Integrating the Healthcare Enterprise

IHE Radiation Oncology Technical Framework

Volume II (RO TF-2)

Revision 1.7 – Final Text
9 May, 2011

Contents

1 Introduction

Integrating the Healthcare Enterprise® (IHE) is an initiative designed to advance the integration of the health information systems. Its fundamental objective is to ensure that in the care of patients all required information for medical decisions is available to authorized healthcare professionals.

IHE is both a process and a forum for encouraging integration efforts. It defines technical frameworks for the implementation of established standards to achieve specific clinical goals. It includes a rigorous testing process for systems implementing this framework. And it organizes educational sessions and exhibits at major meetings of medical professionals to demonstrate the benefits of these frameworks and encourage their adoption by developers and users of health information systems.

IHE International, the organization overseeing development of the IHE Technical Frameworks is sponsored by the Healthcare Information and Management Systems Society (HIMSS) and the Radiological Society of North America (RSNA). The following organizations are responsible for sponsoring development activities in their respective domains:

- Anatomic Pathology - Association pour le Developpement de l'Informatique en Anatomie et Cytologie Pathologique (ADICAP)/ Groupement pour la Modernisation du Système d'Information Hospitalier (GMSIH)
- Cardiology - American College of Cardiology (currently dormant)
- Eye Care - Academy of American Ophthalmologists
- IT Infrastructure - HIMSS
- Laboratory - GMSIH/ Société Française d'Informatique de Laboratoire (SFIL)
- Patient Care Coordination - American College of Physicians (ACP)/HIMSS
- Patient Care Devices - American College of Clinical Engineering (ACCE)/HIMSS
- Quality, Research and Public Health - American Heart Association, HIMSS, RSNA
- Radiation Oncology - American Society of Radiation Oncology (ASTRO)
- Radiology - RSNA
- Mammography - American College of Radiology (ACR)/RSNA
- Nuclear Medicine - Society of Nuclear Medicine

Other organizations representing healthcare professionals are invited to join in the expansion of the IHE process across disciplinary and geographic boundaries.

1.1 Overview of Technical Framework

The IHE Technical Frameworks are expanded annually, after a period of public review, and maintained regularly through the identification and correction of errata. The IHE Radiation Oncology Technical Framework is maintained by the IHE Radiation Oncology Technical Committee. The current version, rev. 1.6, specifies the IHE transactions defined and implemented as of February, 2007. The latest version of the document is always available at http://www.ihe.net/Technical_Framework/.

The IHE Technical Framework identifies functional components of health information systems, called IHE Actors, and specifies their interactions as coordinated, standards-based transactions. Volume I provides a high-level view of IHE functionality, showing the transactions organized into functional units called Integration Profiles that highlight their capacity to address specific clinical needs. Volumes, II and III, provide detailed technical descriptions of each IHE transaction including the clinical problem it is intended to address and the IHE Actors and transactions it comprises.

The appendices following the main body of the document provide detailed discussion of specific issues related to the integration profiles and a glossary of terms and acronyms used.

Where applicable in these volumes, references are made to Technical Frameworks of other IHE domains. For the conventions used to reference Technical Frameworks from other domains, see Section 1.6.4 in this volume.

1.2 Audience

The intended audience of this document is:

- Technical staff of vendors participating in the IHE initiative
- IT departments of healthcare institutions
- Experts involved in standards development
- Anyone interested in the technical aspects of integrating healthcare information systems

1.3 Relationship to Standards

IHE does not define standards, but rather facilitates the use of existing standards — including HL7, W3C, Web Services, DICOM and others, as appropriate — in an integrated manner by specifying detailed implementations of these standards. When clarifications or extensions to standards are necessary, IHE refers recommendations to the relevant standards bodies.. Vendors who have implemented IHE integration capabilities can use an IHE Integration Statement to describe the conformance of their product to the Actors and Profiles in the IHE Technical Framework. See RAD TF-1: Appendix D for the format of such IHE Integration Statements. IHE encourages implementers to ensure that products implemented in accordance with the IHE Technical Framework also meet the full requirements of the standards underlying IHE. Standards conformance claims should be made in direct reference to the specific standard in question.

1.4 Relationship to Real-world Architectures

The IHE Actors and transactions described in the IHE Technical Frameworks are abstractions of real-world health information systems. The IHE Technical Framework intentionally avoids associating functions or actors with specific product categories. For each actor, the IHE Technical Framework defines only those functions associated with their interactions with other health information systems. The IHE definition of an actor should therefore not be taken as the complete definition of any product that might implement it, nor should the framework itself be taken to comprehensively describe the architecture of a health information system.

IHE takes no position as to the relative merits of an integrated environment based on a single, all-encompassing information system versus one based on multiple systems that together achieve the same end.

1.5 Reserved

1.6 Conventions

This document has adopted the following conventions for representing the framework concepts and specifying how the standards upon which the IHE Technical Framework is based should be applied.

1.6.1 Actor and Transaction Diagrams and Tables

Each integration profile is a representation of a real-world capability that is supported by a set of actors that interact through transactions. Actors are information systems or components of information systems that produce, manage, or act on categories of information required by operational activities in the enterprise. Transactions are interactions between actors that transfer the required information through standards-based messages. The tables of actors and transactions starting with section 3 indicate which transactions each actor in a given profile must support. The convention used in these diagrams is that the arrow indicating the direction for the transaction points from the initiator of the transaction to the destination. In some cases, a profile is dependent on a pre-requisite profile in order to function properly and be useful. For example, Presentation of Grouped Procedures depends on both Scheduled Workflow and Consistent Presentation of Images being implemented as pre-requisites. These dependencies can be found by locating the desired profile in Table 2-1 and seeing which profiles are listed as required pre-requisites. An actor must implement all required transactions in the pre-requisite profiles in addition to those in the desired profile. In some cases, the pre-requisite is that the actor selects any one of a given set of profiles to satisfy the pre-requisite. For example, Post-processing depends on any one of the content profiles being supported.

1.6.2 Process Flow Diagrams

The descriptions of integration profiles that follow include Process Flow Diagrams that illustrate how the profile functions as a sequence of transactions between relevant actors. These diagrams are intended to provide a “big picture” so the transactions can be seen in the context of the overall workflow. Certain transactions and activities not defined in detail by IHE are shown in these diagrams in italics to provide additional context on where the relevant IHE transactions fit into the broader scheme of healthcare information systems. These diagrams are not intended to present the only possible scenario. Often other actor groupings are possible, and complementary transactions from other profiles may be interspersed. In some cases the sequence of transactions may be flexible. Where this is the case there will generally be a note pointing out the possibility of variations.

The convention used in these diagrams is that the arrow on the line for the transaction points from the initiator of the transaction to the destination.

1.6.3 Normative versus informative contents of the Technical Framework

Most parts of the Technical Framework describe required or optional characteristics of Integration Profiles, Actors and Transactions: these are normative. For a better understanding of the text, there also exist illustrating parts in the Technical Framework that are informative and non-normative.

According to IETF RFC 2119, certain words indicate whether a specific content of the Technical Framework is normative: either required (e.g. “must”, “required”, “shall”) or optional (e.g. “may”, “recommended”). Informative content does not contain these key words.

1.6.4 Technical Framework Referencing

When references are made to a section within the same Technical Framework volume, a section number is used by itself. When references are made to other volumes or to a Technical Framework in another domain, the following format is used:

<domain designator> TF-<volume number>: <section number>, where

<domain designator> is a short designator for the IHE domain (ITI = IT Infrastructure, RO = Radiation Oncology)

<volume number> is the applicable volume within the given Technical Framework (e.g., 1, 2, 3), and

<section number> is the applicable section number.

For example: ITI TF-1: 3.1 refers to section 3.1 in volume 1 of the IHE IT Infrastructure Technical Framework, RAD TF-3: 4.33 refers to section 4.33 in volume 3 of the IHE Radiology Technical Framework.

When references are made to specific transactions (transaction numbers) the following format is used:

<domain designator>-<transaction number>

For example RAD-4 refers to transaction number 4 (Procedure Scheduled) in the Radiology Technical Framework.

1.7 History of Annual Changes

- 2007: Initiated the IHE Radiation Oncology Technical Frameworks with the *Basic Radiation Therapy Objects* Integration Profile (BRTO).
- 2011: Updated the front matter sections of Volumes 1 and 2 of the IHE Radiation Oncology Technical Frameworks to be consistent with newly released domain-wide sections.

1.8 Comments

ASTRO welcomes comments on this document and the IHE-RO initiative. They should be directed to the discussion server at http://forums.rsna.org/ or to:

Sidrah Abdul
IHE Radiation Oncology Secretary
American Society for Radation Oncology

8280 Willow Oaks Corporate Drive, Suite 500
Fairfax, VA
sidraha@astro.org

1.9 Copyright Permission

Health Level Seven, Inc., has granted permission to the IHE to reproduce tables from the HL7 standard. The HL7 tables in this document are copyrighted by Health Level Seven, Inc. All rights reserved.

The National Electrical Manufacturers Association (NEMA) has granted permission to the IHE to incorporate portions of the DICOM standard.

Material drawn from these documents is credited where used.

1.10 IHE Technical Framework Development and Maintenance Process

The IHE Radiation Oncology Technical Framework is continuously maintained and expanded on an annual basis by the IHE Radiation Oncology Technical Committee. The development and maintenance process of the Framework follows a number of principles to ensure stability of the specification so that both vendors and users may use it reliably in specifying, developing and acquiring systems with IHE integration capabilities.

The first of these principles is that any extensions, clarifications and corrections to the Technical Framework must maintain backward compatibility with previous versions of the framework in order to maintain interoperability with systems that have implemented IHE Actors and Integration Profiles defined there.

The IHE Radiation Oncology Technical Framework is developed and re-published annually following a three-step process:

1. The Radiation Oncology Technical Committee develops supplements to the current stable version of the Technical Framework to support new functionality identified by the IHE Strategic and Planning Committees and issues them for public comment.
2. The Committee addresses all comments received during the public comment period and publishes an updated version of the Supplement for "Trial Implementation". It is this version of the Supplement used by vendors in developing trial implementation software for the annual Radiation Oncology Connectathon.
3. The Committee regularly considers change proposals to the Trial Implementation version of a Supplement, including those from implementers who participate in the Connectathon. After resolution of all change proposals received, the Supplement is approved for Final Text and added to the current Technical Framework at its next revision.

2 Conventions

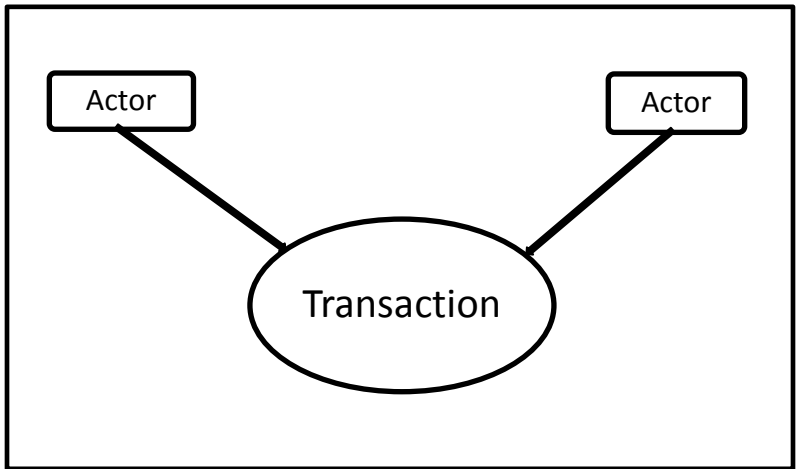
This document has adopted the following conventions for representing the framework concepts and specifying how the standards upon which the IHE Technical Framework is based shall be applied.

