, “Column Angulation”)	1	UC	XOR Rows 10,11	Units = EV (deg, UCUM, “º”)
15	>	CONTAINS	NUM	EV (113790, DCM, “Collimated Field Area”	1	U		Units = EV (m2, UCUM, “m^2”)
16	>	CONTAINS	CONTAINER	EV (113771, DCM, “X-Ray Filters”)	1-n	U		
17	>>	CONTAINS	CODE	EV (113772, DCM, “X-Ray Filter Type”)	1	U		DCID (10007) X-Ray Filter Types
18	>>	CONTAINS	CODE	EV (113757, DCM, “X-Ray Filter Material”)	1	U		DCID (10006) X-Ray Filter Materials
19	>>	CONTAINS	NUM	EV (113758, DCM, “X-Ray Filter Thickness Minimum”)	1	U		Units = EV (mm, UCUM, “mm”)
20	>>	CONTAINS	NUM	EV (113773, DCM, “X-Ray Filter Thickness Maximum”)	1	U		Units = EV (mm, UCUM, “mm”)
21	>	CONTAINS	CODE	EV (113732, DCM, “Fluoro Mode”)	1	UC	IFF Row 3 value = (P5-06000, SRT, “Fluoroscopy”)	DCID (10004) Fluoro Modes
22	>	CONTAINS	NUM	EV (113791, DCM, “Pulse Rate”)	1	MC	IFF Row 21 value = (113631, DCM, “Pulsed”)	Units = EV ({pulse}/s, UCUM, “pulse/s”)
23	>	CONTAINS	NUM	EV (113768, DCM, “Number of Pulses”)	1	M		Units = EV (1, UCUM, “no units”)
24	>>	HAS CONCEPT MOD	CODE	EV (121401, DCM, “Derivation”)	1	MC	IFF count of pulses in Row 23 is estimated	EV (R-10260, SRT, “Estimated”)
25	>	CONTAINS	NUM	EV (113733, DCM, “KVP”)	1-n	U		Units = EV (kV, UCUM, “kV”)
26	>	CONTAINS	NUM	EV (113734, DCM, “X-Ray Tube Current”)	1-n	U		Units = EV (mA, UCUM, “mA”)
27	>	CONTAINS	NUM	EV (113735, DCM, “Exposure Time”)	1	U		Units = EV (ms, UCUM, “ms”)
28	>	CONTAINS	NUM	EV (113793, DCM, “Pulse Width”)	1-n	U		Units = EV (ms, UCUM, “ms”)
29	>	CONTAINS	NUM	EV (113736, DCM, “Exposure”)	1-n	U		Units = EV (uAs, UCUM, “uAs”)
30	>	CONTAINS	NUM	EV (113766, DCM, “Focal Spot Size”)	1	U		Units = EV (mm, UCUM, “mm”)
31	>	CONTAINS	NUM	EV (113742, DCM, “Irradiation Duration”)	1	U		Units = EV (s, UCUM, “s”)
32	>	CONTAINS	NUM	EV (113767, DCM, “Average X-Ray Tube Current”)	1	U		Units = EV (mA, UCUM, “mA”)

33	>	CONTAINS	CODE	EV (113745, DCM, “Patient Table Relationship”)	1	U		DCID (21) Patient Gantry Relationship
34	>	CONTAINS	CODE	EV (113743, DCM, “Patient Orientation”)	1	U		DCID (19) Patient Orientation
35	>>	HAS CONCEPT MOD	CODE	EV (113744, DCM, “Patient Orientation Modifier”)	1	M		DCID (20) Patient Orientation Modifier
36	>	CONTAINS	NUM	DCID (10008) Dose Related Distance Measurements	1-n	U		Units = EV (mm, UCUM, “mm”)
37	>	CONTAINS	NUM	EV (113754, DCM, “Table Head Tilt Angle”)	1	U		Units = EV (deg, UCUM, “°”)
38	>	CONTAINS	NUM	EV (113755, DCM, “Table Horizontal Rotation Angle”)	1	U		Units = EV (deg, UCUM, “°”)
39	>	CONTAINS	NUM	EV (113756, DCM, “Table Cradle Tilt Angle”)	1	U		Units = EV (deg, UCUM, “°”)
40	>	CONTAINS	CODE	EV (123014 , DCM, (”Target Region”)	1	U		DCID (4031) Common Anatomic Regions
41	>	CONTAINS	TEXT	EV (121106, DCM, “Comment”)	1	U		

