ASTRO

Integrating the Healthcare Enterprise

IHE-Radiation Oncology Technical Framework Volume 1 – Integration Profiles

2008

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Comments may be submitted to:

http://forums.rsna.org under the "*IHE*" forum

Select the "*Radiation Oncology Technical Framework*" sub-forum.

Contents

1 Foreword

Integrating the Healthcare Enterprise (IHE) is an initiative designed to stimulate the integration of the information systems that support modern healthcare institutions. Its fundamental objective is to ensure that in the care of patients all required information for medical decisions is both correct and available to healthcare professionals. The IHE initiative is both a process and a forum for encouraging integration efforts. It defines a technical framework for the implementation of established messaging standards to achieve specific clinical goals. It includes a rigorous testing process for the implementation of this framework. And it organizes educational sessions and exhibits at major meetings of medical professionals to demonstrate the benefits of this framework and encourage its adoption by industry and users.

The approach employed in the IHE initiative is not to define new integration standards, but rather to support the use of existing standards, HL7, DICOM, IETF, and others, as appropriate in their respective domains in an integrated manner, defining configuration choices when necessary. When clarifications or extensions to existing standards are necessary, IHE refers recommendations to the relevant standards bodies.

This initiative has numerous sponsors and supporting organizations in different medical specialty domains and geographical regions. In North America the primary sponsors are the American College of Cardiology (ACC), the Healthcare Information and Management Systems Society (HIMSS) and the Radiological Society of North America (RSNA). IHE Canada has also been formed. IHE Europe (IHE-EUR) is supported by a large coalition of organizations including the European Association of Radiology (EAR) and European Congress of Radiologists (ECR), the Coordination Committee of the Radiological and Electromedical Industries (COCIR), Deutsche Röntgengesellschaft (DRG), the EuroPACS Association, Groupement pour la Modernisation du Système d'Information Hospitalier (GMSIH), Société Francaise de Radiologie (SFR), and Società Italiana di Radiologia Medica (SIRM). In Japan IHE-J is sponsored by the Ministry of Economy, Trade, and Industry (METI); the Ministry of Health, Labor, and Welfare; and MEDIS-DC; cooperating organizations include the Japan Industries Association of Radiological Systems (JIRA), the Japan Association of Healthcare Information Systems Industry (JAHIS), Japan Radiological Society (JRS), Japan Society of Radiological Technology (JSRT), and the Japan Association of Medical Informatics (JAMI). Other organizations representing healthcare professionals are actively involved and others are invited to join in the expansion of the IHE process across disciplinary and geographic boundaries.

The IHE Technical Frameworks for the various domains (Patient Care Coordination, IT Infrastructure, Cardiology, Laboratory, Radiation Oncology, Radiology, etc.) define specific implementations of established standards to achieve integration goals that promote appropriate sharing of medical information to support optimal patient care. These are expanded annually, after a period of public review, and maintained regularly through the identification and correction of errata. The current version for these Technical Frameworks may be found at www.ihe.net.

The IHE Technical Framework identifies a subset of the functional components of the healthcare enterprise, called IHE Actors, and specifies their interactions in terms of a set of coordinated, standards-based transactions. It describes this body of transactions in progressively greater depth. The 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. The subsequent volumes provide detailed technical descriptions of each IHE transaction.

1.1 Content of the IHE-RO Technical Framework

This profile defines the relevant standards and constraints on those standards in order to implement a specific use case for the transfer of information between systems. This document is organized into 2 volumes as follows:

1.1.1 Volume 1 – Integration Profiles

This volume is provided as a high level overview of the profiles including descriptions of the use cases, the actors involved, the process flow, and dependencies on other standards and IHE profiles. It is of interest to care providers, vendors' management and technical architects and to all users of the profile

1.1.2 Volume 2 – Transactions

This volume is intended as a technical reference for the implementation of specific transactions in the use case including references to the relevant standards, constraints, and interaction diagrams. It is intended for the technical implementers of the profile.

2 Preface to Volume 1

2.1 Intended Audience

The intended audience of this document is:

- Healthcare professionals involved in informatics
- IT departments of healthcare institutions
- Technical staff of vendors participating in the IHE initiative
- Experts involved in standards development
- Those interested in integrating healthcare information systems and workflows

2.2 How this Volume is Organized

Section 2 describes the general nature, purpose and function of the Technical Framework.

Section 3 and the subsequent sections of this volume provide detailed documentation on each integration profile, 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 a summary list of the actors and transactions, detailed discussion of specific issues related to the integration profiles and a glossary of terms and acronyms used.

2.3 Conventions Used in this Document

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.

2.3.1 Technical Framework Cross-references

When references are made to another section within a 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 (PCC= Patient Care Coordination, ITI = IT Infrastructure, RAD = Radiology, RO = Radiation Oncology)

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

<section number> is the applicable section number.

For example: RO TF-1: 3.1 refers to Section 3.1 in volume 1 of the IHE Radiation Oncology Technical Framework, ITI TF-2: 4.33 refers to Section 4.33 in volume 2 of the IHE IT Infrastructure Technical Framework.

2.3.2 IHE 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 communicate the required information through standards-based messages.

The diagrams and tables of actors and transactions in subsequent sections indicate which transactions each actor in a given profile must support.

The transactions shown on the diagrams are identified both by their name and the transaction number as defined in RO TF-2 (Volume 2 of the RO Technical framework). The transaction numbers are shown on the diagrams as bracketed numbers prefixed with the specific Technical Framework domain.

