IHE-Radiation Oncology
Technical Framework Supplement

Supplement Proposal for Dose Compositing

Draft

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This is a supplement to the IHE-Radiation Oncology Technical Framework V3.x.

It is submitted for Public Comment between January 26, 2010 and February 26, 2010. Comments shall be submitted within that period to http://forums.rsna.org:

1. Select the "IHE" forum
2. Select Radiation Oncology Technical Framework
3. Select 2009 IHE-RO Supplements for Public Comment
4. Select Dose Composting

Please use the Public Comment Template provided there when starting your New Thread.

Details about IHE may be found at: www.ihe.net

Details about the IHE Radiation Oncology Domain may be found at:
http://www.ihe.net/Domains/index.cfm

Details about the structure of IHE Technical Frameworks and Supplements may be found at: http://www.ihe.net/About/process.cfm and http://www.ihe.net/profiles/index.cfm

The current version of the IHE Radiation Oncology Technical Framework may be found at:. http://www.ihe.net/Technical_Framework/index.cfm

These "boxed" instructions are for the author to indicate to the Volume Editor how to integrate the relevant section(s) into the overall Technical Framework

Replace Section X.X by the following:

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Introduction

This supplement defines the relevant standards and constraints on those standards needed to implment interoperable transfer of spatially related dose information between systems.

Profile Abstract

In the present context, the term *Dose Compositng* is used to denote the process of combining information from two spatially-related 3-D dose (matrices). Two use cases are supported by this profile. The first use case (*Registered Dose Compositor*) involves accepting two dose instances and a spatial registration instance and combining the spatially-registered doses to produce a new dose instance. The second use case (*Compositing Planner*) involves accepting a (prior) dose instance and a spatial registration instance and creating a new treatment plan and dose instance(s) based on the prior dose.

Open Issues and Questions

Closed Issues

1. Is an RT Plan Instance needed to accompany an RT Dose either for the source or result of dose compositing? NO.

2. How are composite dose instance identified? See DICOM CP_938 (LB Mar 09) – Adds Dose Summation Type = (3004,000a) = MULTI_PLAN and allows multiple values in Referenced RT Plan Sequence (300c,0002)

    a. A Dose Reference Plan is not needed.

    b. If any of the summed plans is a Dosimetric Plan, the first item in the Referenced RT Plan Sequence must be a Dosimetric Plan (for legacy Dose Viewers)

3. Can the Dose Compositor *scale* constituent RT Doses? Yes: document scaling in Dose Comment

4. Need **new Composite Dose Viewer** to support composite RT Dose, i.e. with Dose Summation Type = MULTI_PLAN and multiple values in Referenced RT Plan Sequence

5. RT Dose IOD Attribute Requirements for Composite Dose

    a. **Dose Type**: If *any* contributing dose has Dose Type = EFFECTIVE, the Composite Dose must have Dose Type = EFFECTIVE.

    b. **Dose Summation Type:** Composite Dose has Dose Summation Type = MULTI_PLAN (see CP_938)

    c. **Referenced RT Plan Sequence:** Composite Dose has Referenced RT Plan Sequence containing SOP Instance Macro references to each constituent RT Plan.

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If any of the summed plans is a Dosimetric Plan, the first item in the Referenced RT Plan Sequence must be a Dosimetric Plan (for legacy Dose Viewers)

    d. **Tissue Heterogeneity Correction**: has items representing all tissue heterogeneity correction techniques used in computing all constituent doses.

6. The *Composite Dose Viewer* extends the *Registered Dose Display Actor:* do we need an extended version of the *Dose Viewer Actor* (without registration)? Per 7/9/09 TC T-con: Re-cast the *Composite Dose Viewer* as two Actors, one with optional spatial registration, and one without registration: [Done, now have *General Dose Viewer and Registered General Dose Viewer*, 11/7/2009]

    a. *Composite Dose Viewer*: accepts Modality Image, RT Structure Set, Composite Dose – displays composite dose (requires that composite dose, images, and structure set share the same frame of reference)

    b. *Registered Composite Dose Viewer*: accepts Modality Image(s), Registered RT Structure Set, Composite Dose, Spatial Registration – displays composite doses registered to image/structure set frame of reference

7. (7/9/09) Change *Compositing Dosimetric Planner* to *Compositing Planner* to de-couple specifications of dose compositing and planning. Thus, it is expected that a product might behave as both an *Advance RT Objects Plan Producer* and a *Compositing Planner*. The *Compositing Planner Actor* does the following: [Done, with slight mods, 11/7/2009]

    a. Retrieve (Composite) Dose [RO-DC3], Spatial Registration [RO-13] objects

    b. Compute new composite dose matrix using retrieved dose and internal (Plan) doses.

    c. Store Composite Dose [RO-DC2]