Content Item Descriptions

Row 5	Reference Point definition if not provided in TID 10001
Row 6	Reference to Image instances created during this event, if any. The UID reference(s) provided here shall be the values at the time the images were initially created. (Note that image UIDs may be changed as the images are managed over a long term.)
Row 7	If the image generating entity does not assign a DICOM UID to the irradiation event (e.g., for non-digital imaging equipment), the application generating this report shall assign a UID.
Row 9	Dose applied by this irradiation event, relative to defined reference point.
Row 10	Angle in patient’s “equatorial” plane (LAO to RAO). For dynamically changing angle during the event, the start value shall be provided. Equivalent to (0018,1510) in an image instance.
Row 11	Angle in patient’s “sagittal” plane (CRAN to CAUD). For dynamically changing angle during the event, the start value shall be provided. Equivalent to (0018,1511) in an image instance.
Row 12	In case of motion during irradiation event, Positioner Primary ending angle
Row 13	In case of motion during irradiation event., Positioner Secondary ending angle
Row 14	Column device Angle in equipment based coordinates
Row 15	Collimated area at the receptor plane.
Row 16	If one or more Filter(s) were applied during this irradiation event
Row 23	If a precise count of pulses is not available, an estimated number shall be provided, and the Row 24 Concept Modifier shall indicate “Estimated”
Row 25	KVP value as measured/recorded by system, either as a single mean value, or as multiple values. If multiple values are provided, their number shall match the value in Row 23 “Number of Pulses”.
Row 26	Tube current as measured/recorded by system, either as a single mean value, or as multiple values. If multiple values are provided, their number shall match the value in Row 23 “Number of Pulses”.
Row 27	Exposure time as measured/recorded by the system.
Row 28	Pulse width as measured/recorded by the system, either as a single total value, or as multiple values. If multiple values are provided, their number shall match the value in Row 23 “Number of Pulses”.
Row 29	Exposure as measured/recorded by system, either as a single total value, or as multiple values. If multiple values are provided, their number shall match the value in Row 23 “Number of Pulses”. The Exposure will be affected by the shape of the pulse and other factors, and may not be a simple multiplication of tube current and exposure time.

Row 40	The target region is the anatomy exposed.

Item #12: Add the following CID's to Part 16 Annex B:

CID 10000 Scope of Accumulation

Context ID 10000
Scope of Accumulation

Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113014	Study
DCM	113015	Series
DCM	113016	Performed Procedure Step

CID 10001 UID Types

Context ID 10001
UID Types

Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	110180	Study Instance UID
DCM	112002	Series Instance UID
DCM	121126	Performed Procedure Step SOP Instance UID

CID 10002 Irradiation Event Types

Context ID 10002
Irradiation Event Types

Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SRT	P5-06000	Fluoroscopy
DCM	113611	Stationary Acquisition
DCM	113612	Stepping Acquisition
DCM	113613	Rotational Acquisition

CID 10003 Equipment Plane Identification

Context ID 10003
Equipment Plane Identification
Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113620	Plane A
DCM	113621	Plane B
DCM	113622	Single Plane

CID 10004 Fluoro Modes

Context ID 10004
Fluoro Modes
Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113630	Continuous
DCM	113631	Pulsed