In some cases, a profile is dependent on a prerequisite profile in order to function properly and be useful. These dependencies, if any would be found by locating the desired profile in Table 2.6-1 to determine which profile(s) are listed as prerequisites. An actor must implement all required transactions in the prerequisite profiles in addition to those in the desired profile.

2.3.3 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 an overview so the transactions can be seen in the context of an institution's or cross-institutions' 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 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. Transactions are shown as arrows oriented according to the flow of the primary information handled by the transaction and not necessarily the initiator.

2.4 Copyright Permissions

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2.5 Comments

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

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3 Introduction

This document, the IHE Radiation Oncology Technical Framework (RO TF), defines specific implementations of established standards. These are intended to achieve integration goals that promote appropriate exchange of medical information to coordinate the optimal patient care among care providers in different care settings. It is expanded annually, after a period of public review, and maintained regularly through the identification and correction of errata. The latest version of the document is always available via the Internet at http://www.ihe.net/Technical_Framework/ , where the technical framework volumes specific to the various healthcare domains addressed by IHE may be found.

The IHE Radiation Oncology Technical Framework identifies a subset of the functional components of the healthcare enterprises and health information networks, called IHE actors, and specifies their interactions in terms of a set of coordinated, standards-based transactions.

The other domains within the IHE initiative also produce Technical Frameworks within their respective areas that together form the IHE Technical Framework. Currently, the following IHE Technical Framework(s) are available:

- IHE IT Infrastructure Technical Framework
- IHE Cardiology Technical Framework
- IHE Eye Care
- IHE Laboratory Technical framework
- IHE Radiology Technical Framework
- IHE Patient Care Coordination Technical Framework

Where applicable, references are made to other technical frameworks. For the conventions on referencing other frameworks, see the preface of this volume.

3.1 Relationship to Standards

The IHE Technical Framework identifies functional components of a distributed healthcare environment (referred to as IHE actors), solely from the point of view of their interactions in the healthcare enterprise. At its current level of development, it defines a coordinated set of transactions based on standards (such as HL7, IETF, ASTM, DICOM, ISO, OASIS, etc.) in order to accomplish a particular use case. As the scope of the IHE initiative expands, transactions based on other standards may be included as required.

In some cases, IHE recommends selection of specific options supported by these standards. However, IHE does not introduce technical choices that contradict conformance to these standards. If errors in or extensions to existing standards are identified, IHE's policy is to report them to the appropriate standards bodies for resolution within their conformance and standards evolution strategy.

IHE is therefore an implementation framework, not a standard. Conformance claims for products must still be made in direct reference to specific standards. In addition, vendors who have implemented IHE integration capabilities in their products may publish IHE Integration Statements to communicate their products' capabilities. Vendors publishing IHE Integration Statements accept full responsibility for their content. By comparing the IHE Integration Statements from different products, a user familiar with the IHE concepts of actors and integration profiles can determine the level of integration between them. See http://www.ihe.net/Resources/upload/ihe_integration_statements.pdf for the format of IHE Integration Statements.

3.2 Relationship to Product Implementations

The IHE actors and transactions described in the IHE Technical Framework are abstractions of the real-world healthcare information system environment. While some of the transactions are traditionally performed by specific product categories (e.g. HIS, Clinical Data Repository, Electronic Health record systems, Radiology Information Systems, Clinical Information Systems or Cardiology Information Systems), the IHE Technical Framework intentionally avoids associating functions or actors with such product categories. For each actor, the IHE Technical Framework defines only those functions associated with integrating 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 healthcare information system.

The reason for defining actors and transactions is to provide a basis for defining the interactions among functional components of the healthcare information system environment. In situations where a single physical product implements multiple functions, only the interfaces between the product and external functions in the environment are considered to be significant by the IHE initiative. Therefore, the IHE initiative 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.

3.3 Framework Development and Maintenance

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 or clarifications to the Technical Framework must maintain backward compatibility with previous versions of the framework (except in rare cases for corrections) 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 RO 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 Technical Framework for "Trial Implementation." This version contains both the stable body of the Technical Framework from the preceding cycle and the newly developed supplements. It is this version of the Technical Framework that is used by vendors in developing trial implementation software for the IHE Connectathons.
3. The Committee regularly considers change proposals to the Trial Implementation version of the Technical Framework, including those from implementers who participate in the Connectathon. After resolution of all change proposals received within 60 days of the Connectathon, the Technical Framework version is published as "Final Text".

The Committee as part of the Technical framework maintenance will consider change proposals received after the publication to the "Final Text".

3.4 Integration Profiles Overview

In this document, each IHE Integration Profile is defined by:

- The IHE actors involved
- The specific set of IHE transactions exchanged by each IHE actor.

These requirements are presented in the form of a table of transactions required for each actor supporting the Integration Profile. Actors supporting multiple Integration Profiles are required to support all the required transactions of each Integration Profile supported. When an Integration Profile depends upon another Integration Profile, the transactions required for the dependent Integration Profile have not been included in the table.

Note that IHE Integration Profiles are not statements of conformance to standards, and IHE is not a certifying body. Users should continue to request that vendors provide statements of their conformance to standards issued by relevant standards bodies, such as HL7 and DICOM. Standards conformance is a prerequisite for vendors adopting IHE Integration Profiles.

Also note that there are critical requirements for any successful integration project that IHE cannot address. Successfully integrating systems still requires a project plan that minimizes disruptions and describes fail-safe strategies, specific and mutually understood performance expectations, well-defined user interface requirements, clearly identified systems limitations, detailed cost objectives, plans for maintenance and support, etc.