2.1 The Generic IHE Transaction Model

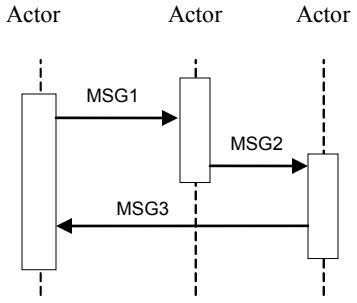
Transaction descriptions are provided in section 3. In each transaction description, the actors, the roles they play, and the transactions between them are presented as use cases.

The generic IHE transaction description includes the following components:

- *Scope*: a brief description of the transaction.
- *Use Case Roles*: textual definitions of the actors and their roles, with a simple diagram relating them, e.g.:



- *Referenced Standards*: the standards (stating the specific parts, chapters or sections thereof) to be used for the transaction.
- *Interaction Diagram*: a graphical depiction of the actors and transactions, with related processing within an actor shown as a rectangle and time progressing downward, similar to:



The interaction diagrams used in the IHE Technical Framework are modeled after those described in Grady Booch, James Rumbaugh, and Ivar Jacobson, *The Unified Modeling*

Language User Guide, ISBN 0-201-57168-4. Simple acknowledgment messages are omitted from the diagrams for brevity.

- *Message definitions:* descriptions of each message involved in the transaction, the events that trigger the message, its semantics, and the actions that the message triggers in the receiver.

2.2 DICOM Usage Conventions

For some DICOM transactions described in this document, IHE has strengthened the requirements on the use of selected Type 2 and Type 3 attributes. These situations are explicitly documented in section 3 and in the appendices. IHE specifically emphasizes that DICOM Type 2 attributes (for instance, Patient Name, Patient ID) shall be transmitted with zero length if the source system does not possess valid values for such attributes; in other words, the source system shall not assign default values to such attributes. The receiving system must be able to handle zero-length values for such attributes.

IHE has defined requirements related to the support for and use of attributes in DICOM storage transactions by both Service Class Users (SCUs) and Service Class Providers (SCPs):

O The attribute or its value is optional, i.e., in DICOM it is Type 2 or 3.

R The attribute is required, and is not an IHE extension of the DICOM requirements; i.e., it is already Type 1 in DICOM, but additional constraints are placed by IHE, for example on the value set that may be used for the attribute.

R+ The Requirement is an IHE extension of the DICOM requirements, and the attribute shall be present, i.e., is Type 1, whereas the DICOM requirement may be Type 2 or 3.

RC+ The Requirement is an IHE extension of the DICOM requirements, and the attribute shall be present when the condition is satisfied, i.e., is Type 1C, whereas the DICOM requirement may be Type 2 or 3.

IHE has also defined requirements related to the support for and use of matching and return keys in DICOM queries by both Service Class Users (SCUs) and Service Class Providers (SCPs). Matching keys are used to select instances for inclusion in the response by the query SCP to the SCU, whereas return keys only return specific data and are not used for matching.

- Required matching key SCU:

  A key that the Query SCU shall have the ability to offer to its user as a selection criterion. The definition of the means offered to the user of the Query SCU to trigger the sending of a matching key in the Query request is beyond the scope of IHE (e.g. enter a value, select an entry).

- Required matching key SCP:

  An IHE required matching key is processed by the Query SCP just as if it were a DICOM-required matching key. In most cases, IHE-required matching keys are also DICOM-required matching keys.

- Required return key SCU:

  A key that the Query SCU requests from the Query SCP, receives in the query responses, and displays for the user, if required. The definition of the means offered to the user of the Query

SCU to request a return key (e.g. by default, check a box) and to make it visible to the user is beyond the scope of IHE.

- Required return key SCP:

  IHE-required return keys specified within DICOM as type 1 or type 2 return keys are processed according to their DICOM type. IHE-required return keys specified within DICOM as type 3 will be processed as if they were type 2.

Query Key Requirement Tables in the framework use the following legend to specify requirements for SCUs and SCPs:

R Required O Optional

The following modifiers are also used:

R+	The Requirement is an IHE extension of the DICOM requirements
R*	The attribute is not required to be displayed
R+*	The Requirement is an IHE extension of the DICOM requirements, but it is NOT required to be displayed

Table 2.2-1 in RAD TF-2 provides an example table defining matching and return keys. Note that sequence attributes are used as a structuring header in these matching and return key tables, and requirements are given for individual sequence items.

2.3 HL7 Profiling Conventions

HL7 profiling conventions are discussed in RAD TF-2:2.3. For those individuals interested, please refer to that reference.

2.4 HL7 Implementation Notes

2.4.1 Network Guidelines

The HL7 2.3.1 standard does not define a network communications protocol. The HL7 2.1 standard defines lower layer protocols in an appendix. These definitions were moved to the Implementation Guide in 2.2 and subsequent versions, but are not HL7 requirements. The IHE Framework makes these recommendations:

1. Applications shall use the Minimal Lower Layer Protocol defined in Appendix C of the HL7 Implementation Guide.
2. An application that wants to send a message (initiate a transaction) will initiate a network connection to start the transaction. The receiver application will respond with an acknowledgement or response to query but will not initiate new transactions on this network connection.

2.4.2 Message Control

According to the HL7 standard, each message shall begin with the MSH (message header) segment. Table RAD TF-2:2.4-1 identifies all required fields in this message. This table shall be interpreted according to the HL7 Standard unless otherwise noted in Section 2.3.

The IHE Technical Framework requires that applications support HL7-recommended values for the fields *MSH-1 Field Separator* and *MSH-2 Encoding Characters*.

Field *MSH-18 Character Set* shall only be valued if the message utilizes character sets other than ISO IR-6, also known as ASCII.

Implementations supporting sequence number protocol (and using the field *MSH-13 Sequence Number*) shall be configurable to allow them to perform transactions without such protocol.

2.4.3 Acknowledgment Modes

Applications that receive HL7 messages shall send acknowledgments using the HL7 Original Mode (versus Enhanced Acknowledgment Mode).

The IHE Technical Framework provides for each HL7 message to be acknowledged by the HL7 ACK message sent by the receiver of an HL7 message to its sender. The segments of the ACK message listed in the references below are required, and their detailed descriptions are provided in tables RAD TF-2:2.4-1, RAD TF-2:2.4-2 and corresponding notes. The ERR segment is optional and may be included if the *MSA-1 Acknowledgement Code* field identifies an error condition.

2.4.4 HL7 Versioning

The selection of a particular version of HL7 for any given HL7 based transaction within the Technical Framework is based upon a number of factors. These include:

- Whether the version of HL7 provides the functionality needed for the transaction.
- How widely the version of HL7 is supported at the time of specification

Since the transactions are self-contained communications, the implementation of each HL7 transaction may use a different version of HL7.

An application implementing an IHE transaction which uses HL7 messaging must comply with the message structure and contents defined by the specified version of HL7 and the Technical Framework. It is acceptable if the version (MSH-12) is higher than that specifed in the Framework as long as the message structure and contents meet the requirements of the specification.

2.5 HL7 and DICOM Mapping Considerations

Field lengths are explicitly defined in the DICOM Standard, but an HL7 element might consist of multiple components that do not have a defined maximum length. It is recognized that there are some HL7 component lengths that could be longer than the DICOM attribute lengths. Data values for mapped fields are required not to exceed the smaller of either the HL7 or the DICOM field length definitions. Systems supporting alternative character sets must take into account the number of bytes per character in such sets. All systems are required to support the DICOM Default Character Set (ISO-IR 6 or ASCII). In addition, other character sets may be supported. Maintaining consistency of data encoded using alternative character sets is outside of the scope of the IHE Technical Framework.

Value Representations are not explicitly addressed. Attention shall be given to the mapping of the HL7 representation and the DICOM representation. Examples of these include Patient Name, dates and times.

2.6 Use of Coded Entities and Coding Schemes

IHE does not produce, maintain or otherwise specify a coding scheme or other resource for controlled terminology (coded entities). Where applicable, coding schemes required by the HL7 and DICOM Standards take precedence. In the cases where such resources are not explicitly identified by the Standards, implementations may utilize any resource (including proprietary or local) provided any licensing/copyright requirements are satisfied.

3 IHE Transactions

This section defines each IHE transaction in detail, specifying the standards used, the information transferred, a nd the conditions under which the transaction is required or optional.

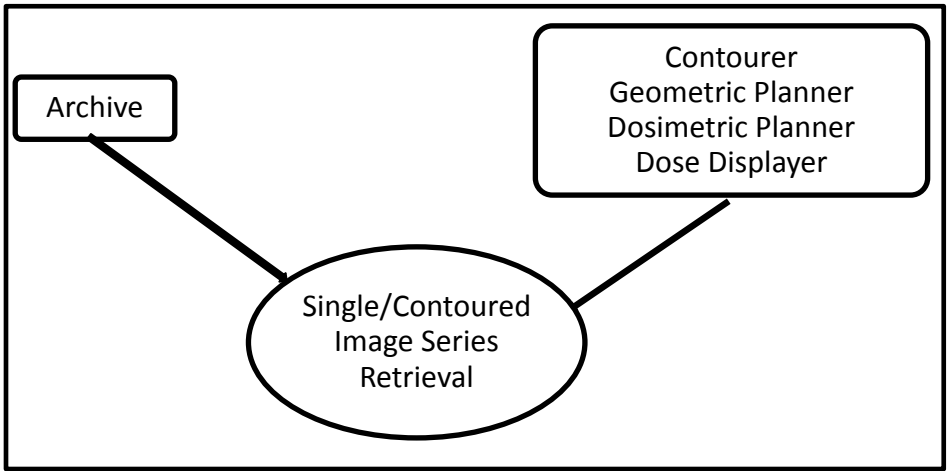
3.1 Single/Contoured Image Series Retrieval

This corresponds to transaction RO-1 of the IHE Radiation Oncology Technical Framework. Transaction RO-1 is used by the ***Archive***, ***Contourer***, ***Geometric Planner***, ***Dosimetric Planner***, and ***Dose Displayer*** actors.

3.1.1 Scope

This transaction is used to send a series of CT-Images from an ***Archive*** to an application.

3.1.2 Use Case Roles



Actor: Archive

Role: Send CT Series to Contourer, Geometric Planner, Dosimetric Planner or Dose Displayer

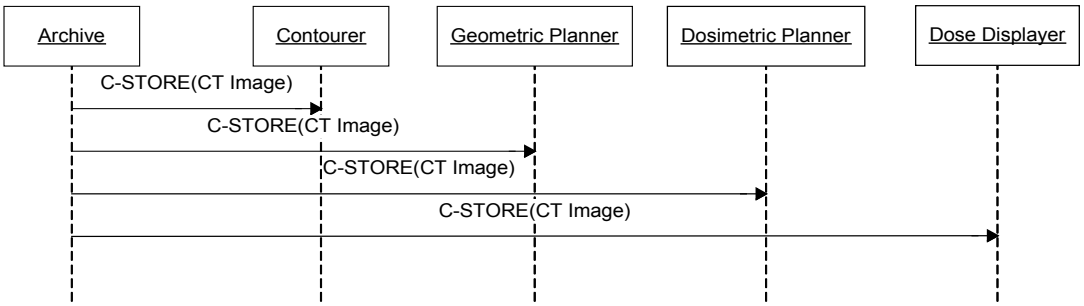
Actor: Contourer, Geometric Planner, Dosimetric Planner or Dose Displayer

Role: Receives and stores CT Series from Archive

3.1.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.1.4 Interaction Diagram



3.1.4.1 Single/Contoured Image Series Retrieval

3.1.4.1.1 Trigger Events

The user of the ***Contourer***, in order to generate a set of contours, determines that a certain CT-Series is required, and requests that the ***Archive*** send the necessary CT-Series to the ***Contourer***.