CID 10006 X-Ray Filter Materials

Context ID 10006
X-Ray Filter Materials
Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SRT	C-150F9	Molybdenum or Molybdenum compound
SRT	C-120F9	Aluminum or Aluminum compound
SRT	C-127F9	Copper or Copper compound
SRT	C-167F9	Rhodium or Rhodium compound
DCM	113710	Niobium or Niobium compound
DCM	113711	Europium or Europium compound
SRT	C-132F9	Lead or Lead compound
SRT	C-156F9	Tantalum or Tantalum compound

388

CID 10007 X-Ray Filter Types

390 **Context ID 10007**
X-Ray Filter Types

392 **Type: Extensible Version: 20051101**

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113650	Strip filter
DCM	113651	Wedge filter
DCM	113652	Butterfly filter
DCM	111609	No Filter

394

CID 10008 Dose Related Distance Measurements

396 **Context ID 10008**
Dose Related Distance Measurements

398 **Type: Extensible Version: 20051101**

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113748	Distance Source to Isocenter
DCM	113737	Distance Source to Reference Point
DCM	113750	Distance Source to Detector
DCM	113751	Table Longitudinal Position
DCM	113752	Table Lateral Position
DCM	113753	Table Height Position
DCM	113792	Distance Source to Table Plane

400

CID 10009 Measured/Calculated

402 **Context ID 10009**
Measured/Calculated

404 **Type: Extensible Version: 20051101**

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SRT	R-41D41	Measured
SRT	R-41D2D	Calculated
SRT	R-10260	Estimated

CID 10010 Dose Measurement Devices

Context ID 10010
Dose Measurement Devices

Type: Extensible Version: 20051101

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
SRT	A-2C090	Dosimeter

Item #13: Modify the following Definitions in Annex D

DICOM Code Definitions (Coding Scheme Designator "DCM" Coding Scheme Version "01")

Code Value	Code Meaning	Definition
122322	Calibration Factor	~~**Calibration**~~ Factor **by which a measured or calculated value is multiplied to obtain the estimated real-world value**
122505	Calibration	Procedure used to calibrate **measurements or measurement devices** ~~**pixel size**~~

Item #14: Add the following Definitions to Annex D

DICOM Code Definitions (Coding Scheme Designator "DCM" Coding Scheme Version "01")

Code Value	Code Meaning	Definition
….		
113611	Stationary Acquisition	Acquisition where the x-ray source does not move in relation to the patient
113612	Stepping Acquisition	Acquisition where the x-ray source moves laterally in relation to the patient
113613	Rotational Acquisition	Acquisition where the x-ray source moves angularly in relation to the patient
113620	Plane A	Primary plane of a Biplane acquisition equipment
113621	Plane B	Secondary plane of a Biplane acquisition equipment
113622	Single Plane	Single plane acquisition equipment
113630	Continuous	Continuous x-ray radiation is applied during an irradiation event

113631	Pulsed	Pulsed x-ray radiation is applied during an irradiation event
113650	Strip filter	Filter with uniform thickness
113651	Wedge filter	Filter with variation in thickness from one edge to the opposite edge
113652	Butterfly filter	Filter with two triangular sections
113701	X-Ray Radiation Dose Report	X-Ray Radiation Dose Report
113702	Accumulated X-Ray Dose Data	X-Ray dose data accumulated over multiple irradiation events, e.g., for a study or a performed procedure step
113704	Projection X-Ray	Imaging using a point X-ray source with a diverging beam projected onto a 2 dimensional detector
113705	Scope of Accumulation	Entity over which dose accumulation values are integrated
113706	Irradiation Event X-Ray Data	X-Ray dose data for a single Irradiation Event
113710	Niobium or Niobium compound	Material containing Niobium or a Niobium compound
113711	Europium or Europium compound	Material containing Europium or a Europium compound
113721	Irradiation Event Type	Denotes the type of irradiation event recorded
113722	Dose Area Product Total	Total calculated Dose Area Product (in the scope of the including report)
113723	Calibration Date	Last calibration Date for the integrated dose meter or dose calculation
113724	Calibration Responsible Party	Individual or organization responsible for calibration
113725	Dose (RP) Total	Total Dose related to Reference Point (RP). (in the scope of the including report)
113726	Fluoro Dose Area Product Total	Total calculated Dose Area Product applied in Fluoroscopy Modes (in the scope of the including report).
113727	Acquisition Dose Area Product Total	Total calculated Dose Area Product applied in Acquisition Modes (in the scope of the including report).
113728	Fluoro Dose (RP) Total	Dose applied in Fluoroscopy Modes, related to Reference Point (RP). (in the scope of the including report)
113729	Acquisition Dose (RP) Total	Dose applied in Acquisition Modes, related to Reference Point (RP). (in the scope of the including report)
113730	Total Fluoro Time	Total accumulated time of Fluoroscopy (in the scope of the including report)
113731	Total Number of Radiographic Frames	Accumulated Count of Frames (single or multi-frame) created from irradiation events performed with high dose (acquisition).