3.5 Radiation Oncology Integration Profiles

3.5.1 Overview

IHE Integration Profiles offer a common language that healthcare professionals and vendors can use to discuss integration needs of healthcare enterprises and the integration capabilities of information systems in precise terms. Integration Profiles specify implementations of standards that are designed to meet identified clinical needs. They enable users and vendors to state which IHE capabilities they require or provide, by reference to the detailed specifications of the IHE Radiation Oncology Technical Framework.

Integration profiles are defined in terms of IHE Actors, transactions and their content. Actors (listed in RO TF-1: Appendix A) are information systems or components of information systems that produce, manage, or act on information associated with clinical and operational activities. Transactions (listed in RO TF-1: Appendix B) are interactions between actors that communicate the required information through standards-based messages.

Vendor products support an Integration Profile by implementing the appropriate actor(s) and transactions. A given product may implement more than one actor and more than one integration profile as in example below.

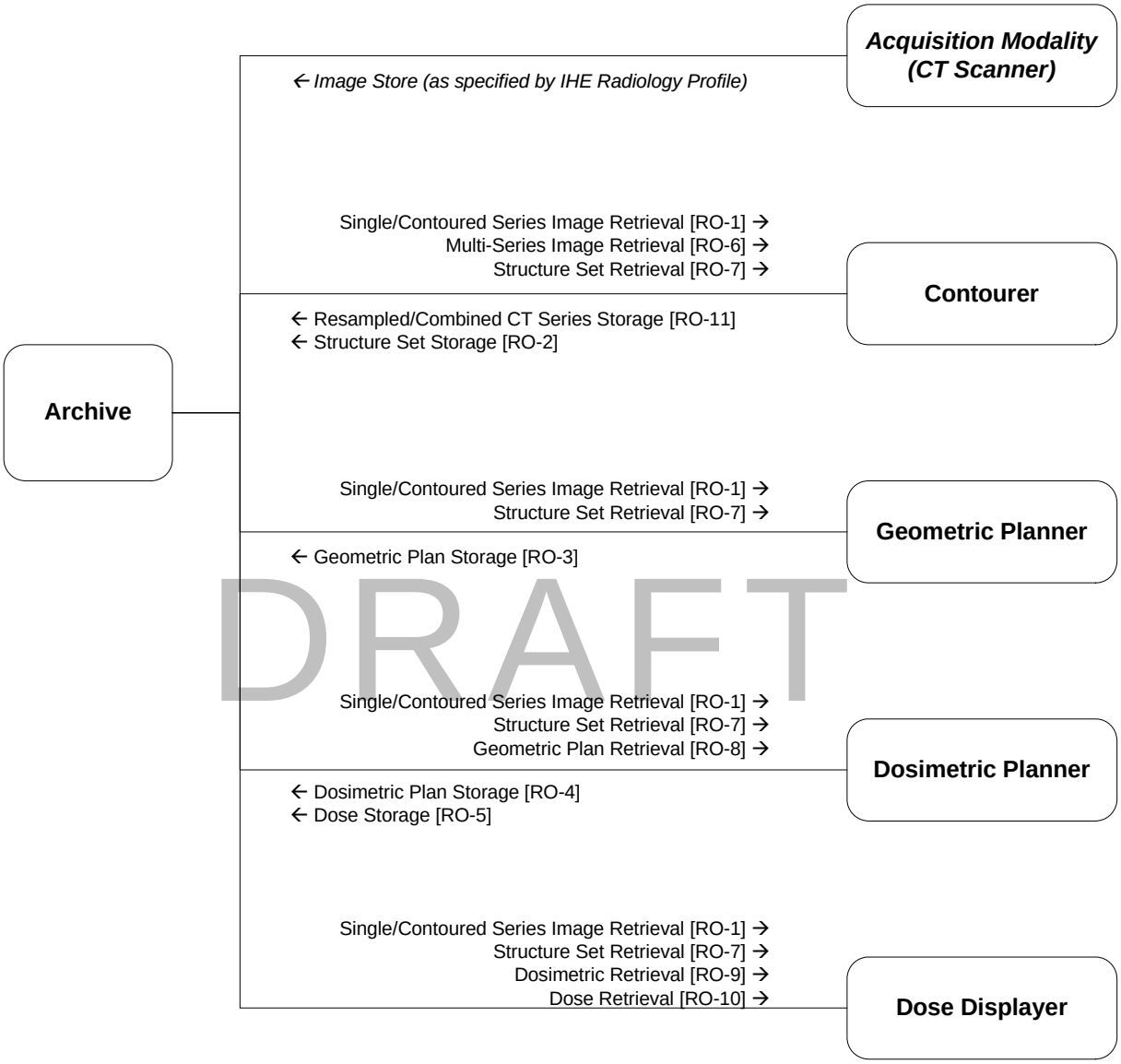


Figure 3.5-1 IHE Radiation Oncology Integration Profiles

To support a dependent profile, an actor must implement all required transactions in the prerequisite profiles in addition to those in the dependent profile. In some cases, the prerequisite is that the actor selects any one of a given set of profiles.

The following profiles are documented in this framework:

- **RT Objects Integration Profile:** The integration profile for 2008 involves the flow of DICOM images and treatment planning data, from CT scan through dose display, for 3D conformal, external beam radiation therapy. The emphasis for this first Integration Profile is on reducing ambiguity and facilitating basic interoperability in the exchange of DICOM RT objects.