8. What, if any, options should be specified for the actors? [None so far]

9. Discussion of Dose Compositing Actors Supplement at IHE-RO Techincal Committee meeting 9/20/09: [Done, changes made as needed, 11/7/2009]

    a. Check Transactions with respect to IHE-RO Profile v. 3.1

    b. Require Dose Compositor and Compositing Planner to support multiple prior doses

    c. Allow scaling (for RBE, delivered fractions, etc.) of (prior) doses

    d. Need to define Dose Producer Actor (specifies requirements for dose accepted by other compositing actors)

Volume 1 – Integration Profiles

Glossary

Add the following terms to the Glossary:

<any glossary additions associated with the profile draft go here>

1.7 History of Annual Changes

<Brief overview of "what's new" in the given year of the Technical Framework.>

Add the following bullet to the end of the bullet list in section 1.7

- Added the XYZ Profile which does blah, blah, blah…..

2.1 Dependencies among Integration Profiles

Add the following to Table 2-1

Dose Compositing Profile	<?>	<?>	<->

Add the following section to section 2.2

2.2.X Radiation Oncology Dose Compositing Integration Profile

This supplement defines the relevant standards and constraints on those standards needed to implement interoperable transfer of spatially-related dose information between systems for the purpose of combining or *compositing* radiation doses. In this context, the term *Dose Compositng* is used to denote the process of combining information from two or more spatially-related 3-D dose matrices for a patient, where the dose matrices are encoded as DICOM RT Dose instances. The spatial relationship between doses is defined by the rigid transformation encoded in a DICOM Spatial Registration object. (Affine and deformable registrations are not supported by this profile.) The process of combining two or more 3-D dose matrices may involve resampling of the dose array or scaling of dose values as needed to account for differing fractionation and radiation type.

Add Section X

X. Radiation Oncology Dose Compositing Integration Profile

This supplement defines the relevant standards and constraints on those standards needed to implement interoperable transfer of spatially-related dose information between systems for the

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purpose of combining or *compositing* radiation doses. In this context, the term *Dose Compositng* is used to denote the process of combining information from two or more spatially-related 3-D dose matrices for a patient, where the dose matrices are encoded as DICOM RT Dose instances. The spatial relationship between doses is defined by the rigid transformation encoded in a DICOM Spatial Registration object. (Affine and deformable registrations are not supported by this profile.) The process of combining two 3-D dose matrices may involve resampling, scaling, or transformations needed to account for differing fractionation and radiation type.

Two distinct Use Cases are supported by this profile. Both involve accepting one or more "prior" dose matricies, each defined in its own frame of reference, as well as Spatial Registration object(s) relating those frames of reference to a second "destination" frame of reference. In the first Use Case, the *Registered Dose Compositor Actor* combines two or more, spatially-related dose instances to produce an output dose instance in the destination frame of reference. In the second Use Case, the *Compositing Planner Actor* uses one or more dose instances as the basis ("prior dose") for creating a new treatment plan and dose instances. Dose objects accepted by the *Registered Dose Compositor* and *Compositing Planner Actors* are those stored by the *Single Plan Dose Producer* or the *Compositing Planner* actors.

In addition, the profile defines two dose viewer actors to permit display of single plan or composite doses without requiring an accompanying plan instance. The *General Dose Viewer Actor* retrieves and displays Modality Image(s), RT Structure Set, and a General Dose. It requires that dose, images, and structure set share the same frame of reference. The *Registered General Dose Viewer Actor* retrieves Modality Image(s), Registered RT Structure Set, General Dose, and Spatial Registration. It displays doses registered to the image/structure set frame of reference.

X.1 Actors/ Transactions

The Dose Compositing Profile defines five new Actors: a *Registered Dose Compositor Actor*, a *Compositing Planner Actor,* a *Single Plan Dose Producer Actor,* a *General Dose Viewer Actor,* and a *Registered General Dose Viewer Actor*. All transactions are between these actors and an *Archive Actor*. Four new transactions are defined in this profile: Single Plan Dose Storage [RO-DC3], General Dose Retrieval [RO-DC1], and Composite Dose Storage [RO-DC2].

The *Registered Dose Compositor Actor* retrieves one or more prior General Dose instances [RO-DC1] and a subsequent General Dose instance [RO-DC1], as well as spatial registration instances representing the spatial relationship between each of the prior dose instances and the subsequent dose instance from an *Archive* [RO-13]**.** It combines the spatially-registered doses to produce a new dose instance that represents the composite dose and stores this new instance [RO-DC2] to the *Archive.*

The *General Dose Viewer Actor* is an extension of the *Dose Display Actor.* This actor retrieves Modality Images [RAD 4.8], an RT Structure Set [RO-7], and a General Dose instance [RO-

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DC1]. It presents a registered display of images, structures, and dose. It requires that the images, structure set, and dose it displays share a common frame of reference.