113732	Fluoro Mode	Mode of application of X-Rays during Fluoroscopy
113733	KVP	Applied X-Ray Tube voltage at peak of X-ray generation, in kilovolts; Mean value if measured over multiple peaks (pulses)
113734	X-Ray Tube Current	Mean value of applied Tube Current
113735	Exposure Time	Cumulative time the patient has received X-Ray exposure during the irradiation event
113736	Exposure	Mean value of X-Ray Current Time product
113737	Distance Source to Reference Point	Distance to the Reference Point (RP) defined according to IEC 60601-2-43 or equipment defined.
113738	Dose (RP)	Dose applied at the Reference Point (RP).
113739	Positioner Primary End Angle	Positioner Primary Angle at the end of an irradiation event. For further definition see (112011,DCM,"Positioner Primary Angle")
113740	Positioner Secondary End Angle	Positioner Secondary Angle at the end of an irradiation event. For further definition see (112012,DCM,"Positioner Secondary Angle")
113742	Irradiation Duration	Clock time from the start of the first irradiation in the irradiation event until the end of the last irradiation in the same irradiation event. For continuous modes this the time the irradiation intensity is above a 50% threshold with respect to the maximum intensity achieved during an irradiation event.
113743	Patient Orientation	Orientation of the Patient with respect to Gravity
113744	Patient Orientation Modifier	Enhances or modifies the Patient orientation specified in Patient Orientation
113745	Patient Table Relationship	Orientation of the Patient with respect to the Head of the Table
113748	Distance Source to Isocenter	Distance from the X-Ray Source to the Equipment C-Arm Isocenter.(Center of Rotation).
113750	Distance Source to Detector	Measured or calculated distance from the X-Ray source to the detector plane in the center of the beam.
113751	Table Longitudinal Position	Table Longitudinal Position with respect to an arbitrary chosen reference by the equipment. Table motion towards LAO is positive assuming that the patient is positioned supine and its head is in normal position.
113752	Table Lateral Position	Table Lateral Position with respect to an arbitrary chosen reference by the equipment. Table motion towards CRA is positive assuming that the patient is positioned supine and its head is in normal position.