- **Integrated Positioning and Delivery Profile:** In this profile a single system, a Positioning and Delivery System (PDS) acquires positioning images or other information, performs a registration of that data with the desired position, adjusts the patient position accordingly, and finally performs a treatment delivery using internal verification (see DICOM Supplement 74).
- **Image Registration Profile:** The Image Registration Integration Profile specifies communications between systems creating and registering image sets. It defines how DICOM objects for spatial registration and the images themselves are created, stored, queried, retrieved, and processed.

3.5.2 Scope of Future Work

In the course of this work the following profiles were identified as suitable for implementation in following years:

- A standalone device acquires positioning information (e.g. an image or fiducial set) and performs a registration. A second device then performs the indicated adjustments and delivers the radiation.

  Performing Actor 1: Acquisition and Registration

  Performing Actor 2: Patient position correction and Delivery

- A standalone device acquires positioning information (e.g. an in-room CT, portal imaging device, or non-image-based device). A second device performs a registration. A third device then performs the indicated adjustments and delivers the radiation.

  Performing Actor 1: Acquisition

  Performing Actor 2: Registration

  Performing Actor 3: Patient position correction and Delivery

Evolution

The Treatment Delivery Workflow integration profile for 2008 involves the flow of DICOM data necessary for treatment delivery from Archive and Treatment Management System (TMS) actors to Positioning, Delivery, and Positioning and Delivery systems.

This document describes the first profiles in a progression of profiles that will implement workflow features in radiation oncology. The intended sequence of development for these profiles is as follows:

- **Phase 1 (these profiles):** Scheduled workflow for patient positioning and delivery.
- **Phase 2:** Scheduled workflow for remaining procedure step types in radiation oncology. These steps may include items such as simulation, planning, plan review, and treatment review, as well as other modes of positioning and delivery. At this stage, the profile will then cover the vast majority of cases in radiation therapy, and enable charge capture by the Treatment Management System or billing system.

  Managed Workflow can be used to support a number of other common use case scenarios currently relevant in the clinic. For example, if a number of fractions are delivered, then subsequently the stored registration images and position registration results can be transmitted from the archive to a treatment planning system (TPS). The TPS could then correlate the images, deform the original structures onto the new 3D datasets, recalculate the doses to PTVs and organs at risk, and evaluate a potential need for replanning. These operations can be initiated by non-managed transfer of necessary data using Storage or Query/Retrieve, but ultimately the goal is to manage all departmental activities using Managed Workflow.
- **Phase 3:** ADT (admission, discharge, and transfer) support. This profile will enable a Treatment Management System to acquire patient demographic information from a Hospital Information System (via the HL7 protocol), based upon existing IHE patient registration profiles. This functionality has already been implemented in some commercially available products and this phase may potentially be combined with Phase 2.
- **Phase 4:** Non-managed workflow. Special cases such as emergency treatments may result in performed procedures that have no corresponding Unified Procedure Step. This profile will be concerned with updating the Treatment Management System to take this into account, so that the performed items are then recorded and billed through the normal processes. This phase may require the RT Course IOD being developed as part of DICOM WG7 work on second-generation RT objects.
- **Phase 5:** Partially-managed workflow and media archive. This profile will support situations where some procedures (e.g. CT acquisition and an initial plan) have not been performed under managed workflow, but the output objects from those procedures are introduced into the workflow environment via media archive. It will also support generation of media archives. This phase may require the RT Course IOD being developed as part of DICOM WG7 work on second-generation RT objects.

3.6 Product Implementations

Developers have a number of options in implementing IHE actors and transactions in product implementations. The decisions cover three classes of optionality:

- For a system, select which actors it will incorporate (multiple actors per system are acceptable).

- For each actor, select the integration profiles in which it will participate.
- For each actor and profile, select which options will be implemented.

All required transactions must be implemented for the profile to be supported.

Implementers should provide a statement describing which IHE actors, IHE integration profiles and options are incorporated in a given product. The recommended form for such a statement is defined at http://www.ihe.net/Resources/upload/ihe_integration_statements.pdf .

In general, a product implementation may incorporate any single actor or combination of actors. When two or more actors are grouped together, internal communication between actors is assumed to be sufficient to allow the necessary information flow to support their functionality. The exact mechanisms of such internal communication are outside the scope of the IHE Technical Framework.

When multiple actors are grouped in a single product implementation, all transactions originating or terminating with each of the supported actors shall be supported (i.e., the IHE transactions shall be offered on an external product interface).