The *Registered General Dose Viewer Actor* retrieves Modality Images [RAD 4.8], a Registered Structure Set [RO-15], a General Dose instance [RO-DC1] and a spatial registration instance [RO-13] relating the dose to to the image series frame of reference. It presents a registered display of images, structures, and dose.

The *Compositing Planner Actor* retrieves General Dose [RO-DC1] and Spatial Registration [RO-13] objects, computes a new composite dose matrix using retrieved dose and an internal (plan) dose, and stores Composite Dose [RO-DC2]. Details regarding the retrieval and storage of data objects used to create the internal dose and is out of band for this profile.

The *Single Plan Dose Producer Actor* creates and stores Single Plan Dose instances [RO-DC3] in an *Archive*. Details regarding the process used to create this dose matrix are out of band for this profile. This actor is included to specify the requiremets for Single Plan Dose instances used by the *Registered Dose Compositor* and *Compositing Planner Actors.*
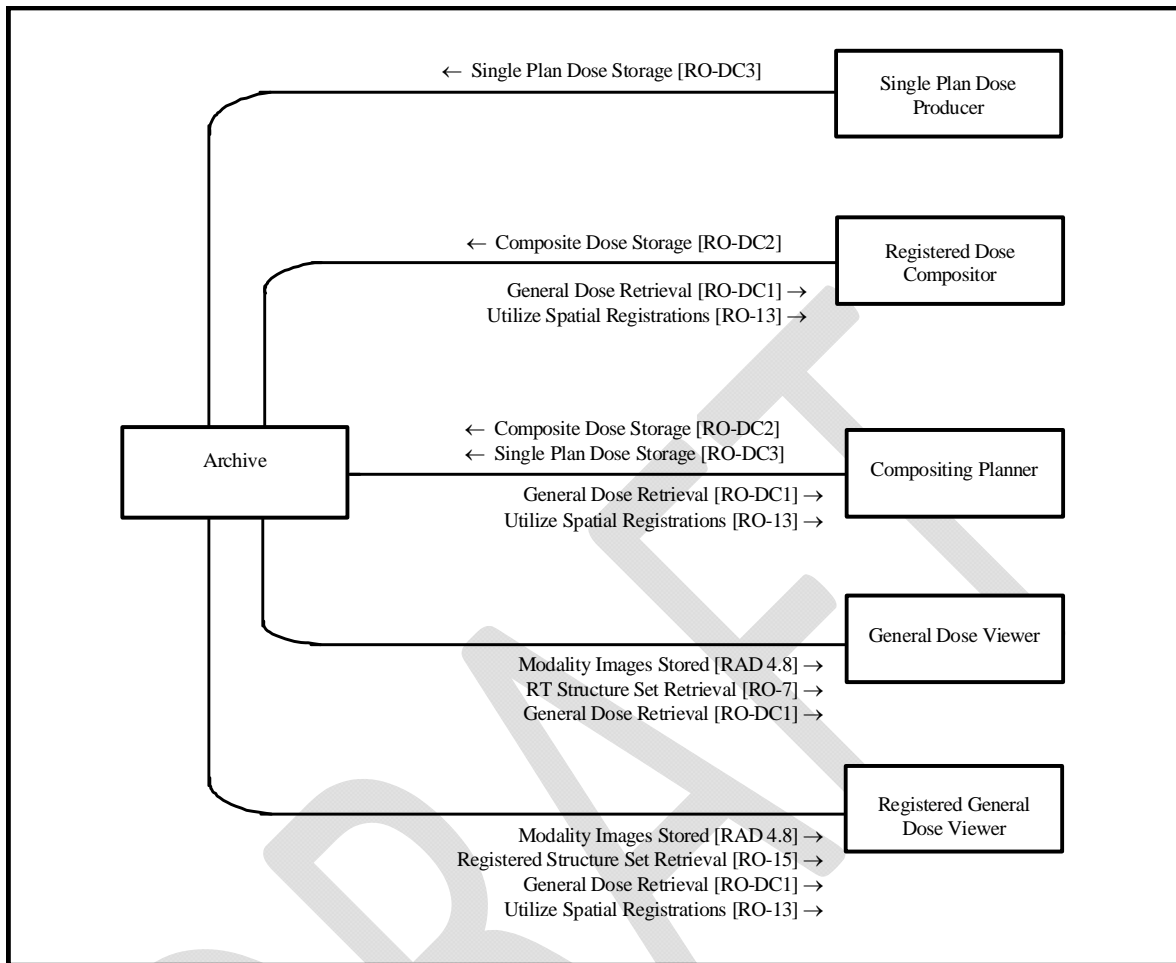
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Figure X.1-1. Radiation Oncology Dose Compositing Profile Actor/Transaction Diagram

Figure X.1-1 shows the actors directly involved in the Dose Compositing Integration Profile and the relevant transactions between them. Other actors that may be indirectly involved due to their participation in the Basic Treatment Planning Profile and Spatial Registration Profile, etc. are not shown.