113753	Table Height Position	Table Height Position with respect to an arbitrary chosen reference by the equipment in (mm). Table motion downwards is positive
113754	Table Head Tilt Angle	Angle of the head-feet axis of the table in degrees relative to the horizontal plane. Positive values indicate that the head of the table is upwards.
113755	Table Horizontal Rotation Angle	Rotation of the table in the horizontal plane (clockwise when looking from above the table).
113756	Table Cradle Tilt Angle	Angle of the left-right axis of the table in degrees relative to the horizontal plane. Positive values indicate that the left of the table is upwards.
113757	X-Ray Filter Material	X-Ray absorbing material used in the filter.
113758	X-Ray Filter Thickness Minimum	The minimum thickness of the X-Ray absorbing material used in the filters.
113763	Calibration Uncertainty	Uncertainty of the ‘actual’ value.
113764	Acquisition Plane	Identification of Acquisition Plane with Biplane systems.
113766	Focal Spot Size	Nominal Size of Focal Spot of X-Ray Tube
113767	Average X-Ray Tube Current	Average X-Ray Tube Current averaged over time for pulse or for continuous Fluoroscopy
113768	Number of Pulses	Number of pulses applied by X-Ray systems during an irradiation event (acquisition run or pulsed fluoro)
113769	Irradiation Event UID	Unique identification of a single irradiation event
113770	Column Angulation	Angle of the X-Ray beam in degree relative to an orthogonal axis to the detector plane.
113771	X-Ray Filters	Devices used to modify the energy or energy distribution of X-rays
113772	X-Ray Filter Type	Type of filter(s) inserted into the X-Ray beam (e.g. wedges).
113773	X-Ray Filter Thickness Maximum	The maximum thickness of the X-Ray absorbing material used in the filters.
113780	Reference Point Definition	System provided definition of the Reference Point used for Dose calculations.
113790	Collimated Field Area	Collimated field area at image receptor. Area for compatibility with IEC 60601-2-43.
113791	Pulse Rate	Pulse rate applied by equipment during Fluoroscopy
113792	Distance Source to Table Plane	Measured or calculated distance from the X-Ray source to the table plane in the center of the beam.
113793	Pulse Width	(Average) X-ray pulse width
113794	Dose Measurement Device	Calibrated device to perform dose measurements.
113795	Acquired Image	Image acquired during a specified event.

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426 # Changes to NEMA Standards Publication PS 3.17-2004

Digital Imaging and Communications in Medicine (DICOM)

428 # Part 17: Explanatory Information

Item #15: Add Radiation Dose Reporting Use Cases Annex

ANNEX XX: RADIATION DOSE REPORTING USE CASES (INFORMATIVE)

XX.1 PURPOSE OF THIS ANNEX

This Annex describes the use of the X-Ray Radiation Dose SR Object. Multiple systems contributing to patient care during a visit may expose the patient to irradiation during diagnostic and/ or interventional procedures. Each of those equipments may record the dose in an X-Ray Dose Reporting information object. Radiation safety information reporting systems may take advantage of this information and create dose reports for a visit, parts of a procedure performed or accumulation for the patient in total, if information is completely available in a structured content.

XX.2 DEFINITIONS

Irradiation Event

An irradiation event is the occurrence of radiation being applied to a patient in single continuous time-frame between the start (release) and the stop (cease) of the irradiation. The irradiation event is the "smallest" information entity to be recorded in the realm of Radiation Dose reporting. Individual Irradiation Events are described by a set of accompanying physical parameters that are sufficient to understand the "quality" of irradiation that is being applied. This set of parameters may be different for the various types of equipment that are able to create irradiation events. Any on-off switching of the irradiation source during the event is not treated as separate events, rather the event includes the time between start and stop of irradiation as triggered by the user. E.g., a pulsed fluoro X-Ray acquisition is treated as a single irradiation event.

Irradiation events include all exposures performed on X-Ray equipment, independent of whether a DICOM Image Object is being created. That is why an irradiation event needs to be described with sufficient attributes to exchange the physical nature of irradiation applied.

Accumulated Dose Values

Accumulated Dose Values describe the integrated results of performing multiple irradiation events. The scope of accumulation is typically a study or a performed procedure step.

XX.3 USE CASES

The following use cases illustrate the information flow between participating roles and the possible capabilities of the equipment that is performing in those roles. Each case will include a use case diagram and denote the integration requirements. The diagrams will denote actors (persons in role or other systems involved in the process of data handling and/or storage). Furthermore, in certain cases it is assumed that the equipment (e.g. Acquisition Modality) is capable of displaying the contents of any dose reports it creates.