4 RT Objects Integration Profile

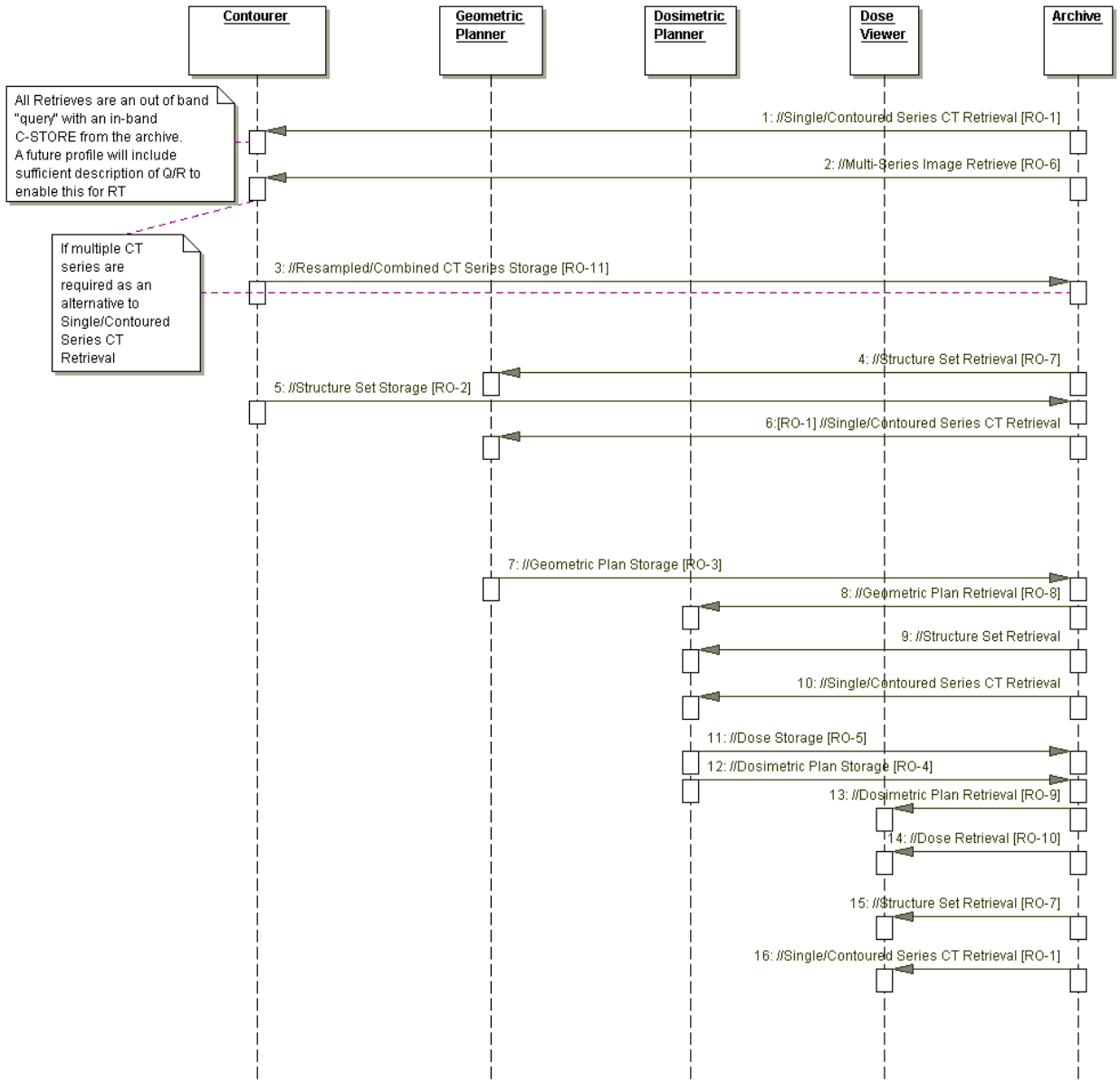
4.1 Scope and Purpose

The integration profile for 2008 involves the flow of DICOM images and treatment planning data, from CT scan through dose display, for 3D conformal, external beam radiation therapy. The emphasis for this first Integration Profile is on reducing ambiguity and facilitating basic interoperability in the exchange of DICOM RT objects.

4.2 RT Object Process Flow

The process flow of the RT Object Integration Profile is shown in Figure 4.2-1.

Figure 4.2-1 IHE RT Object Integration Profile



5 Image Registration Integration Profile

5.1 Scope and Purpose

This Integration Profile specifies how images, RT Structure Sets, RT Doses, and associated spatial registration information can be exchanged, stored, processed and displayed. For a display workstation, it is essential that a workstation correctly identifies the corresponding image sets, matches data from single-slice and multi-slice datasets, matches coordinate systems, and performs spatial translations. The use of relevant DICOM objects (Spatial Registration) is clarified and constrained in order to avoid misinterpretation.

Image Registration Integration Profile focuses on content for image registration and does not define a registration workflow. Such workflow could be managed by using mechanisms described in the Post-Processing Workflow Integration Profile.