Table X.1-1 lists the transactions for each actor directly involved in the Dose Compositing Profile. In order to claim support of this Integration Profile, an implementation must perform the required transactions (labeled "R"). Transactions labeled "O" are optional. A complete list of options defined by this Integration Profile and that implementations may choose to support is listed in Volume I, Section X.2.

Table X.1-1. Dose Compositing Integration Profile - Actors and Transactions

Actors	Transactions	Optionality	Section in Vol. 2
Registered Dose Compositor	Utilize Spatial Registrations [RO-13]	R	?
	Single Plan Dose Retrieval [RO-DC1]	R	?
	Composite Dose Storage [RO-DC2]	R	?
Compositing Planner	Single Plan Dose Retrieval [RO-DC1]	R	?
	Utilize Spatial Registrations [RO-13]	R	?
	Simple Dose Storage [RO-DC3]	R	?
	Composite Dose Storage [RO-DC2]	R	?
General Dose Viewer	Modality Images Stored [RAD 4.8]	R	?
	RT Structure Set Retrieval [RO-7]	R	?
	General Dose Retrieval [RO-DC1]	R	?
Registered General Dose Viewer	Modality Images Stored [RAD 4.8]	R	?
	Registered Structure Set Retrieval [RO-15]	R	?
	General Dose Retrieval [RO-DC1]	R	?
	Utilize Spatial Registrations [RO-13]	R	?
Single Plan Dose Producer	Single Plan Dose Storage [RO-DC3]	R	?
Archive	Structure Set Retrieval [RO-7]	R	?
	Registered Structure Set Retrieval [RO-15]	R	?
	Modality Images Stored [RAD 4.8]	R	?
	Utilize Spatial Registrations [RO-13]	R	?
	Single Plan Dose Storage [RO-DC3]	R	?
	General Dose Retrieval [RO-DC1]	R	?
	Composite Dose Storage [RO-DC2]	R	?

X.2 Radiation Oncology Dose Compositing Integration Profile Options

<Table describing the options available for this integration profile and references to all sections that state requirements for compliance to the Option.>

Options that may be selected for this Integration Profile are listed in the table X.2-1 along with the Actors to which they apply. Dependencies between options when applicable are specified in notes.

Table X.2-1 Dose Compositing Integration Profile - Actors and Options

Actor	Options	Vol & Section

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Actor	Options	Vol & Section
Registered Dose Compositor	*No options defined*	- -
Compositing Planner	*No options defined*	- -
Composite Dose Viewer	*No options defined*	- -
Registered Composite Dose Viewer	*No options defined*	- -
Single Plan Dose Producer	*No options defined*	- -
Archive	*No options defined*	- -