These use cases are only examples of possible uses for the Dose Report, and are by no means exhaustive.

XX.3.1 Basic Dose Reporting

This is the basic use case for electronic dose reporting. See Figure XX.3-1

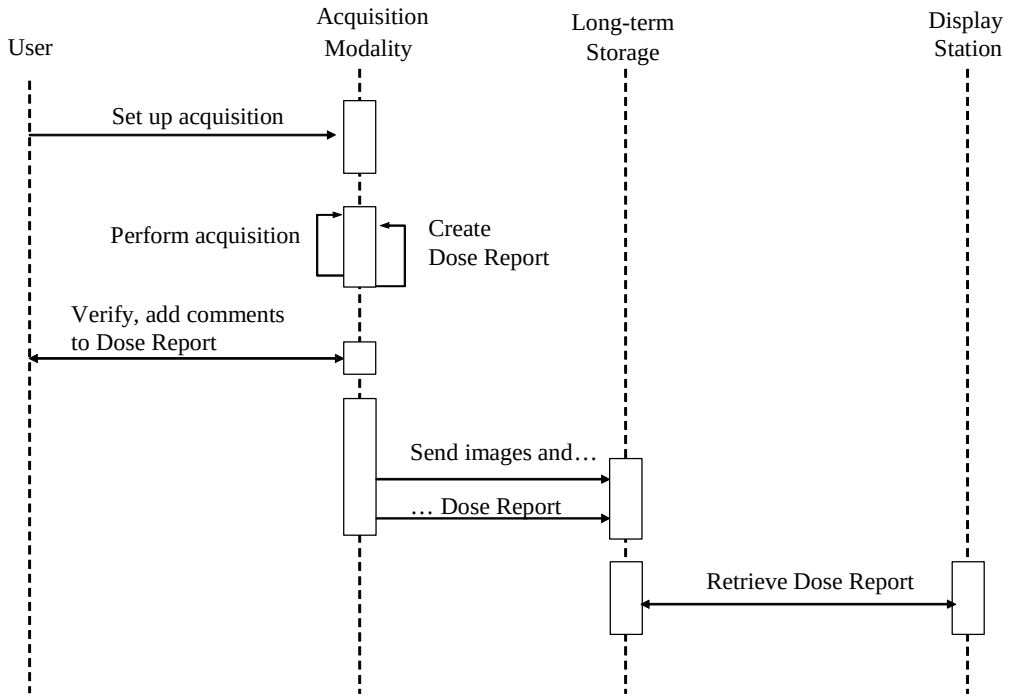

Figure XX.3-1 Basic Dose Reporting

In this use case the user sets up the Acquisition Modality, and performs the study. The Modality captures the irradiation event exposure information, and encodes it together with the accumulated values in a Dose Report. The Modality may allow the user to review the dose report, and to add comments. The acquired images and Dose Report are sent to a Long-Term Storage system (e.g., PACS) that is capable of storing Dose Report objects.

A Display Station may retrieve the Dose Report from the Storage system, and display it. Because the X-Ray Radiation Dose SR object is a proper subset of the Enhanced SR object, the Display Station may render it using the same functionality as used for displaying any Enhanced SR object.

XX.3.2 Dose Reporting for Non-Digital Imaging

The Dose Report may also be used for image acquisitions using non-digital Acquisition Modalities. See Figure XX.3-2.