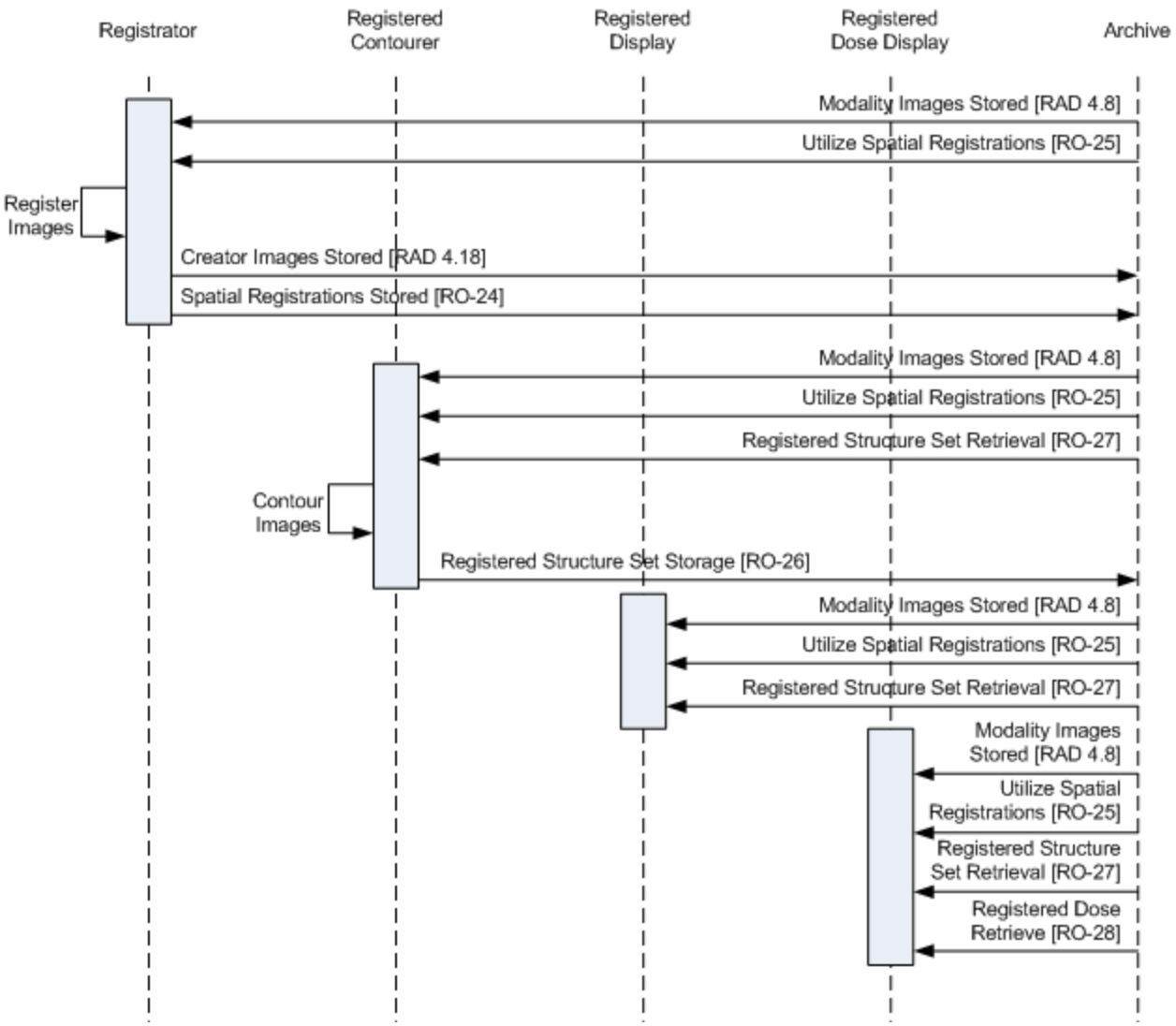
The Image Registration Integration Profile currently only handles rigid registration. The intention is to add deformable registration as an extension to the Profile in the future.

The Image Registration Profile does not specify the use of quantification methods for the image data that is created or displayed. In particular interoperability for PET Standard Uptake Values (SUV) is considered a relevant future work item for IHE. Note that vendors may wish to provide SUV capability even though not required under this Profile.

5.2 Process Flow

The process flow of the Image Registration Integration Profile is shown in Figure 5.2-1.

Figure 5.2-1 IHE Image Registration Integration Profile



5.3 Actors/ Transactions

Figure 5.3-1 shows the actors directly involved in the Image Registration Integration Profile and the relevant transactions between them. Other actors that may be indirectly involved due to their participation in other relevant transactions are not necessarily shown.

The Image Registration Profile defines a new Registered Contourer actor, but must be compatible with RT Structure Set objects created by the Contourer actor.

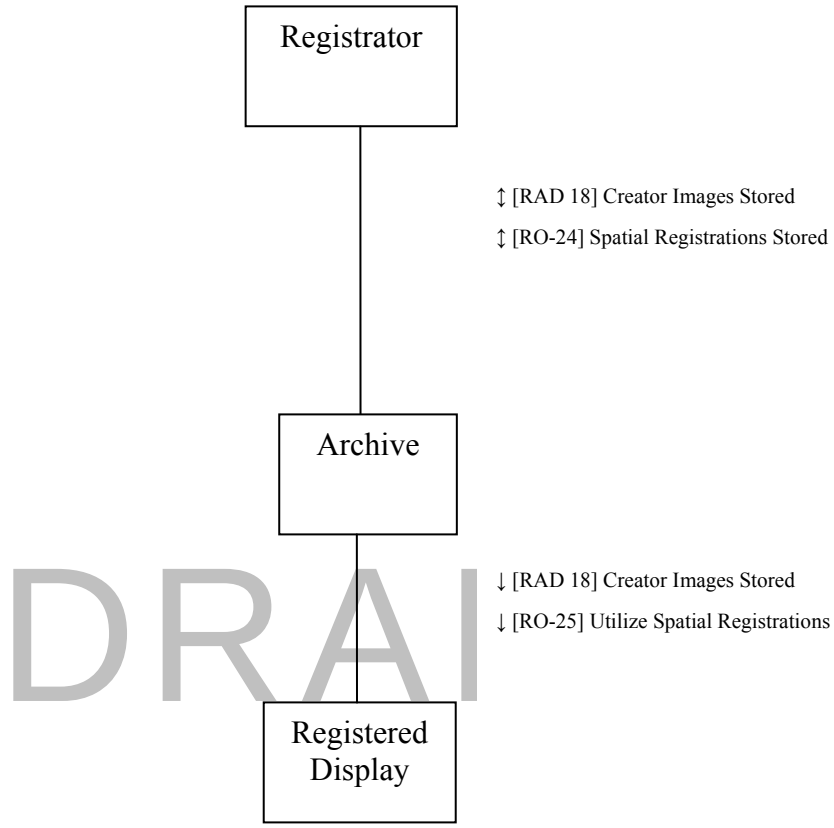


Figure 5.3-1 Image Registration Profile Actors Diagram

Table A.2-2 lists the transactions for each actor directly involved in the Image Registration 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, Appendix A.2.