The user of a ***Geometric Planner***, in order to generate a geometric plan, determines that a certain CT Series is required, and requests that the ***Archive*** send the necessary CT series to the ***Geometric Planner***.

The user of a ***Dosimetric Planner***, in order to generate a dosimetric plan and calculate dose, determines that a certain CT Series is required, and requests that the ***Archive*** send the necessary CT series to the ***Dosimetric Planner***.

The user of a ***Dose Displayer***, in order to view dose, determines that a certain CT Series is required, and requests that the ***Archive*** send the necessary CT series to the ***Dose Displayer.***

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

3.1.4.1.2 Message Semantics

The ***Archive*** uses the DICOM C-STORE message to transfer the all of the CT Images in the series to the ***Contourer***, ***Geometric Planner***, ***Dosimetric Planner*** or ***Dose Displayer***. The ***Archive*** is the DICOM Storage SCU and the ***Contourer***, ***Geometric Planner***, ***Dosimetric Planner*** or ***Dose Displayer*** is the DICOM Storage SCP.

Also refer to Appendix A for an overview of specific requirements on the DICOM attributes that are included in a CT Image Object. In particular, all of the CT images involved in this transaction must share a single series instance UID and a single frame of reference UID.

3.1.4.1.3 Expected Actions

The ***Contourer*** will store all of the CT Images, and will relate the images based on the study, series, and image identification information. These images will then be available to the user of the ***Contourer*** for use in construction a set of contours which will later be exported as a structure set (RO-2).

The ***Geometric Planner*** will store all of the CT Images, and will relate the images based on the study, series, and image identification information. These images will then be available to the user of the ***Geometric Planner*** for use in construction of a geometric plan which will later be exported as a Geometric Plan (RO-3).

The ***Dosimetric Planner*** will store all of the CT Images, and will relate the images based on the study, series, and image identification information. These images will then be available to the user of the ***Dosimetric Planner*** for use in construction of a dosimetric plan which will later be exported (RO-4). These images will also be involved in the calculation of a related dose, which will be exported later as an RT Dose (RO-5).

The ***Dose Displayer*** will store all of the CT Images, and will relate the images based on the study, series, and image identification information. These images will then be available to the user of the ***Dose Displayer*** for use in construction of a dose display.

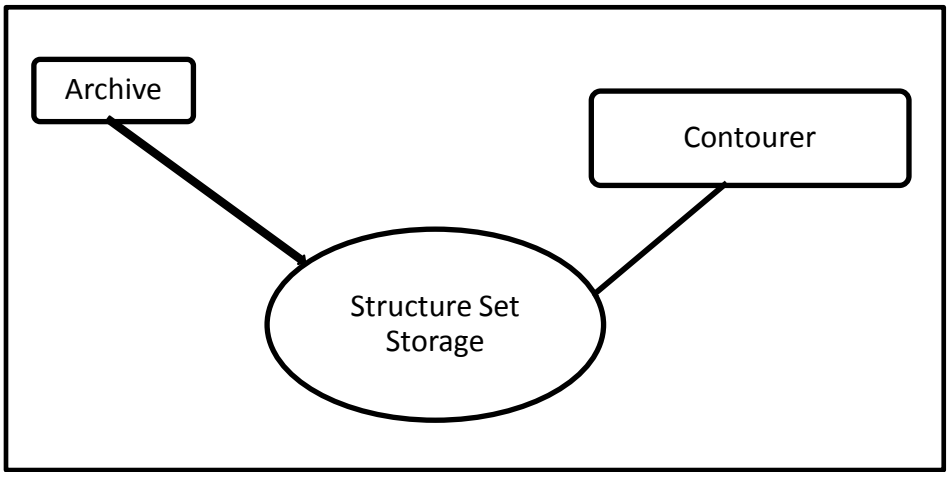
3.2 Structure Set Storage

This corresponds to transaction RO-2 of the IHE Radiation Oncology Technical Framework. Transaction RO-2 is used by the ***Archive*** and ***Contourer*** actors.

3.2.1 Scope

In the Structure Set Storage Transaction, the ***Contourer*** stores a Structure Set on an ***Archive*** to make it available.

3.2.2 Use Case Roles



Actor: Contourer

Role: Sends Structure Set to Archive

Actor: Archive

Role: Stores Structure Set received from Contourer

3.2.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.2.4 Interaction Diagram

3.2.4.1 Structure Set Storage

3.2.4.1.1 Trigger Events

The user of the ***Contourer*** selects a Structure Set to store.

3.2.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Contourer*** is the storage SCU and the ***Archive*** is the storage SCP.

The Contours in the ROI Contour module are restricted to Geometric Type POINT and CLOSED_PLANAR. ROI contours must correspond to exported image plane locations. If a system does not support unequally-spaced slices, for example, that system is responsible for creating a resampled image set (see RO-11) and creating a structure set in which the ROI contours reference the resampled image set. Furthermore, absence of an ROI contour on slice(s) between those containing contours of that ROI does not imply the existence of the ROI on the intervening slice(s).

Also refer to Appendix A for an overview of the specific requirements on the DICOM attributes that are included in an RT Structure Set object. In particular, the structure set must share a single frame of reference UID with the images.

3.2.4.1.3 Expected Actions

Upon receipt of the Structure Set, the ***Archive*** shall store it. This Structure Set is then available for subsequent retrieval (RO-7).

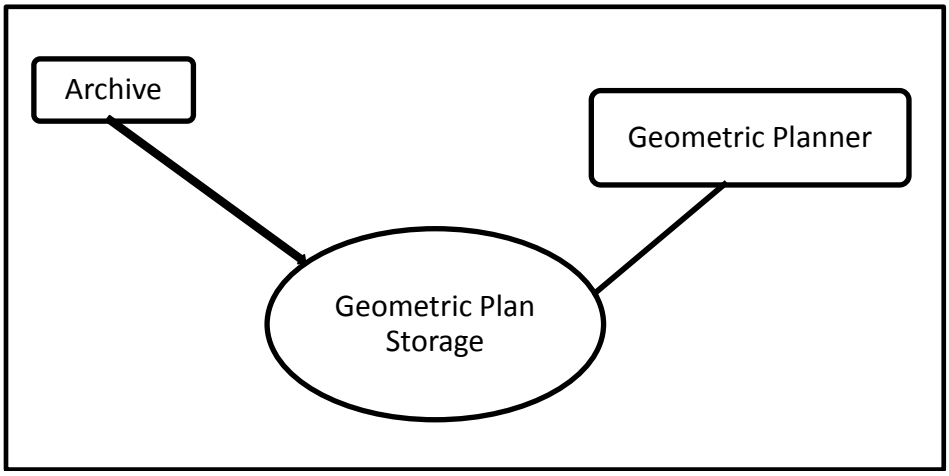
3.3 Geometric Plan Storage

This corresponds to transaction RO-3 of the IHE Radiation Oncology Technical Framework. Transaction RO-3 is used by the ***Archive*** and ***Geometric Planner*** actors.

3.3.1 Scope

In the ***Geometric Plan*** Storage transaction, the ***Geometric Planner*** sends the newly created ***Geometric Plan*** to the ***Archive***.

3.3.2 Use Case Roles



Actor: Geometric Planner

Role: Transmit generated Geometric Plan to the Archive

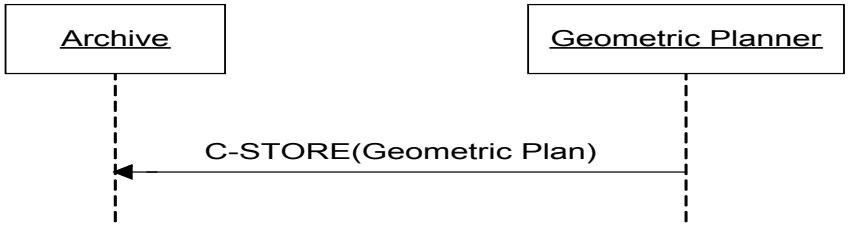
Actor: Archive

Role: Receives and stores Geometric Plans from the Geometric Planner

3.3.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.3.4 Interaction Diagram



3.3.4.1 Geometric Plan Storage

3.3.4.1.1 Trigger Events

Upon successful creation of the Geometric Plan, the user of the ***Geometric Planner*** decides to store the Geometric Plan. The ***Geometric Planner*** transfers the ***Geometric Plan*** to the ***Archive*** within a DICOM association.

3.3.4.1.2 Message Semantics

The ***Geometric Planner*** uses the DICOM C-STORE message to transfer the Geometric Plan. The ***Geometric Planner*** is the DICOM Storage SCU and the ***Archive*** is the DICOM Storage SCP.

Also refer to Appendix A for an overview of ***Geometric Plan*** specific requirements on the DICOM attributes that are included in an RT Plan object.

3.3.4.1.3 Expected Actions

The ***Archive*** will store the received Geometric Plan.

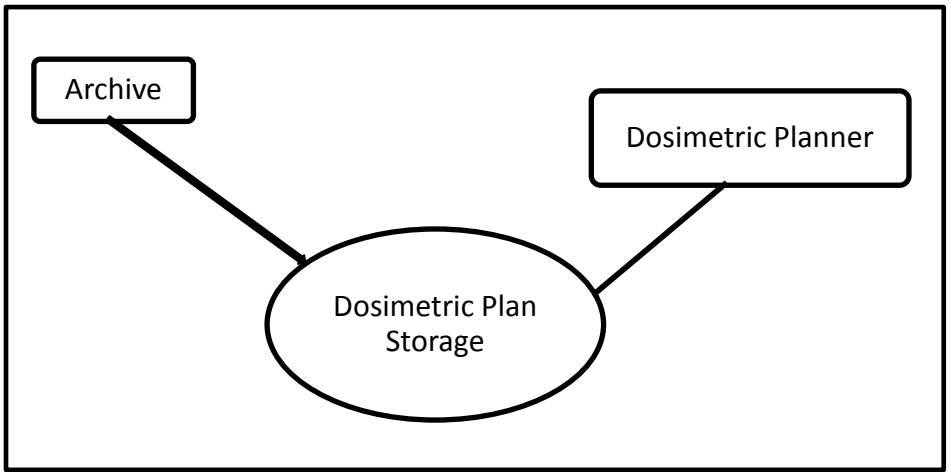
3.4 Dosimetric Plan Storage

This section corresponds to Transaction RO-4 of the IHE-RO Technical Framework. Transaction RO-4 is used by the ***Archive*** and ***Dosimetric Planner*** actors.

3.4.1 Scope

In this transaction, the ***Dosimetric Planner*** sends the plan containing the references to the structure set to the ***Archive***.

3.4.2 Use Case Roles



Actor: Dosimetric Planner

Role: Transmit generated plan to Archive.