X.3 Radiation Oncology Dose Compositing Process Flow
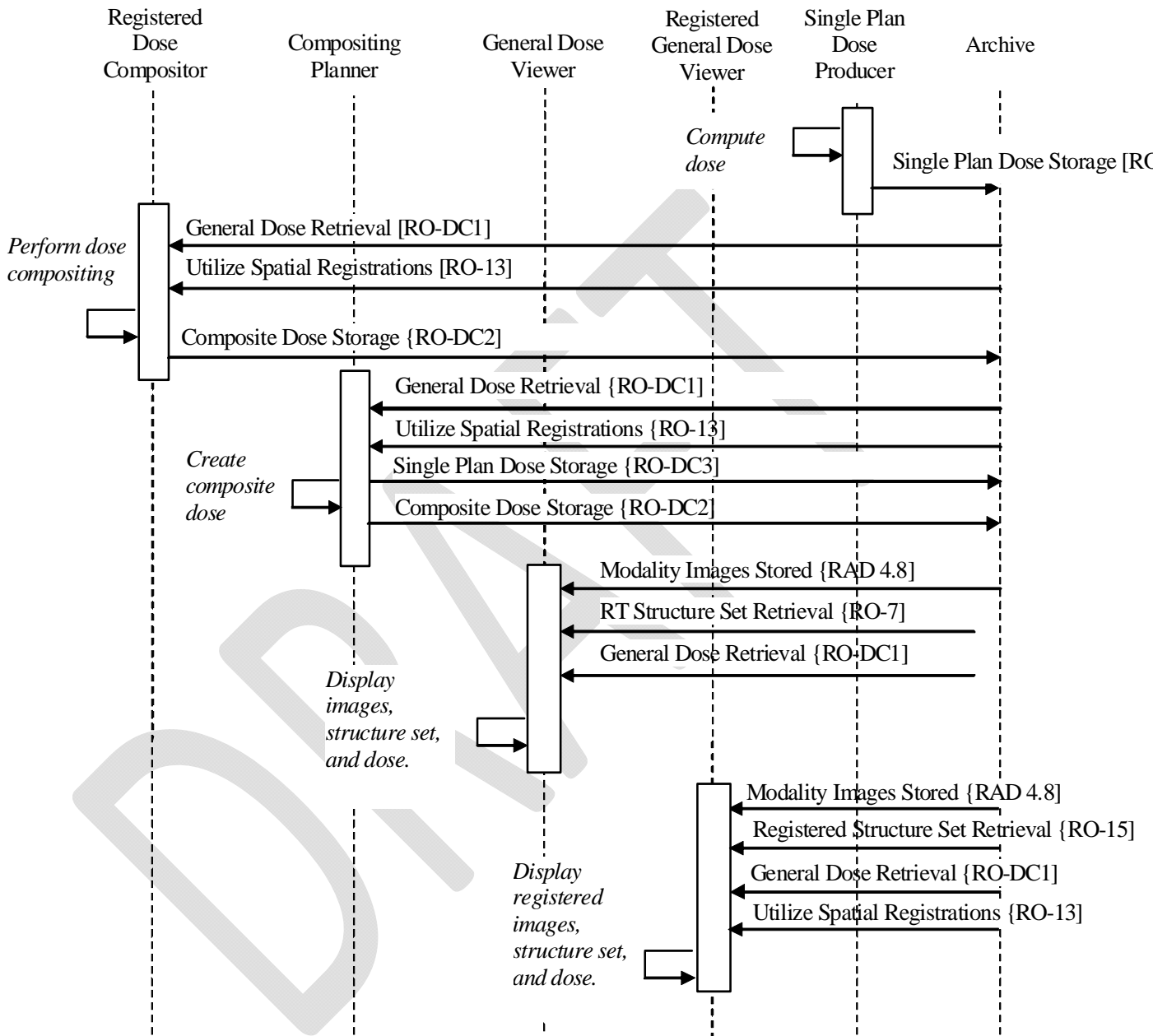
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Figure X.2-1. Basic Process Flow in Radiation Oncology Dose Compositing Profile

X.4 Radiation Oncology Dose Compositing Security Considerations

<Description of the Profile specific security considerations. This should include the outcomes of a risk assessment. This likely will include profile groupings, and residual risks that need to be assigned to the product design, system administration, or policy.>

Volume 2 - Transactions
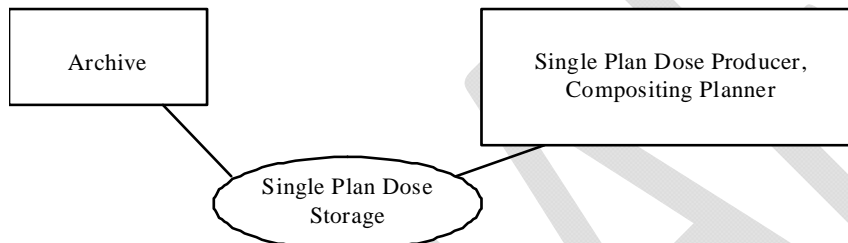
Add section 3.Y

3.W Single Plan Dose Storage [RO-DC3]

This section corresponds to Transaction RO-DC3 of the IHE Technical Framework. Transaction RO-DC3 is used by the ***Single Plan Dose Producer***, ***Compositing Planner***, and ***Archive*** actors.

3.W.1 Scope

In the Single Plan Dose Storage Transaction, the relevant actor stores an RT Dose instance on an Archive to make it available.

3.W.2 Use Case Roles

Actor: *Single Plan Dose Producer*

Role: Transmit RT Dose instance to Archive

Actor: *Compositing Planner*

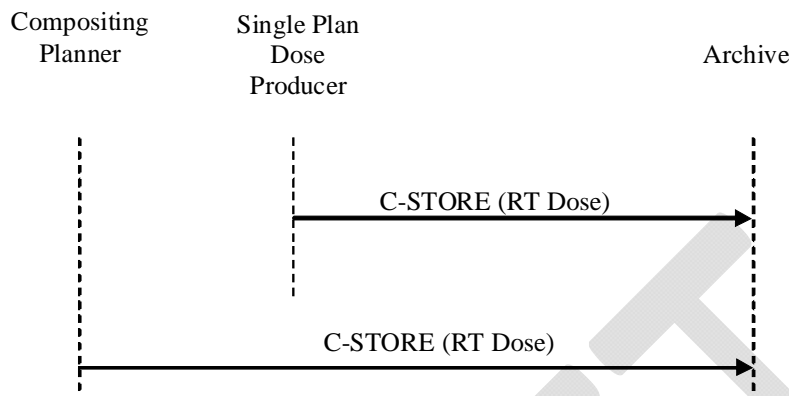**Role:** Transmit RT Dose instance to Archive

Actor: *Archive*

Role: Receives and stores RT Dose instance from ***Single Plan Dose Producer and Compositing Planner***

3.W.3 Referenced Standard

DICOM 2008 PS 3.4: Storage Service Class

3.W.4 Interaction Diagram

3.W.4.1 Single Plan Dose Storage

3.W.4.1.1 Trigger Events

The user of the *Single Plan Dose Producer* or a *Compositing Planner* requests that a Single Plan dose instance be stored.