5.4 Image Registration Integration Profile Options

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

5.5 Image Registration Integration Profile Process Flow

Image Registration presents information registering two datasets in a common Frame of Reference. The basic process steps to Image Registration are:

- Creation of each of the datasets.
- Registration (if necessary) to find the transformation that spatially aligns the datasets.
- If registering more than 2 datasets, the registration step must be repeated. All registered datasets must be registered to the same coordinate system specified by a common Frame of Reference UID.
- Application of the registration transformation to multiple datasets in order to display the registration result.

The registered image series may be utilized by a Radiation Oncologist for contouring, planning, and reviewing dose distributions.

5.5.1 General Contouring Case

This case uses the Image Registration mechanisms along with contouring.

- Two series of images (data sets), for example a CT or MR series and a PET series, are acquired and reconstructed on multiple different Acquisition Modalities (see Figure 5.5-1).
- The image datasets, each with a different Frame of Reference, are stored to the Archive.
- A Contourer Actor receives the image sets and creates an RT Structure Set in the same Frame of Reference as one of the datasets. Each dataset may have a RT Structure Set created in its Frame of Reference.
- The Registered Contourer will store the RT Structure Set(s) to the Archive.
- A Registrator obtains the datasets and determines the transformation for mapping each dataset from their respective Frame of Reference into the first Frame of Reference and records the transformations in Spatial Registration objects. For example: To describe the registration of all 3 image sets, 2 Spatial Registration objects will be required. The first will register the MR to the CT, and the second will register the PET to the CT. In this case the CT establishes the Registered Frame of Reference. More complex relationships may be described by the Spatial Registration objects, which do not subscribe to the above example and do satisfy the DICOM standard. Support for those relationships are out of band for this profile. However, the Registrator may accept those Spatial Registration objects, and reorganize the registrations to satisfy this profile. This capability is not required to satisfy this profile.
- To render the display, the Registered Display uses the transformation in the Spatial Registration to translate the superimposed data into the same space as the underlying data. Because the RT Structure Set shares a Frame of Reference UID with one of the datasets, the structures will be transformed by applying the same transformation to the coordinates in the structure set as the dataset.

- The appearance of the fused display is out of band for this profile.

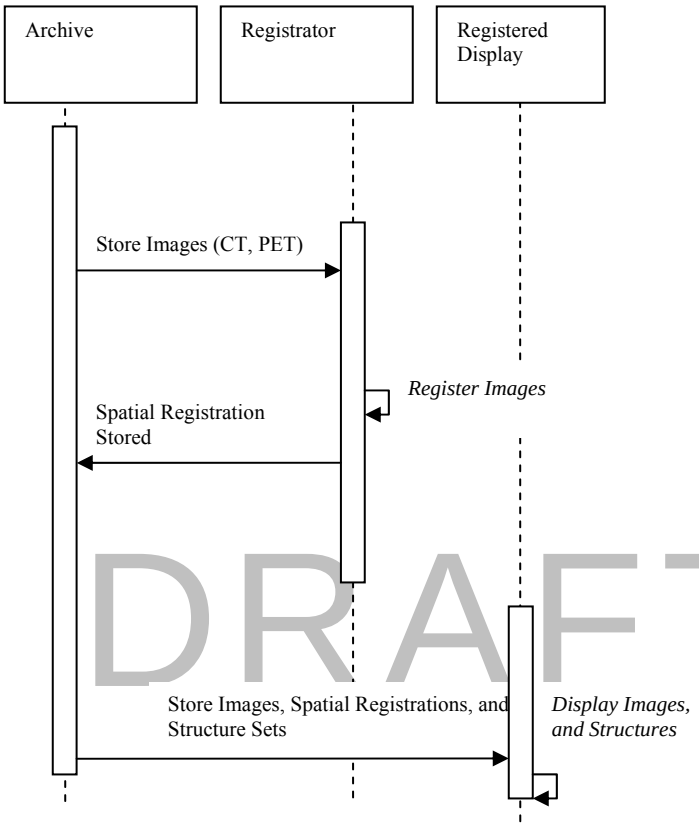


Figure 5.5-1 Image Registration - General Case

5.5.2 Shared Frame of Reference Case

Hybrid Modalities, (e.g. PET/CT Scanner) combine two modalities into a single system. Typically they calibrate the couch motion and scan space, and, assuming the patient does not move, can store the two datasets already mapped into a common space. This also applies to RT objects, such as RT Structure Set and RT Dose objects, as they will share a common Frame of Reference with the dataset.

- Two series of images (data sets), for example a PET series and a CT series, are acquired and reconstructed on a single hybrid system (see Figure 5.5-2).
- The image datasets, each with the ***same*** Frame of Reference, are stored to the Archive. A common Frame of Reference implies that the two datasets are already in the same coordinate system and no transformation is required.
- A Registered Contourer Actor retrieves the image sets and creates an RT Structure Set in the same Frame of Reference as the datasets. The resulting RT Structure Set

shall explicitly reference the images from only one of the series in the Frame of Reference. If structures are defined for both image sets two RT Structure Set instances will be required. Each RT Structure Set references a single image set.