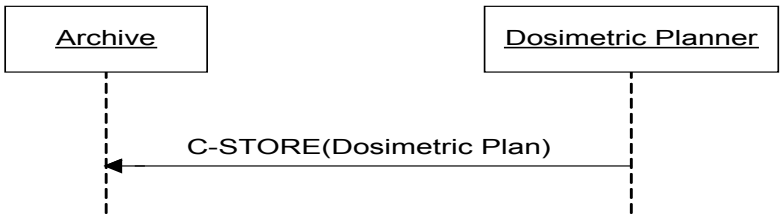
Actor: Archive

Role: Accept and store plan from Dosimetric Planner.

3.4.3 Referenced Standards

DICOM 2007, PS 3.3: RT Modules, PS 3.4: Storage Service Class.

3.4.4 Interaction Diagram



3.4.4.1 Dosimetric Plan Storage

3.4.4.1.1 Trigger Events

The ***Dosimetric Planner*** transfers the ***Dosimetric Plan*** to the ***Archive***, once the dose calculation is finished.

3.4.4.1.2 Message Semantics

The ***Dosimetric Planner*** uses the DICOM C-STORE message to transfer the plan. The ***Dosimetric Planner*** is the DICOM Storage SCU and the ***Archive*** is the DICOM Storage SCP.

The ***Dosimetric Planner*** may create a new series containing the plan or may use an existing series, where previous plan(s) are contained.

The study where the series of the plan is contained shall be the same study as the one containing the structure set referenced in the plan.

The purpose of the Dosimetric Plan transferred is to convey the reference to the structure set, which has been used in definition of the plan and which contains the references to the CT Images used for plan calculation. The ***Dose Displayer*** will use this sequence to retrieve the structure set and the CT images referenced in the structure set for display.

The following table shows the IHE-RO extension of the DICOM requirements for the RT General Plan module.

Table 3.4-1 Required Attributes for RT General Plan Module

Attribute	Tag	Type	Attribute Description
RT Plan Label	(300A,0002)	R+	The label, which serves as the identification of the plan for the user.
RT Plan Date	(300A,0006)	R+	The date, when the plan was last modified.
RT Plan Time	(300A,0007)	R+	The time, when the plan was last modified.
RT Plan Geometry	(300A,000C)	R+	Shall be PATIENT. This implies, that the RT Structure Set exists and is referenced in the General Plan module.

The following table shows the IHE-RO extension of the DICOM requirements for the General Equipment module.

Table 3.4-2 Required Attributes for General Equipment Module

Attribute	Tag	Type	Attribute Description
Manufacturer	(0008,0070)	R+	The manufacturer of the Dosimetric Planner equipment creating the plan shall be provided.
Manufacturer's Model Name	(0008,1090)	R+	The manufacturer's model name of the Dosimetric Planner equipment creating the plan shall be provided.
Software Versions	(0008,1020)	R+	The software version of the Dosimetric Planner equipment creating the plan shall be provided.

On all other attributes of the RT Plan IOD, no IHE-RO extension to the DICOM requirements exists.

The Dosimetric Plan may not contain an RT Brachy Application Setup module.

The Dosimetric Plan may have zero beams, i.e. it may lack an RT Beams module. This is to support teletherapy plans that do not match the traditional isocentric model.

Applications should display Plan Label, Date and Time in order to safely identify matching Dose and Plan pairs.

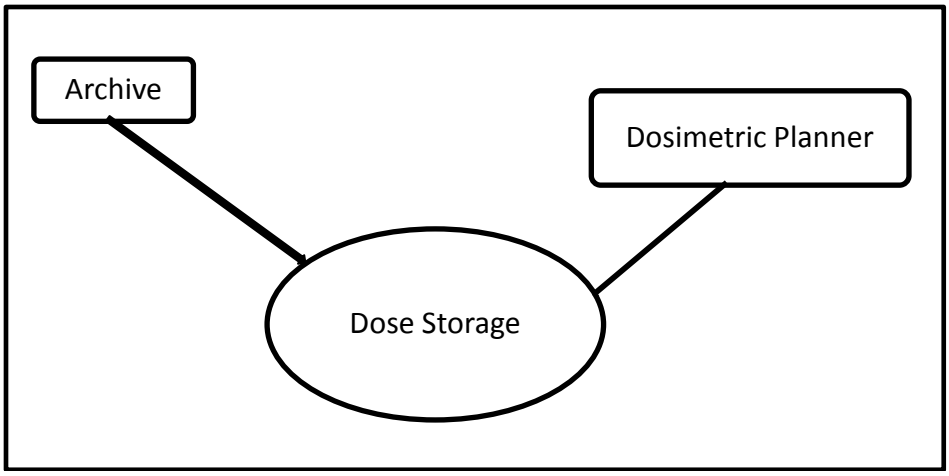
3.5 Dose Storage

This corresponds to RO-5 of the IHE-RO technical framework. Transaction RO-5 is used by the ***Archive*** and ***Dosimetric Planner*** actors.

3.5.1 Scope

In the Dose Storage transaction, the ***Dose planner*** sends the newly created Dose to the ***Archive***.

3.5.2 Use Case Roles



Actor: Dosimetric Planner

Role: Transmit generated Dose to the Archive

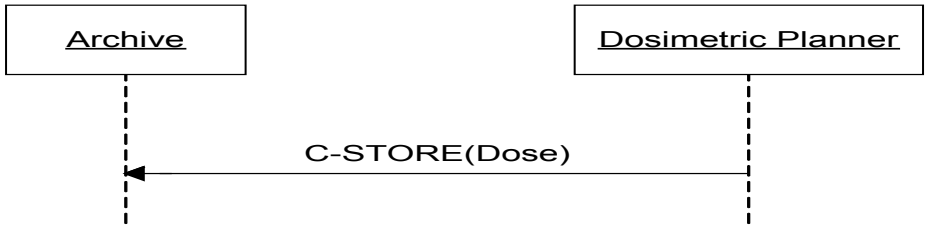
Actor: Archive

Role: Receives and stores Doses from the Dosimetric Planner

3.5.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.5.4 Interaction Diagram



3.5.4.1 Dose Storage

3.5.4.1.1 Trigger Events

The ***Dosimetric Planner*** transfers the Dose to the ***Archive*** within a DICOM association.

3.5.4.1.2 Message Semantics

The ***Dosimetric Planner*** uses the DICOM C-STORE command to transfer the Dose. The ***Dosimetric Planner*** is the DICOM Storage SCU and the ***Archive*** is the DICOM Storage SCP.

Also refer to Appendix A for an overview of Dose specific requirements on the DICOM attributes that are included in an RT Dose object.

3.5.4.1.3 Representation of Dose

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].

Not supported are point doses, projection of dose onto an oblique plane, isodose contours and dose-volume histograms. The dose pixels shall represent absolute physical dose in units of Gray. The value of Dose Units (3004,0002) shall be GY. The value of Pixel Representation (0028,0103) shall be 0; negative dose values shall not be present.

3.5.4.1.4 Expected Actions

The ***Archive*** will store the received Dose.

The DICOM RT Dose object will be stored such that it can be later retrieved (See RO-10 Dose Retrieval) in a fashion meeting the requirements defined for a DICOM level 2 SCP (Refer to DICOM PS 3.4 B.4.1).

The DICOM SOP Class UID and Name for the RT Dose object is defined in the table below.

SOP Class UID	SOP Class Name
1.2.840.10008.5.1.4.1.1.481.2	RT Dose Storage

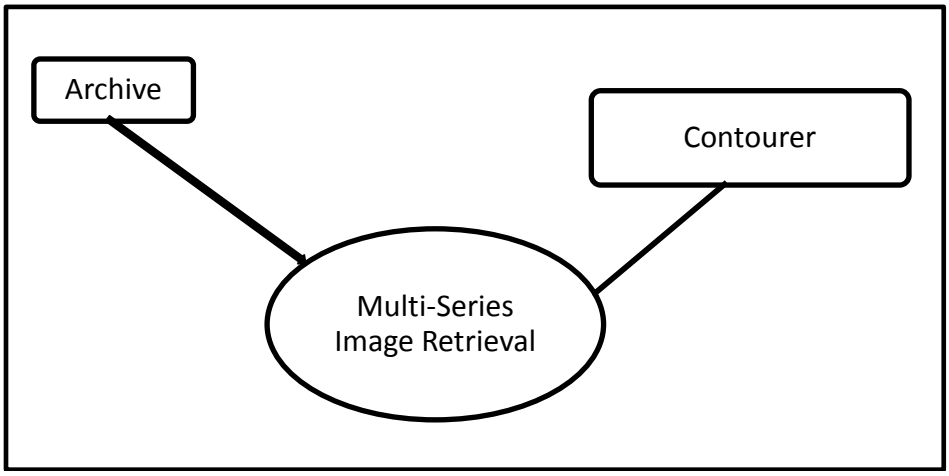
3.6 Multi-Series Image Retrieval

This corresponds to RO-6 of the IHE-RO technical framework. Transaction RO-6 is used by the ***Archive*** and ***Contourer*** actors.

3.6.1 Scope

In the Multi-Series Image Retrieval Transaction, the ***Archive*** stores CT Images from multiple series (but a single study) on a ***Contourer*** to make these images available for contouring.

3.6.2 Use Case Roles



Actor: Archive

Role: Sends CT Images to the Contourer

Actor: Contourer

Role: Stores CT Images received from Archive

3.6.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.6.4 Interaction Diagram

3.6.4.1 Multi-Series Image Retrieval

3.6.4.1.1 Trigger Events

The user of the ***Contourer*** determines that images from multiple CT Series are to be used in the construction of a single set of contours, and requests that the ***Archive*** send these Series to the ***Contourer***.

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

3.6.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Archive*** is the SCU of this service class, and the ***Contourer*** is the SCP of this service Class.

Also refer to Appendix A for an overview of the specific requirements on the DICOM attributes that are included in a CT Image object. In particular, these CT Images are required to share a study instance UID and a frame of reference UID, but not a series instance UID.

3.6.4.1.3 Expected Actions

Upon receiving the multiple CT Series, the ***Contourer*** will resample the series, if necessary, and will combine images from the various series into a single, new CT Series with a new series instance UID. A ***Contourer*** shall be required to support retrieval of multiple (1, 2, or 3) image series. Images in this new series will all share the same study instance UID with the original images. These new images must also share a single frame of reference UID with the original images. This new series will be sent back to the ***Archive*** using the Resampled/Combined CT Series Stored transaction (RO-11).

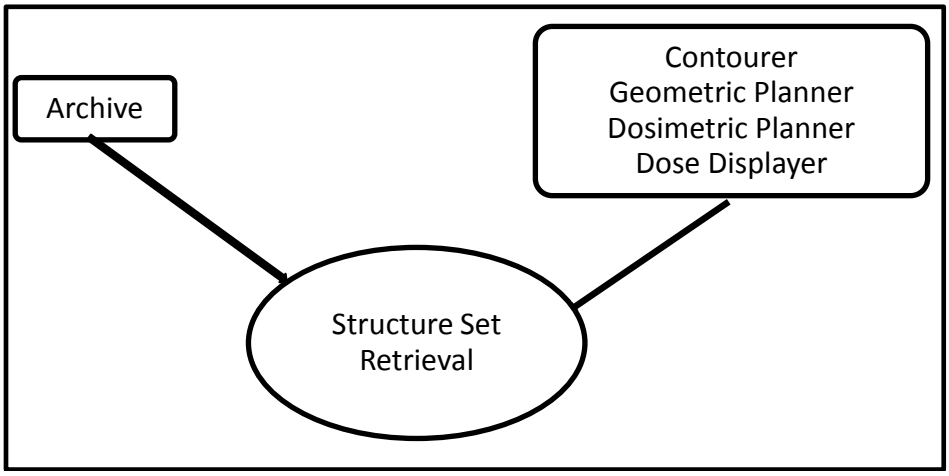
3.7 Structure Set Retrieval

This corresponds to RO-7 of the IHE-RO technical framework. Transaction RO-7 is used by the ***Archive, Contourer, Geometric Planner, Dosimetric Planner, and Dose Displayer*** actors.