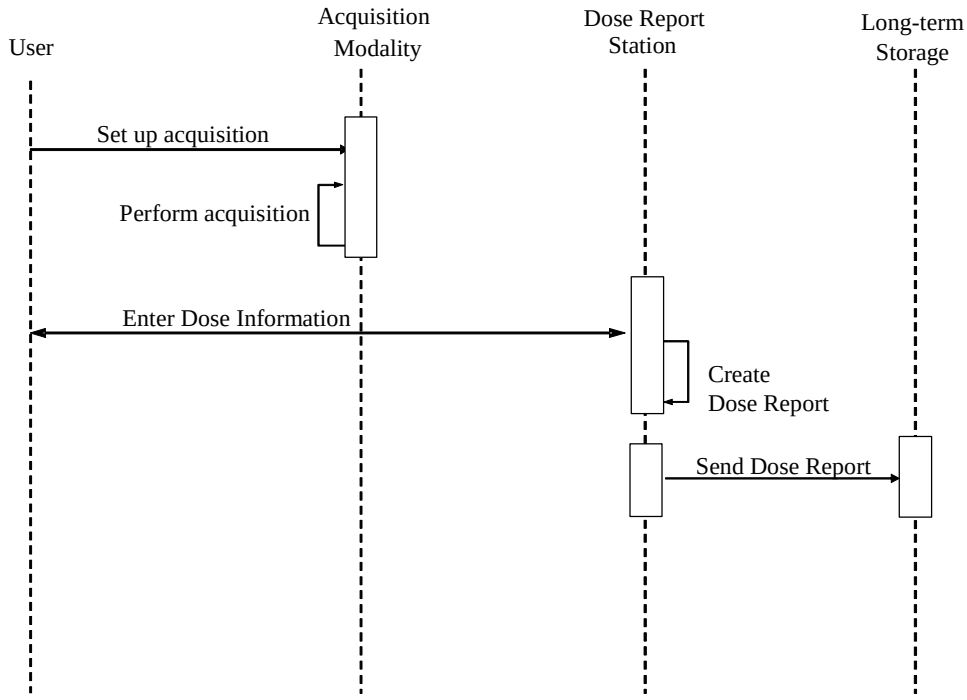

Figure XX.3-2 Dose Reporting for Non-Digital Imaging

In this use case the user may manually enter the irradiation event exposure information into a Dose Reporting Station, possibly transcribing it from a dosimeter read-out display. The station encodes the data in a Dose Report and sends it to a Storage system. The same Dose Reporting Station may be used to support several acquisition modalities.

This case may be useful in film-only radiography environments, or in mixed film and digital environments, where the DICOM X-Ray Radiation Dose SR Object provides a standard format for recording and storing irradiation events.

Note that in a non-PACS environment, the Dose Reports may be sent to a Long-Term Storage function built into a Radiation Safety workstation or information system.

XX.3.3 Dose Reporting Post-Processing

A specialized Radiation Safety workstation the may contribute to the process of dose reporting in terms of more elaborate calculations or graphical dose data displays, or by aggregating dose data over multiple studies. See Figure XX.3-3. The Radiation Safety workstation may or may not be integrated with the Long-Term Storage function in a single system; such application entity architectural decisions are outside the scope of DICOM, but DICOM services and information objects do facilitate a variety of possible architectures.