3.W.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The *Single Plan Dose Producer* or the *Compositing Planner* is the storage SCU and the *Archive* is the storage SCP.

This transaction shall support Dose represented as a three-dimensional dose array sampled onto axial image planes in the same DICOM Patient coordinate system Frame of Reference as the images used to compute it. The dose image shall be orthogonal with respect to the DICOM patient coordinate system: the value of Image Orientation (Patient) (0020,0037) shall be [$\pm$1, 0, 0, 0, $\pm$1, 0], within an uncertainty of 0.001 Radians. Dose Planes may be irregularly spaced, and they need not correspond to image planes.

Not supported are point doses, projection of dose onto an oblique plane, iso-dose contours and dose-volume histograms. The Dose Summation Type (3004,000A) shall be PLAN. The Dose Type (3004,0004) shall be either PHYSICAL or EFFECTIVE. The value of Dose Units (3004,0002) shall be GY. The value of Pixel Representation (0016,0103) shall be 0; negative dose values shall not be present.

The following table shows the IHE extension of the DICOM requirements for the RT Dose

Table W-1 Required Attributes for RT Dose Module

Attribute	Tag	Type	Attribute Description

Dose Units	(3004,0002)	R+	Shall be GY
Dose Type	(3004,0004)	R+	Shall be either PHYSICAL or EFFECTIVE.
Dose Summation Type	(3004,000A)	R+	Shall be PLAN
Pixel Representation	(0016,0103)	R+	Shall be 0.
Tissue Heterogeneity Correction	(3004,0014)	R+	Shall be present. Multi-valued attrubute has items representing tissue heterogeneity correction techniques corresponding to contributing entries in the Referenced RT Plan Sequence.

3.W.4.1.3 Expected Actions

Upon receipt of the Single Plan Dose instance, the *Archive* shall store it. This Single Plan Dose instance is then available for subsequent retrieval (RO-DC1).
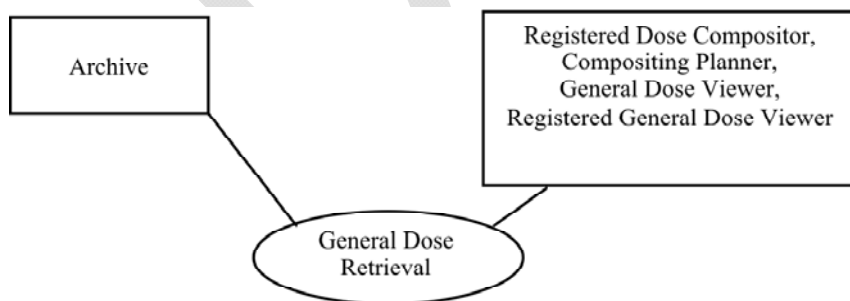
3.X General Dose Retrieval [RO-DC1]

This section corresponds to Transaction RO-DC1 of the IHE Technical Framework. Transaction RO-DC1 is used by the *Registered Dose Compositor*, *Compositing Planner*, *General Dose Viewer*, *Registered General Dose Viewer*, and *Archive* actors.

3.X.1 Scope

In the General Dose Retrieval Transaction, the *Archive* stores an RT Dose instance on the relevant actor to make it available for use in dose compositing and viewing.