3.7.1 Scope

In the Structure Set Retrieval Transaction, the ***Archive*** stores a Structure Set on a ***Contourer***, ***Geometric Planner***, ***Dosimetric Planner***, or ***Dose Displayer***.

3.7.2 Use Case Roles



Actor: Archive

Role: Sends Structure Set to Contourer, Geometric Planner, Dosimetric Planner, or Dose Displayer

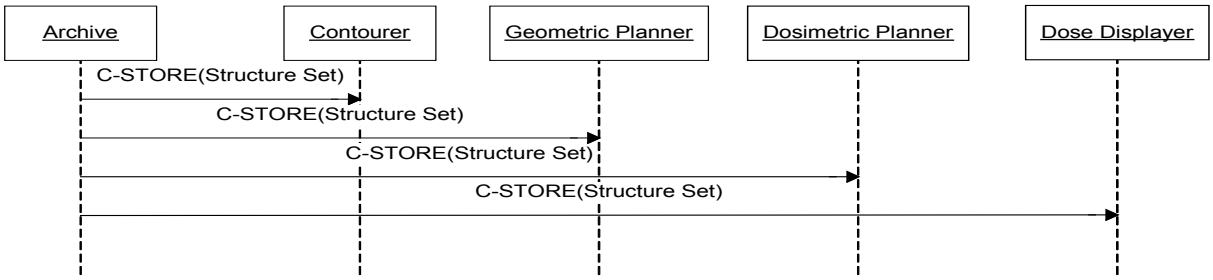
Actor: Contourer, Geometric Planner, Dosimetric Planner, or Dose Displayer

Role: Stores Structure Set received from Archive

3.7.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.7.4 Interaction Diagram



3.7.4.1 Structure Set Retrieval

3.7.4.1.1 Trigger Events

The user of the ***Contourer*** determines that a new set of contours is to be based upon an existing Structure Set and requests that the ***Archive*** send this Structure Set to the ***Contourer***.

The user of the ***Geometric Planner*** determines that a new ***Geometric Plan*** is to be based upon an existing Structure Set and requests that the ***Archive*** send this Structure Set to the ***Geometric Planner***.

The user of the ***Dosimetric Planner*** determines that a new dosimetric plan is to be based upon an existing Structure Set and requests that the ***Archive*** send this Structure Set to the ***Dosimetric Planner***.

The user of the ***Dose Displayer*** determines that a dose display is to be based upon an existing Structure Set and requests that the ***Archive*** send this Structure Set to the ***Dose Displayer***.

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

3.7.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Contourer***, ***Geometric Planner***, ***Dosimetric Planner***, or ***Dose Displayer*** is the storage SCP and the ***Archive*** is the storage SCU.

Also refer to Appendix A for an overview of the specific requirements on the DICOM attributes that are included in an RT Structure Set object. In particular, the structure set must have the same study instance UID, but a different series instance UID, than the CT series upon which the contours are based.

3.7.4.1.3 Expected Actions

The ***Contourer*** will store all of the Structure Set, and will relate it to images based on the study, series, and image identification information. The contours contained will then be available to the user of the ***Contourer*** for use in construction a new set of contours which will later be exported as a structure set (RO-2). This new structure set will have the same frame of reference UID and study instance UID of the original images and structure set. It may have the same series instance UID as the original structure set.

The ***Geometric Planner*** will store the structure set, and will relate it to images based on the study, series, and image identification information. The contours contained in this structure set will then be available to the user of the ***Geometric Planner*** for use in construction of a geometric plan which will later be exported as a ***Geometric Plan*** (RO-3).

The ***Dosimetric Planner*** will store the structure set, and will relate it to images based on the study, series, and image identification information. These contours contained in this structure set will then be available to the user of the ***Dosimetric Planner*** for use in construction of a dosimetric plan which will later be exported (RO-4). These images will also be involved in the calculation of a related dose, which will be exported later as an RT Dose (RO-5).

The ***Dose Displayer*** will store the structure set, and will relate it to images based on the study, series, and image identification information. These contours contained in this structure set will then be available to the user of the ***Dose Displayer*** for display in relation to images, doses in the same frame of reference.

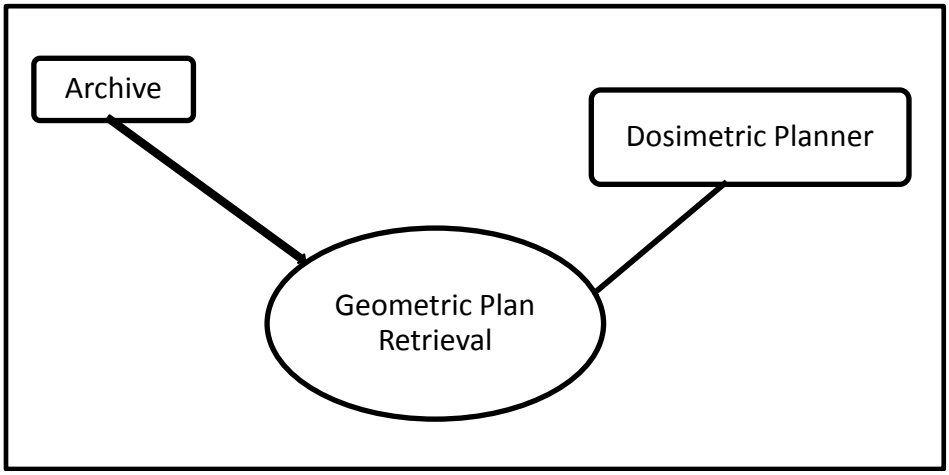
3.8 Geometric Plan Retrieval

This corresponds to RO-8 of the IHE-RO technical framework. Transaction RO-8 is used by the ***Archive*** and ***Geometric Planner*** actors.

3.8.1 Scope

In the Geometric Plan Retrieval Transaction, the requested Geometric Plan is transferred from the ***Archive*** to the ***Dosimetric Planner***.

3.8.2 Use Case Roles



Actor: Dosimetric Planner

Role: Receives requested Geometric Plan from the Archive

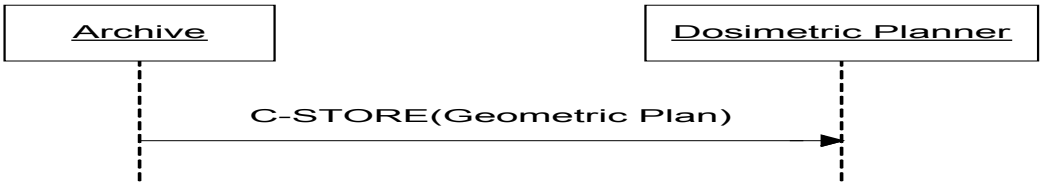
Actor: Archive

Role: Sends requested Geometric Plan instance to the Dosimetric Planner

3.8.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.8.4 Interaction Diagram



3.8.4.1 Geometric Plan Retrieval

3.8.4.1.1 Trigger Events

The user of the ***Dosimetric Planner*** selects a Geometric Plan for completion of the plan and dose calculation.

3.8.4.1.2 Message Semantics

The plan shall be sent from the ***Archive*** to the ***Dosimetric Planner***. Also refer to Appendix A for an overview of Geometric Plan specific requirements on the DICOM attributes that are included in an RT Plan object.

3.8.4.1.3 Expected Actions

The ***Archive*** shall return the requested Geometric Plan to the ***Dosimetric Planner***. The ***Dosimetric Planner*** shall validate the received Geometric Plan. In cases where the received Geometric Plan is valid, it shall be loaded into the ***Dosimetric Planner***. In cases where it is not valid, a warning message shall be displayed to the user, indicating the reason why it is not valid.

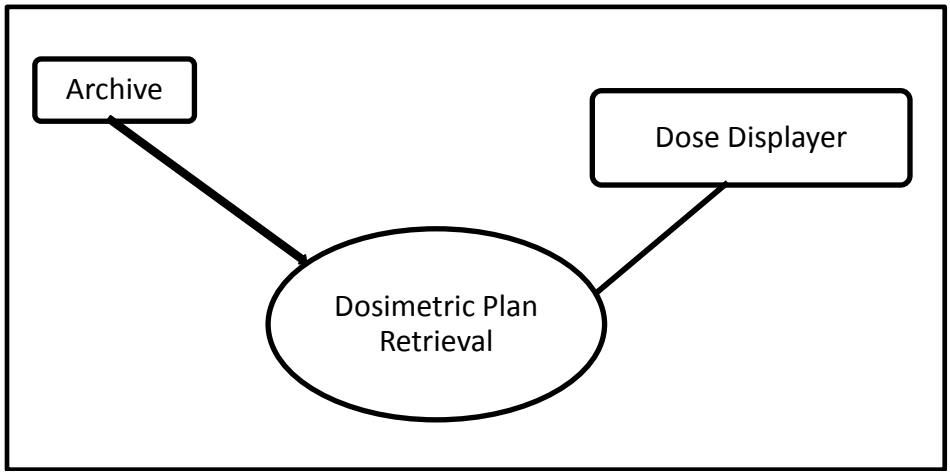
3.9 Dosimetric Plan Retrieval

This corresponds to RO-9 of the IHE-RO technical framework. Transaction RO-9 is used by the ***Archive*** and ***Dose Displayer*** actors.

3.9.1 Scope

In this transaction, the ***Dose Displayer*** retrieves the plan containing the references to the structure set from the ***Archive***.

3.9.2 Use Case Roles



Actor: Dose Displayer

Role: Accepts plan from Archive.

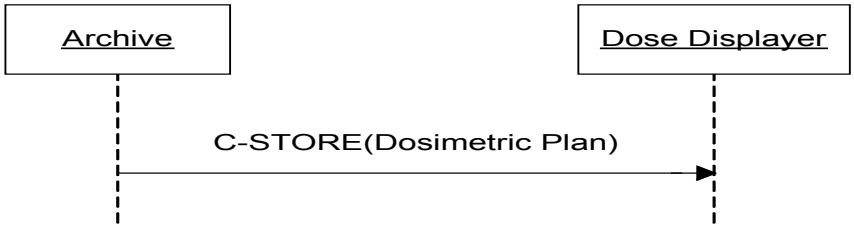
Actor: Archive

Role: Transmits plan to Dose Viewer.

3.9.3 Referenced Standards

DICOM 2007, PS 3.3: RT Modules, PS 3.4: Storage Service Class.

3.9.4 Interaction Diagram



3.9.4.1 Dosimetric Plan Retrieval

3.9.4.1.1 Trigger Events

The ***Archive*** transfers the Dosimetric Plan to the ***Dose Displayer***. This action is initiated by the user in advance of the dose viewing session.