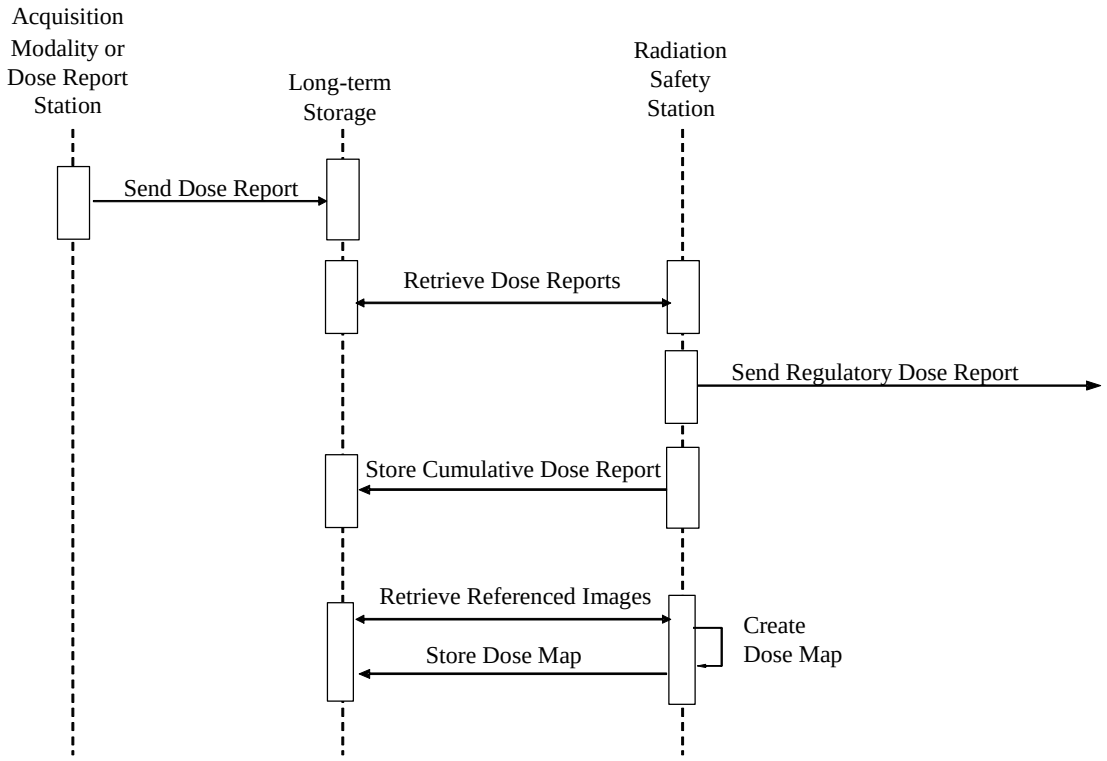

Figure XX.3-3 Dose Reporting Post-Processing

The Radiation Safety workstation may be able to create specific reports to respond to dose registry requirements, as established by local regulatory authorities. These reports would generally not be in DICOM format, but would be generated from the data in DICOM X-Ray Radiation Dose SR objects.

The Radiation Safety workstation may also be used to generate more elaborate reports on patient applied dose. The workstation may retrieve the Dose Reports for multiple procedures performed on a particular patient. A report of the cumulative dose for a specified time period, or for a visit/admission, may be generated, encoded as a DICOM Dose Report, and stored in the Long-Term Storage system. Any such further reports will be stored in addition to the “basic report”.

Note that such cumulative Dose Reports may describe irradiation events that are also documented in other Dose Reports. The assignment of a UID to each irradiation event allows the application to identify unique irradiation events that may be reported in multiple objects. The structure of the X-Ray Radiation Dose SR object also allows a cumulative report to reference the contributing report objects using the Predecessor Documents Sequence (0040,A360) attribute.

An advanced application may be able to use the Dose Report data, potentially supplemented by the data in the image objects referenced in the Dose Report, to create a Dose Map that visualizes applied dose. Such a Dose Map may be sent to the Long-Term Storage system using an appropriate object format.

Other purposes of the Radiation Safety workstation may include statistical analyses over all Dose Report Objects in order to gain information for educational or quality control purposes. This may include searches for Reports performed in certain time ranges, or with specific equipment, or using certain protocols.

XX.3.4 Dose Reporting Workflow Management

The dose reporting workflow may be managed using the same DICOM services used for managing the imaging workflow. These services include Modality Worklist (MWL) and Performed Procedure Step

(MPPS), and General Purpose Worklist (GP-WL), Scheduled Procedure Step (GP-SPS), and Performed Procedure Step (GP-PPS) services.

In particular, a Dose Report produced for an Acquisition Modality Performed Procedure Step can be identified in the MPPS Referenced Non-Image Composite SOP Instance Sequence (0040,0220). Dose Report post-processing tasks may be scheduled and monitored using the GP-WL, GP-SPS, and GP-PPS services.