3.X.2 Use Case Roles

Actor: *Archive*

Role: Sends RT Dose instance to the *Registered Dose Compositor, Registered General Dose Viewer, General Dose Viewer* or *Compositing Planner*
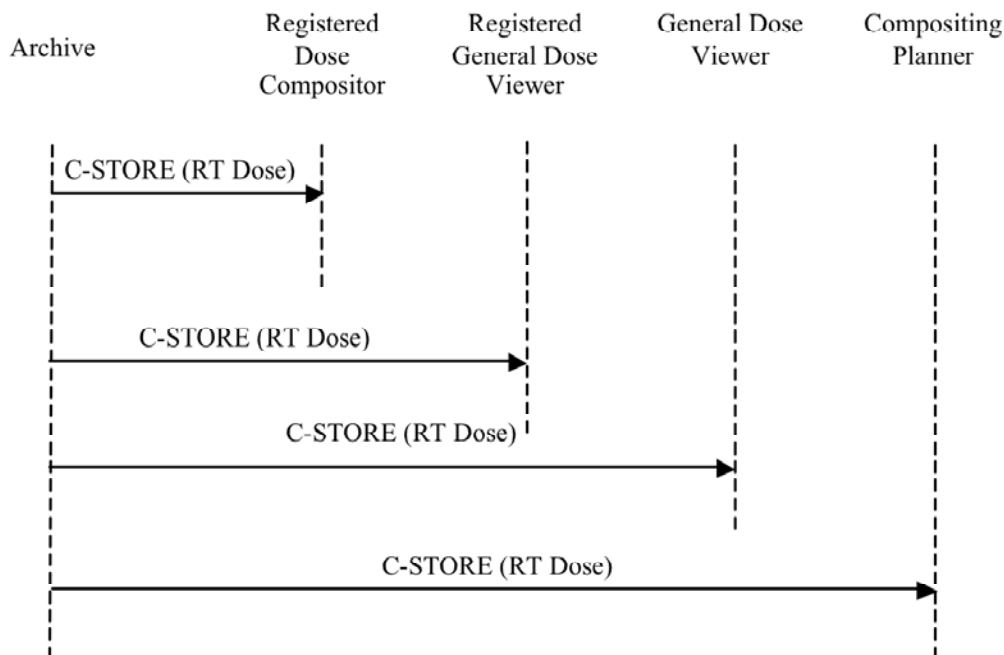
Actor: *Registered Dose Compositor, Compositing Planner, General Dose Viewer, Registered Dose Viewer*

Role: Stores RT Dose instance received from the *Archive*

3.X.3 Referenced Standard

DICOM 2008 PS3.4: Storage Service Class.

3.X.4 Interaction Diagram

3.X.4.1 Dose Retrieval

3.X.4.1.1 Trigger Events

The user of the ***Registered Dose Compositor, Registered General Dose Viewer, General Dose Viewer*** or ***Compositing Planner*** determines that a General Dose instance is needed for computing a composite dose or dose viewing.

The mechanism(s) by which these transfers are initiated is outside the scope of this profile.

3.X.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Archive*** is the SCU of this service class, and the ***Registered Dose Compositor, Registered General Dose Viewer, General Dose Viewer*** or ***Compositing Planner*** is the SCP of this service Class.

This transaction shall support Dose represented as a three-dimensional dose array sampled onto axial image planes in the same DICOM Patient coordinate system Frame of Reference as the diagnostic images used to compute it. The dose image shall be orthogonal with respect to the DICOM patient coordinate system: the value of Image Orientation (Patient) (0020,0037) shall be [± 1, 0, 0, 0, ± 1, 0], within an uncertainty of 0.001 Radians. Dose Planes may be irregularly spaced, and they need not correspond to image planes.

Not supported are point doses, projection of dose onto an oblique plane, iso-dose contours and dose-volume histograms. The Dose Summation Type (3004,000A) shall be PLAN or MULTI_PLAN. The Dose Type (3004,0004) shall be either PHYSICAL or EFFECTIVE. The value of Dose Units (3004,0002) shall be GY. The value of Pixel Representation (0016,0103) shall be 0; negative dose values shall not be present.

Table X-1 Expected Attributes for RT Dose Module

Attribute	Tag	Type	Attribute Description
Dose Units	(3004,0002)	R+	Shall be GY
Dose Type	(3004,0004)	R+	Shall be either PHYSICAL or EFFECTIVE.
Dose Summation Type	(3004,000A)	R+	Shall be PLAN or MULTI_PLAN
Pixel Representation	(0016,0103)	R+	Shall be 0.
Tissue Heterogeneity Correction	(3004,0014)	R+	Shall be present. Multi-valued attrubute has items representing tissue heterogeneity correction techniques corresponding to contributing entries in the Referenced RT Plan Sequence.

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3.X.4.1.3 Expected Actions

Upon receiving the request for retrieval, the **Archive** shall return the requested General Dose to the relevant actor. The actor shall validate the received Dose. If the received Dose is valid, it shall be loaded in the relevant actor. If it is not valid, a warning message shall be displayed to the user, indicating the reason why it is not valid.
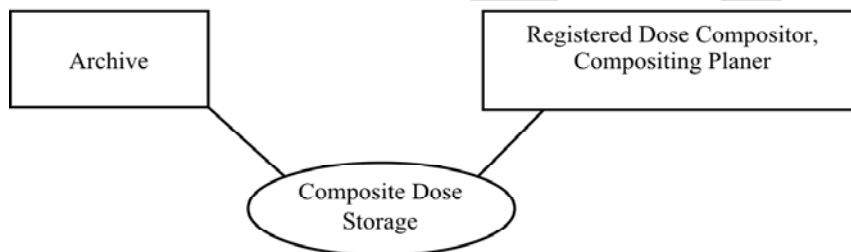
3.Y Composite Dose Storage [RO-DC2]

This section corresponds to Transaction RO-DC2 of the IHE Technical Framework. Transaction RO-DC2 is used by the *Registered Dose Compositor*, *Compositing Planner* and *Archive* actors.