3.9.4.1.2 Message Semantics

The ***Archive*** uses the DICOM C-STORE message to transfer the plan. The ***Archive*** is the DICOM Storage SCU and the ***Dose Displayer*** is the DICOM Storage SCP.

The requirements for the Dosimetric Plan in this transaction are the same as defined in RO-4: Dosimetric Plan Storage.

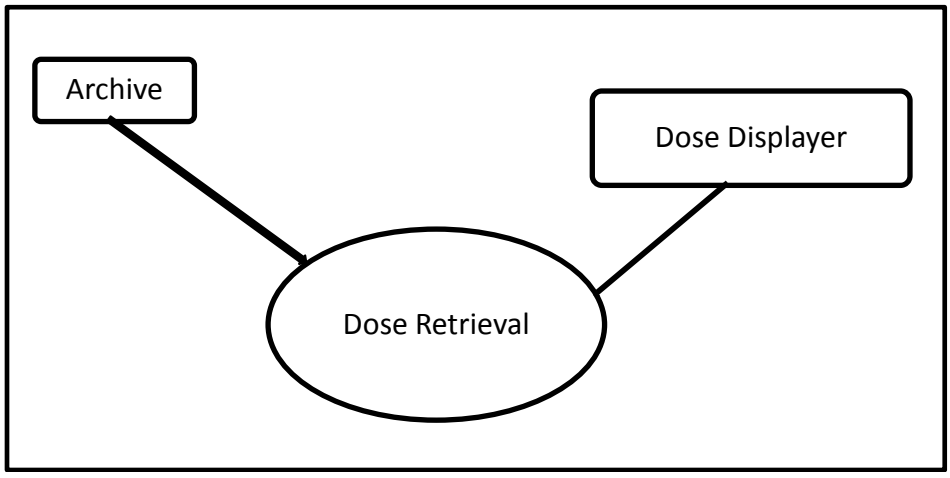
3.10 Dose Retrieval

This corresponds to RO-10 of the IHE-RO technical framework. Transaction RO-10 is used by the ***Archive*** and ***Dose Displayer*** actors.

3.10.1 Scope

In the Dose Retrieval Transaction, the requested Dose is transferred from the ***Archive*** to the ***Dose Displayer***.

3.10.2 Use Case Roles



Actor: Dose Displayer

Role: Receives requested Dose from the Archive

Actor: Archive

Role: Sends requested Dose instance to the Dose Displayer

3.10.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.10.4 Interaction Diagram

3.10.4.1 Dose Retrieval

3.10.4.1.1 Trigger Events

The user of the ***Dose Displayer*** selects a Dose for display in the context of a particular CT Image Set and the targets and avoidance structures defined by an RT Structure Set.

3.10.4.1.2 Message Semantics

The ***Archive*** uses the DICOM C-STORE message to transfer the dose. The ***Archive*** is the DICOM Storage SCU and the ***Dose Displayer*** is the DICOM Storage SCP.

Also refer to Appendix A for an overview of Dose specific requirements on the DICOM attributes that are included in an RT Dose object.

3.10.4.1.3 Representation of Dose

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, isodose contours and dose-volume histograms. The dose pixels shall represent absolute physical dose in units of Gray. The value of Dose Units (3004,0002) shall be GY. The value of Pixel Representation (0028,0103) shall be 0; negative dose values shall not be present.

3.10.4.1.4 Expected Actions

Upon receiving the request for retrieval, the ***Archive*** shall return the requested Dose to the ***Dose Displayer***. The ***Dose Displayer*** shall validate the received Dose. If the received Dose is valid, it shall be loaded into the ***Dose Displayer***. If it is not valid, a warning message shall be displayed to the user, indicating the reason why it is not valid.

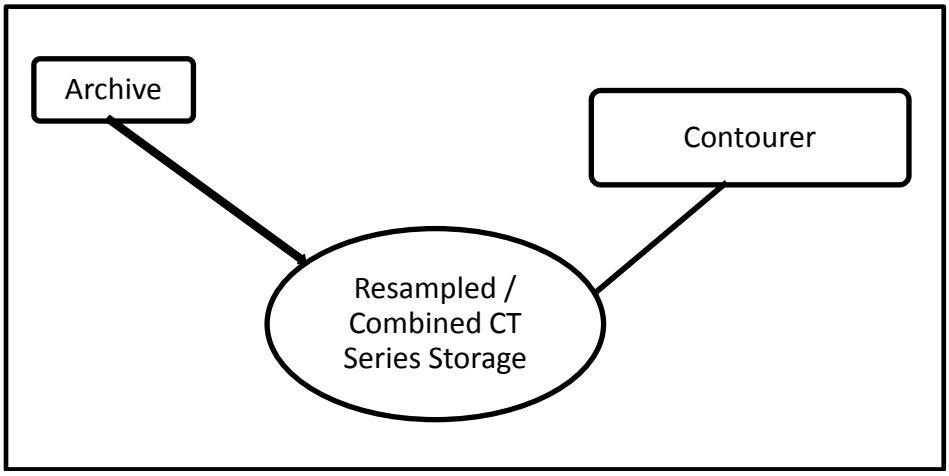
3.11 Resampled/Combined CT Series Storage

This corresponds to RO-11 of the IHE-RO technical framework. Transaction RO-10 is used by the ***Archive*** and ***Contourer*** actors.

3.11.1 Scope

In the Resampled/Combined CT Series Storage Transaction, the ***Contourer*** stores CT Images which have been combined or resampled into a single series on the ***Archive***.

3.11.2 Use Case Roles



Actor: Contourer

Role: Sends CT Images to the Archive

Actor: Archive

Role: Stores CT Images received from Contourer

3.11.3 Referenced standards

DICOM 2007 PS3.4: Storage Service Class.

3.11.4 Interaction Diagram

3.11.4.1 Resampled/Combined CT Series Storage

3.11.4.1.1 Trigger Events

The ***Contourer*** has constructed a new CT Series. It has either combined CT Images from multiple series or has resampled CT Images from a single series to yield a more desirable slice spacing. The ***Contourer*** must export a single CT image series including all images on which Structure Set contours are defined. This new series must be stored on the ***Archive*** to make the images available for subsequent planning or review. This transaction must be performed prior to storage of a structure set (RO-2) which is based upon this new series.

3.11.4.1.2 Message Semantics

The message semantics are defined by the DICOM Storage SOP Class. The ***Archive*** is the SCP of this service class, and the ***Contourer*** is the SCU of this service Class.

Also refer to Appendix A for an overview of the specific requirements on the DICOM attributes that are included in a CT Image object. In particular, these CT Images are required to share a study instance UID, and a frame of reference UID, and a series instance UID.

3.11.4.1.3 Expected Actions

Upon receiving the CT Series, the ***Archive*** will store the images, and will make this series available for subsequent retrieval (RO-1).

Appendix A: Attribute Consistency Between Composite IODs

This appendix is an integral part of the IHE-RO Technical Framework.

- The first section provides attribute mappings for the Evidence Creators with additional IHE Requirements based on a number of critical attributes (Type 2 and 3 in DICOM) common to most composite instances (Images, and RT IODs).
- The second section provides additional constraints on the population and use of a number of modules for particular IODs.
- The third section provides additional constraints on the population and use of a number of critical attributes.

A.1: Radiation Oncology Critical Attribute Mapping

Table A.1-1 describes requirements, recommendations or explanations on integration-critical attributes for radiation oncology cases. They define which integration-critical attributes need to be equal (copied or generated locally). The BRTO IHE-RO Profile does not include the use of Work List, which precludes its use as the source for the integration-critical attributes. It is anticipated that once Work List is utilized in the IHE-RO Profiles, it will be utilized in favor of the preceding Composite IOD (CT, or RT Structure Set) utilized in the BRTO Profile. The purpose in allowing the RT Structure Set to have a differing Study IE is to allow separation of the Study Semantics of a Diagnostic CT from activities that are Oncology related.

For attributes related to clinical trials, it is assumed that the data will be post-processed in to a form suitable for clinical trials after the "complete" set (for the purposes of the clinical trial submission) of a patient's data has been created.

Table A.1-1 structure:

The 1st column denotes the DICOM attributes whose values shall be mapped between the DICOM objects (equal values in the same table row), including DICOM attribute tag (for clarity).

The 2nd column and following columns define where attribute values come from: all defined attribute values of one table row are equal.

Table A.1-1 Required Mapping of Corresponding Attributes

Attribute (Tag)	CT Image	RT Structure Set	Geometric RT Plan	Dosimetric RT Plan	RT Dose
Patient's Name (0010,0010)	Source	Copy	Copy	Copy	Copy
Patient ID (0010,0020)	Source	Copy	Copy	Copy	Copy
Patient's Birth Date (0010,0030)	Source	Copy	Copy	Copy	Copy
Patient's Sex (0010,0040)	Source	Copy	Copy	Copy	Copy

Attribute (Tag)	CT Image	RT Structure Set	Geometric RT Plan	Dosimetric RT Plan	RT Dose
Study Instance UID (0020,000D)	Source	New Source (May Copy *)	Copy	Copy	Copy
Study Date (0008,0020)	Source	New Source (May Copy *)	Copy	Copy	Copy
Study Time (0008,0030)	Source	New Source (May Copy *)	Copy	Copy	Copy
Referring Physician's Name (0008,0090)	Source	New Source (May Copy *)	Copy	Copy	Copy
Study ID (0020,0010)	Source	New Source (May Copy *)	Copy	Copy	Copy
Accession Number (0008,0050)	Source	New Source (May Copy *)	Copy	Copy	Copy
Study Description (0008,1030)	Source	New Source (May Copy *)	Copy	Copy	Copy
Frame of Reference UID (0020,0052)	Source	Copy	Copy	Copy	Copy
Position Reference Indicator (0020,1040)	Source	NA	Copy	Copy	Copy

Note 1: If one copies the Study Instance UID, no study level attributes may be altered.

A.2: Radiation Oncology Critical Modules

Tables A.2-1 and A.2-2 describe requirements, recommendations or explanations on integration-critical DICOM modules for radiation oncology cases. They define which integration-critical modules need to be populated for the various RT IODs. The table follows the structure defined in DICOM PS3.3 section A.1.3.

Table A.2-1 RT PLAN IOD MODULES

IE	Module	Reference	Usage	IHE-RO Usage

IE	Module	Reference	Usage	IHE-RO Usage
Patient	Patient	C.7.1.1	M	M
	Clinical Trial Subject	C.7.1.3	U	U
Study	General Study	C.7.2.1	M	M
	Patient Study	C.7.2.2	U	U
	Clinical Trial Study	C.7.2.3	U	U
Series	RT Series	C.8.8.1	M	M
	Clinical Trial Series	C.7.3.2	U	U
Frame of Reference	Frame of Reference	C.7.4.1	U – See Note.	M
Equipment	General Equipment	C.7.5.1	M	M
Plan	RT General Plan	C.8.8.9	M	M
	RT Prescription	C.8.8.10	U	U(geometric), M(dosimetric)
	RT Tolerance Tables	C.8.8.11	U	U
	RT Patient Setup	C.8.8.12	U	U
	RT Fraction Scheme	C.8.8.13	U	U(geometric), M(dosimetric)
	RT Beams	C.8.8.14	C - Required if RT Fraction Scheme Module exists and Number of Beams (300A,0080) is greater than zero for one or more fraction groups	M (Can be excluded for zero beams with non-isocentric model)
	RT Brachy Application Setups	C.8.8.15	C - Required if RT Fraction Scheme Module exists and Number of Brachy Application Setups (300A,00A0) is greater than zero for one or more fraction groups	N/A
	Approval	C.8.8.16	U	M
	SOP Common	C.12.1	M	M

Notes: 1. The RT Structure Set referenced in Referenced Structure Set Sequence (300C,0060) of the RT General Plan Module may contain more than one item in the Referenced Frame of Reference Sequence (3006,0010) in the Structure Set Module. In this case, it is highly recommended that the Frame of Reference Module be supplied in the RT Plan object, to unambiguously specify the frame of reference of the RT Plan contents. (from DICOM 2009 PS3.3).