3.Y.1 Scope

In the Composite Dose Storage Transaction, the *Registered Dose Compositor* and *Compositing Planner* actors store an RT Dose instance on an *Archive* to make it available.

3.Y.2 Use Case Roles

Actor: *Registered Dose Compositor, Compositing Planner*

Role: Transmit RT Dose instance to *Archive*
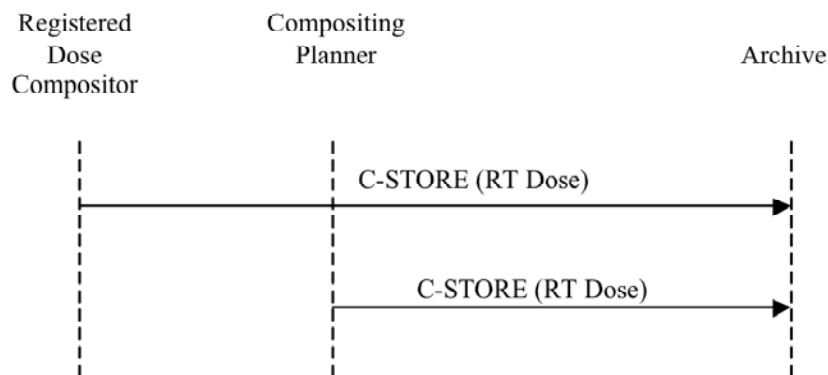
Actor: Archive

Role: Receives and stores RT Dose instance from *Registered Dose Compositor, Compositing Planner*

3.Y.3 Referenced Standard

DICOM 2008 PS 3.4: Storage Service Class

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3.Y.4 Interaction Diagram

3.Y.4.1 Composite Dose Storage

3.Y.4.1.1 Trigger Events

The user of the ***Registered Dose Compositor*** or ***Compositing Planner*** requests that a composite dose be stored.

3.Y.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Registered Dose Compositor*** or ***Compositing Planner*** is the storage SCU and the Archive is the storage SCP.

The composite dose to be stored must be represented as a multi-frame grid-based RT Dose instance. Dose Summation Type (3004,000A) must be MULTI_PLAN and entries of the Referenced RT Plan Sequence (300C,0002) must reference the RT Plan or RT Ion Plan instance(s) associated with the doses used to compute the composite dose. If any of the summed plans is a Dosimetric Plan, the first item in the Referenced RT Plan Sequence must be a Dosimetric Plan (for legacy Dose Viewers).

This transaction shall support Dose represented as a three-dimensional dose array sampled onto axial image planes in the same DICOM Patient coordinate system Frame of Reference as the diagnostic images used to compute it. The dose image shall be orthogonal with respect to the DICOM patient coordinate system: the value of Image Orientation (Patient) (0020,0037) shall be [±1, 0, 0, 0, ±1, 0], within an uncertainty of 0.001 Radians. Dose Planes may be irregularly spaced, and they need not correspond to image planes.

Not supported are point doses, projection of dose onto an oblique plane, iso-dose contours and dose-volume histograms. The Dose Summation Type (3004,000A) shall be MULTI_PLAN. The value of Dose Units (3004,0002) shall be GY. The value of Pixel Representation (0016,0103) shall be 0; negative dose values shall not be present.

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The following table shows the IHE extension of the DICOM requirements for the RT Dose

Table 0-1 Required Attributes for RT Dose Module

Attribute	Tag	Type	Attribute Description
Dose Units	(3004,0002)	R+	Shall be GY
Pixel Representation	(0016,0103)	R+	Shall be 0.
Dose Type	(3004,0004)	R+	If *any* contributing dose has Dose Type = EFFECTIVE, the composite dose must have Dose Type = EFFECTIVE
Dose Summation Type	(3004,000A)	R+	Must be MULTI_PLAN (see DICOM CP 938)
Referenced RT Plan Sequence	(300C,0002)	R+	Must reference the RT Plan or RT Ion Plan instance(s) associated with composited doses. If any of the summed plans is a Dosimetric Plan, the first item in the Referenced RT Plan Sequence must be a Dosimetric Plan.
Tissue Heterogeneity Correction	(3004,0014)	R+	Shall be present. Multi-valued attrubute has items representing tissue heterogeneity correction techniques corresponding to contributing entries in the Referenced RT Plan Sequence.

3.Y.4.1.3 Expected Actions

Upon receipt of the Composite Dose, the Archive shall store it. This Composite Dose is then available for subsequent retrieval (RO-DC1).

<Appendix letter> Appendix_Name

<Detailed cross transaction relationships or mapping details are described in an appendix in Volume 2>

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