Table A.2-2 RT Dose IOD Modules

IE	Module	Reference	Usage	IHE-RO Usage
Patient	Patient	C.7.1.1	M	M
	Clinical Trial Subject	C.7.1.3	U	U
Study	General Study	C.7.2.1	M	M
	Patient Study	C.7.2.2	U	U
	Clinical Trial Study	C.7.2.3	U	U
Series	RT Series	C.8.8.1	M	M
	Clinical Trial Series	C.7.3.2	U	U

IE	Module	Reference	Usage	IHE-RO Usage
Frame of Reference	Frame of Reference	C.7.4.1	M	M
Equipment	General Equipment	C.7.5.1	M	M
Dose	General Image	C.7.6.1	C - Required if dose data contains grid-based doses.	M
	Image Plane	C.7.6.2	C - Required if dose data contains grid-based doses.	M
	Image Pixel	C.7.6.3	C - Required if dose data contains grid-based doses.	M
	Multi-Frame	C.7.6.6	C - Required if dose data contains grid-based doses and pixel data is multi-frame data.	M
	Overlay Plane	C.9.2	U	U
	Multi-Frame Overlay	C.9.3	U	U
	Modality LUT	C.11.1	U	U
	RT Dose	C.8.8.3	M	M
	RT DVH	C.8.8.4	U	Outside the scope of this profile.
	Structure Set	C.8.8.5	C - Required if dose data contains dose points or isodose curves	Outside the scope of this profile.
	ROI Contour	C.8.8.6	C - Required if dose data contains dose points or isodose curves	Outside the scope of this profile.
	RT Dose ROI	C.8.8.7	C - Required if dose data contains dose points or isodose curves	Outside the scope of this profile.
	SOP Common	C.12.1	M	

A.3: Radiation Oncology Critical Attributes

The tables below describe requirements, recommendations or explanations on integration-critical attributes for radiation oncology cases.

There are a number of attributes intended to be populated in the original CT, see section RO TF-2: A.1 for further information.

General table structure:

The 1st column denotes the DICOM attributes whose values have Profile requirements beyond the DICOM Standard.

The 2nd column denotes the DICOM attribute tag (for clarity).

The 3rd column defines the IHE-RO criteria for being present and/or displayed. The plus (+) symbol indicates an IHE extension of DICOM, the star (*) symbol indicates the attribute is not required to be displayed. The letter R indicates that the element is required, the letter O that it is optional. An element with type O (with or without the + or * modifiers) is typically called out specifically because some additional constraint has been made on the use of the element. That additional constraint might be that it is to be propagated from an “input object”, that it must not

be relied upon by an actor using it as input, that it is not to be utilized in output by a particular actor, or that it must be made readily viewable by an actor.

The 4th column provides additional information on the constraints for the attribute as well as guidance in the use of the attribute.

Table A.3-1 Patient Module

Attribute	Tag	Type	Attribute Note
Patient's Name	(0010,0010)	R+	IHE requires that this element be present. This element is one of the primary patient identifying elements, and as such, all DICOM objects with the same Study Instance UID, must have the same value in this element. Equipment which creates new series based on other series (i.e. resampled series, new structure sets, plans, etc) must preserve the value of this element to adhere to this profile.
Patient ID	(0010,0020)	R+	See Patient's Name (0010,0010) See Also RAD TF-2: A.3
Patient's Birth Date	(0010,0030)	O+	See Patient's Name (0010,0010) See Also RAD TF-2: A.3
Patient's Sex	(0010,0040)	O+	See Patient's Name (0010,0010) See Also RAD TF-2: A.3

Table A.3-2 General Study Module

Attribute	Tag	Type	Attribute Note
Study Instance UID	(0020,000D)	R+*	IHE requires that this value be preserved in the following cases: If a set of images are resampled and re-exported. This new set of images will be a new series. This series will belong to the same study and will have the same study date. This is to facilitate grouping the images in a PACS. When a plan is constructed from a structure set. The plan will be in the same study, and will have the same study date. IHE requires that this element be present. Equipment which creates new series based on other series (i.e. resampled series, new structure sets, plans, etc) must preserve the value of this element to adhere to this profile.
Study Date	(0008,0020)	R+	[See Study Instance UID (0020,000D)]
Study Time	(0008,0030)	R+	[See Study Instance UID (0020,000D)]
Study ID	(0020,0010)	R+	[See Study Instance UID (0020,000D)]
Study Description	(0008,1030)	O+	[See Study Instance UID (0020,000D)]

Table A.3-3 General Equipment Module

Attribute	Tag	Type	Attribute Note
Manufacturer	(0008,0070)	R+*	IHE requires that this element be present, and should contain the manufacturer of the equipment creating the image, structure set, plan, or dose. If the equipment is storing and forwarding information, the value of this element shall be preserved. If a new plan is created from a previous plan, the manufacturer of the

Attribute	Tag	Type	Attribute Note
			equipment producing the new plan shall insert their identifier in this element. If a new structure set is created from a previous structure set, the manufacturer of the equipment producing the new structure set shall insert their identifier in this element.
Manufacturer's Model Name	(0008,1090)	R+*	If an application resamples and re-exports a series of CT images, or modifies an instance then this element must be present, and must contain the model name of the equipment doing the resampling.

Table A.3-4 Frame Of Reference Module

Attribute	Tag	Type	Attribute Note
Frame of Reference UID	(0020,0052)	R+*	To adhere to the BRTO Profile, all related DICOM objects (CT images, Structure Sets, Plans, and Doses) are required to be in the same frame of reference and have the same Frame of Reference UID.
Position Reference Indicator	(0020,1040)	O+*	Equipment which creates new series based on other series (i.e. resampled series, new structure sets, plans, etc) must preserve the value of this element to adhere to this profile.

Table A.3-5 RT General Plan Module

Attribute	Tag	Type	Attribute Note
RT Plan Label	(300A,0002)	R+	The label which serves as the identification of the plan for the user.
RT Plan Date	(300A,0006)	R+	The date when the plan was last modified.
RT Plan Time	(300A,0007)	R+	The time when the plan was last modified.
RT Plan Geometry	(300A,000C)	R+*	Shall be PATIENT. This implies that the RT Structure Set exists and is referenced in the General Plan module.

Table A.3-6 RT Patient Setup Module

Attribute	Tag	Type	Attribute Note
Patient Setup Sequence	(300A,0180)	R+*	An actor must not rely on the presence of: Fixation Device Sequence Shielding Device Sequence Setup Device Sequence Table Top Vertical Setup Displacement Table Top Longitudinal Setup Displacement Table Top Lateral Setup Displacement within the Patient Setup Sequence for proper operation.
>Patient Position	(0018,5100)	R+	Shall be one of {HFS, FFS, HFP, FFP}. (Decubitus Left and Decubitus Right Positions shall not be supported in the BRTO Profile.)
>Setup Technique	(300A,01B0)	R+*	

Table A.3-7 RT Fraction Group Module

Attribute	Tag	Type	Attribute Note
Fraction Group Sequence	(300A,0070)	R+*	Shall have only a single item in the sequence
>Number of Brachy Application Setups	(300A,00A0)	R+*	Shall be 0. Brachytherapy is not supported in the BRTO Profile.

Table A.3-8 RT Beams Module (for Geometric Planner)

Attribute	Tag	Type	Attribute Note
Beam Sequence	(300A,00B0)	R+*	An actor must be able to safely handle up to 100 Beam Sequence Items (beams).
>Beam Name	(300A,00C2)	R+	The Beam Name must be unique within the sequence.
>Beam Type	(300A,00C4)	R+*	In the BRTO Profile, for Geometric Plans the value shall be STATIC. Only static beams shall be specified in Geometric Plans. This will allow non-arc-based IMRT (such as Step-and-Shoot or Sliding Window techniques, but not techniques such as fixed aperture arc beams, conformal arc beams, or intensity modulated arc beams. As a result, all beams in Geometric Plans shall consist of exactly two control points.
>Radiation Type	(300A,00C6)	R+*	Any value other than PHOTON is outside the scope of the profile
>High-Dose Technique Type	(300A,00C7)	O+*	Geometric Plans shall not specify this attribute.
>Treatment Machine Name	(300A,00B2)	O+*	An Actor must not rely on the presence of this attribute.
>Source-Axis Distance	(300A,00B4)	R+*	This attribute is critical for providing information regarding beam divergence.
>Beam Limiting Device Sequence	(300A,00B6)		For the BRTO Profile, shall report at least one set of MLC descriptions or the descriptions of two sets of jaws.
>Referenced Patient Setup Number	(300C,006A)	R+*	
>Number of Wedges	(300A,00D0)	R+*	Geometric Plans are constrained to a value of 0 (i.e. a Geometric Plan must not include a Wedge).
>Number of Compensators	(300A,00E0)	R+*	Geometric Plans are constrained to a value of 0 (i.e. a Geometric Plan must not include a Compensator).
>Number of Boli	(300A,00ED)	R+*	Geometric Plans are constrained to a value of 0 (i.e. a Geometric Plan must not include any Boli).
>Number of Blocks	(300A,00F0)	R+*	All actors shall be able to handle 8 block items, of which no more than one may be an aperture
>Block Sequence	(300A,00F4)		
>>Block Divergence	(300A,00FA)	R+*	Must be present and non-null if Block Sequence is present (i.e. when Number of Blocks is 1 or more), with a value of PRESENT
>>Block Number of Points	(300A,0104)	R+*	The value is constrained to be 3 or more.
>>Block Data	(300A,0106)	R+*	Shall be present and non-null. Limitations on the total number of points are limited only by DICOM limitations on representation with 'explicit VR' in total byte lengths. Systems that limit support of legal sequences shall safely handle receipt of such sequences that exceed their

Attribute	Tag	Type	Attribute Note
			limitations, and document this behavior in their IHE-RO Profile adherence statement.
>Applicator Sequence	(300A,0107)		Not expected in Geometric Plans. However, if present, shall be handled in a safe manner by the receiving system (and document this behavior in their IHE-RO Profile adherence statement). Applications exporting this sequence are outside the scope of the BRTO Profile.
>Final Cumulative Meterset Weight	(300A,010E)	O+*	Shall not be present in a Geometric Plan.
>Number of Control Points	(300A,0110)	R+*	Shall have a value of 2 for Geometric Plans.
>Control Point Sequence	(300A,0111)	R+*	In the BRTO Profile, for Geometric Plans the second control point (sequence item) shall contain only: • Control Point Index (300A,0112) with a value of 1 • Cumulative Meterset Weight (300A,0134) set to NULL.
>>Cumulative Meterset Weight	(300A,0134)	O+*	Shall be NULL for Geometric Plans (in both the first and second control point).
>>Referenced Dose Reference Sequence	(300C,0050)	O+*	Shall not be present for Geometric Plans. Must not be relied upon by actors operating on the object as a Geometric Plan.
>>Nominal Beam Energy	(300A,0114)	O+*	Actors must not rely on the presence of this attribute to operate correctly. However, if this attribute is present, actors may not ignore the value.
>>Dose Rate Set	(300A,0115)	O+*	Actors must not rely on the presence of this attribute to operate correctly. However, if this attribute is present, actors may not ignore the value.
>>Wedge Position Sequence	(300A,0116)	O+*	Must not be present in a Geometric Plan
>>Beam Limiting Device Position Sequence	(300A,011A)	R+*	Must be present and correspond to those devices defined in the Beam Limiting Device Sequence. It shall be present for a Geometric Plan for Control Point Index 0 only.
>>Gantry Rotation Direction	(300A,011F)	R+*	For a Geometric Plan for Control Point Index 0 only, must have a value of NONE.

Table A.3-9 Multi-Frame Module

Attribute	Tag	Type	Attribute Note
Frame Increment Pointer	(0028,0009)	R+*	Required For RT Dose, Shall have the same value as the Grid Frame Offset Vector (3004,000C).

Table A.3-10 RT Dose Module

Attribute	Tag	Type	Attribute Note
Samples per Pixel	(0028,0002)	R+*	Shall be present and equal to 1.

Attribute	Tag	Type	Attribute Note
Photometric Interpretation	(0028,0004)	R+*	Shall be present and equal to **MONOCHROME2.**
Bits Allocated	(0028,0100)	R+*	Shall be present and equal to 16 or 32.
Bits Stored	(0028,0101)	R+*	Shall be equal to Bits Allocated.
High Bit	(0028,0102)	R+*	Shall be one less than Bits Stored.
Pixel Representation	(0028,0103)	R+*	Shall have the value 0 = unsigned integer. Negative dose values shall not be present.
Dose Units	(3004,0002)	R+*	Shall be equal to the enumerated value **GY.**
Dose Type	(3004,0004)	R+*	Shall be equal to the defined term **PHYSICAL.**
Dose Comment	(3004,0006)	R+	Shall be present and not empty if Referenced RT Plan Sequence (300C,0002) is missing, in which case it should have the same value as RT Plan Description.
Normalization Point	(3004,0008)	O+*	Shall not be relied on.
Dose Summation Type	(3004,000A)	R+*	Shall have the value **PLAN**.
Referenced RT Plan Sequence	(300C,0002)	R+*	Shall be present if Dose Summation Type (3004,000A) has the value **PLAN**.
>Referenced Fraction Group Sequence	(300C,0020)	R+*	Shall be present if the parent sequence is present, and shall reference a single fraction group within the referenced RT Plan.
Grid Frame Offset Vector	(3004,000C)	R+*	First z coordinate shall be equal to zero. The remaining z coordinates shall be relative to the starting z position in Image Position (Patient) (0020,0032).
Tissue Heterogeneity Correction	(3004,0014)	O+	Shall be present but may be null. The value shall be given if known.

Table A.3-11 Image Plane Module

Attribute	Tag	Type	Attribute Note
Image Orientation (Patient)	(0020,0037)	R+*	This element shall be present in every RT Dose IOD. For BRTO, this element shall be restricted to AXIAL images only. For an axial image, direction cosines shall be (±1, 0, 0, 0, ±1, 0) with an angle tolerance of 0.001 radians (~0.057 degrees)
Slice Thickness	(0018,0050)	O+*	Shall not be relied on.
Slice Location	(0020,1041)	O+*	Shall not be relied on.
Pixel Spacing	(0028,0030)	O+*	For CT, non-isotropic pixels are outside the scope of the profile. For RT Dose, pixel spacing may be non-isotropic.

Table A.3-12 Structure Set Module

Attribute	Tag	Type	Attribute Note
Structure Set Label	(3006,0002)	R+	
Structure Set Date	(3006,0008)	R+	
Structure Set Time	(3006,0009)	R+	
Referenced Frame of Reference Sequence	(3006,0010)	R+*	This element is required for all 3D RT Structure Sets which are image based. It is to contain a set of references to the

Attribute	Tag	Type	Attribute Note
			entire set of images which comprise the volume from which the Structure Set was constructed, and which is to be used for planning. There should only be one item in this sequence, as a BRTO Profile-based structure is based on a single set of images, which are all in the same frame of reference.
>Frame of Reference UID	(0020,0052)	R+*	This frame of reference UID shall be the same as the frame of reference of the CT series from which the Structure Set was constructed. It will also be the same as the frame of reference of any related RTPLAN's or RTDOSE's.
>RT Referenced Study Sequence	(3006,0012)	R+*	Shall be present and contain the series sequence. Only one item allowed in this sequence.
>>Referenced SOP Instance UID	(0008,1155)	R+*	This Study Instance UID shall be the same as the Study Instance UID of the related CT instances.
>>RT Referenced Series Sequence	(3006,0014)	R+*	Shall be present to contain the Contour Image Sequence. Only one item allowed in this sequence.
>>>Series Instance UID	(0020,000E)	R+*	Shall be present and contain the series to which the set of CT images upon which the structure set is based belong.
>>>Contour Image Sequence	(3006,0016)	R+*	Shall be present. Contains an item for each CT image in the volume upon which the Structure Set is based.
>>>>Referenced SOP Class UID	(0008,1155)	R+*	Shall be present with a value of '1.2.840.10008.5.1.4.1.1.2' This profile is for volumes based on CT Images only
>>>>Referenced Frame Number	(0008,1160)	O+*	Shall not be present
Structure Set ROI Sequence	(3006,0020)	R+*	This sequence shall be present. It defines the ROI's in this Structure Set.
>ROI Number	(3006,0022)	R*	This defines an index to be used for referencing a particular ROI item from other sequences. It is required to be unique within the Structure Set in which it is created. No limitation on values other than uniqueness within sequence.
>Referenced Frame of Reference UID	(3006,0024)	R*	This frame of reference UID shall be the same as the frame of reference UID of the CT series from which the Structure Set was constructed. It will also be the same as the frame of reference of any related RTPLAN or RTDOSE instances.
>ROI Name	(3006,0026)	R+	This is the primary identifier for an ROI (from user perspective). Shall be present and should match UI display. Shall be unique within the Structure Set ROI sequence.
>ROI Description	(3006,0028)	O+*	Not required - no compliant implementation shall rely on this element being present for proper operation.
>ROI Volume	(3006,002C)	O+*	Not required - no compliant implementation shall rely on this element being present for proper operation.
>ROI Generation Algorithm	(3006,0036)	R+	Shall be present, with a value of AUTOMATIC, SEMIAUTOMATIC, or MANUAL. This information may be presented to a user, but no semantics for handling a Structure Set is required for this profile. Implementations which create Structure Set instances must provide an appropriate value.

Table A.3-13 RT ROI Observations Module

Attribute	Tag	Type	Attribute Note

Attribute	Tag	Type	Attribute Note
RT ROI Observations Sequence	(3006,0080)	R+*	This sequence contains information about an ROI. It references the ROI in Referenced ROI Number which contains a number which must match one of the ROI numbers in one of the elements of the Structure Set ROI Sequence. In particular, a Structure Set shall contain an element in this sequence for ISOCENTER.
>Referenced ROI Number	(3006,0084)	R+*	Specifies the ROI to which this observation applies. For every item in Structure Set ROI sequence, at least one observation is required, with values in ROI Interpreted Type and ROI Interpreter.
>RT ROI Interpreted Type	(3006,00A4)	O+*	Required if there is not another item in the RT ROI Observations Sequence with the same Referenced ROI Number which has this element populated or the ROI is only utilized to describe a physical property. If referenced ROI has associated contours of type CLOSED_PLANAR, must be one of: EXTERNAL PTV CTV GTV TREATED_VOLUME IRRAD_VOLUME BOLUS AVOIDANCE ORGAN MARKER CONTRAST_AGENT CAVITY If referenced ROI has associated contours of type POINT, must be one of: MARKER REGISTRATION ISOCENTER
>ROI Physical Properties Sequence	(3006,00B0)	O+*	Not required, but shall not be ignored if supplied.
>>ROI Physical Property	(3006,00B2)	R+*	Only relative electron density shall be supported: REL_ELEC_DENSITY

Table A.3-14 ROI Contour Module

Attribute	Tag	Type	Attribute Note
ROI Contour Sequence	(3006,0039)	R*	
>ROI Display Color	(3006,002A)	O+*	Not required - no compliant implementation shall rely on this element being present for proper operation. However applications are allowed to be aware of this element and use it to map display colors.
>Contour Sequence	(3006,0040)	R+*	Shall be present. Shall contain an item for each contour in the ROI. Compliant implementations shall be able to handle as many as 100 contours on a single slice. That is, the number of contours in items in all Contour Sequences with the same z-

Attribute	Tag	Type	Attribute Note
			coordinate (and referenced CT image) should be less than or equal to 100.
>>Contour Image Sequence	(3006,0016)	R+*	Shall be present with a single item. This item is the image upon which this contour should be placed. If the contour type is CLOSED_PLANAR, then the z-coordinates of the contour shall match the z-coordinate of Image Position (Patient) in the image.
>>>Referenced SOP Class UID	(0008,1150)	R+*	Shall be present with a value of '1.2.840.10008.5.1.4.1.1.2'
>>>Referenced SOP Instance UID	(0008,1155)	R*	SOP Instance UID of the image being referenced.
>>>Referenced Frame Number	(0008,1160)	O+*	Shall not be present
>>Contour Geometric Type	(3006,0042)	R+*	Shall be present, with a value of POINT or CLOSED_PLANAR. Conforming implementations must properly interpret this value.
>>Contour Slab Thickness	(3006,0044)	O+*	Not required - no compliant implementation shall rely on this element being present for proper operation.
>>Contour Offset Vector	(3006,0045)	O+*	The profile requires that this attribute be zero if present.
>>Number of Contour Points	(3006,0046)	R+*	Required, and must match the actual number of points in Contour Data. Shall not exceed the number for which the Contour Data can not be encoded when using explicit transfer syntax.
>>Contour Data	(3006,0050)	R+*	Shall be present. If contour type is CLOSED_PLANAR, then all points must have the same z-coordinate. This z-coordinate shall match the z-coordinate in the related CT image within 0.01 mm (contained in the Contour Image sequence in the same item of the ROI Contour Sequence as this data). An implication of this is that the CLOSED_PLANAR contours are axial.

Table A.3-15 SOP Common Module

Attribute	Tag	Type	Attribute Note
SOP Instance UID	(0008,0018)	R+*	If an application alters an Information Object instance, then the new Information Object instance shall be assigned a new UID.
Specific Character Set	(0008,0005)	O+*	Shall be blank or present with value "ISO_IR 100" Only ASCII and ISO_IR 100 are supported in this profile. Character codes in message will reflect value of this element. IHE-RO has a goal of providing broader multi-language support, potentially using Unicode UTF-8 but not in this profile.
Instance Creation Date	(0008,0012)	O+*	Actors must not rely on the presence of this attribute to operate correctly.
Instance Creation Time	(0008,0013)	O+*	Actors must not rely on the presence of this attribute to operate correctly.
Instance Creator UID	(0008,0014)	O+*	Actors must not rely on the presence of this attribute to operate correctly.
Instance Number	(0020,0013)	O+*	Actors must not rely on the presence of this attribute to

Attribute	Tag	Type	Attribute Note
			operate correctly.