- The Registered Contourer will store the RT Structure Set(s) to the Archive.
- A Registered Display is sent the datasets, and RT Structure Set(s), and observes that no Spatial Registration object is referenced. It also observes that the two datasets and RT Structure Set share the same Frame of Reference.
- The Registered Display re-samples the datasets, if necessary to match resolution for display. No spatial registration transformation is required.
- The appearance of the fused display is out of band for this profile.

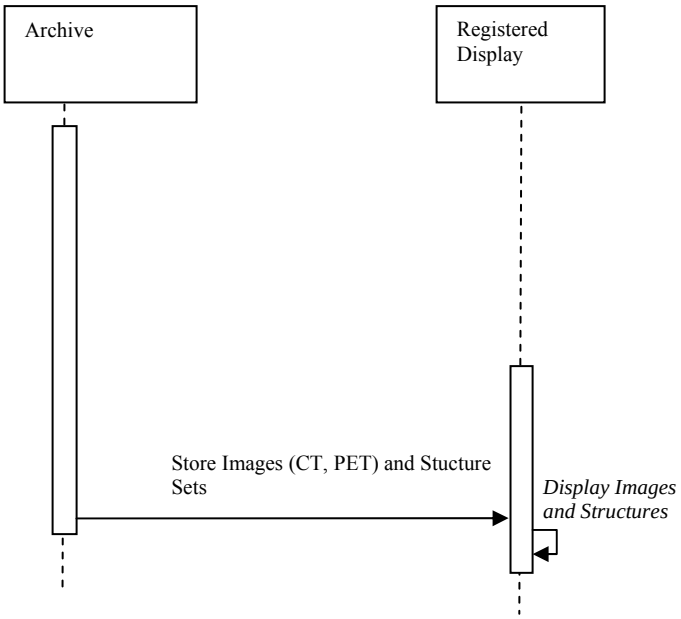


Figure 5.5-2 Image Registration - Hybrid Case

5.6 Image Registration Steps

The following sections describe variants of each Image Registration step, and how they should be handled in this Profile.

5.6.1 Creating datasets

The Image Registration Profile applies to many types of data. Although each type may need to be handled differently, fused display is possible with each type.

The datasets will usually be created by Acquisition Modality actors, however in some scenarios the datasets could be the result of post-processing by a Registrator actor.

This profile only addresses the registration of Volumetric datasets, RT Structure Set and RT Dose objects.

Volumetric datasets refer to a collection of planar images which span a volume and each image has a defined location in space. Typical examples include a set of CT transverse slices, MR slice stacks and PET transaxial images. In the "easiest" situation, multiple volumetric datasets are created in the same Frame Of Reference. Datasets with the same Frame of Reference value are inherently registered and so a registration step is not strictly necessary.

A shared Frame Of Reference may be the result of:

- A hybrid scanner such as a PET/CT being used to image the patient
- A positioning system, such as a fixed head frame, being used to position the patient at the same location and orientation each time for imaging
- A single scanner being used to image the patient at several closely spaced time intervals (e.g. gated cardiac or pulmonary imaging)
- A second dataset being created by a post-processing step (e.g. tissue enhancement or tumor segmentation) and inheriting the Frame of Reference of the first dataset

Note that datasets with a shared Frame of Reference UID implies they are in the same reference coordinate system, but does not guarantee that they overlap. For example, a pelvis series and a head series from the same MR scan may share a Frame of Reference.

More typically, volumetric datasets are each created with a unique Frame Of Reference.

Different Frames of Reference may be the result of:

- Different equipment being used to image the patient
- The same piece of equipment being used to image the patient at different times
- Different patients/subjects being imaged (as in a comparative study or when patient images are mapped to an atlas for display or analysis)

5.6.2 Registering Datasets

To perform registration when datasets do not share a Frame of Refence, it is necessary to define a relationship between them. Even if two datasets ***do*** share a Frame of Reference, for example on the basis of assuming no patient motion, or assuming two acquisition systems are perfectly calibrated, it is sometimes still useful to perform a registration based on fiducials, image content or something else.

Once the registration is complete, the resulting transformation is recorded in a Spatial Registration object which is typically stored in the study with the image data. The DICOM Spatial Registration object supports rigid registrations (translation, rotation and scaling).

Spatial Registration objects will usually be created by Registrator actors; however in some situations a registration object will not be strictly required if the datasets share the same Frame of Reference.

There are many methods/algorithms for registration: matching fiducials that are visible in the datasets, using operator input to help align the data, correlating the information content in the datasets, etc. Specifying a method/algorithm to use to arrive at the transformation is outside the scope of this profile. The specific method/algorithm used may be of interest to the user (especially when several different registrations exist between the same datasets) so it is recommended that the name and description of the method be recorded in the resulting Spatial Registration Object.

If the application wishes to allow registration of more than 2 volumetric datasets it shall produce multiple Spatial Registration objects. The first Spatial Registration Object shall establish the Registered Frame of Reference for all of the Spatial Registration Objects. Subsequent objects shall transform a single volumetric dataset into the Registered Frame of Reference.

In some cases, it is conceivable that an Registrator may combine existing registration information without performing a registration process. For example if a registration exists to map dataset A into Frame of Reference C and another registration exists to map dataset B into Frame of Reference C, the Registrator could use those transforms to produce a new set of Spatial Registration Objects for dataset A and B which transform into a Registered Frame of Reference.

When registering volumetric datasets, the mapping describes the spatial transformation between Frames of Reference. Since the specific images exist in one of those Frames of Reference, they can be mapped to each other.

This profile does not address registering datasets which share a common Frame of Reference. If the application wishes to provide this functionality it should store one or both of the datasets with a new Frame of Reference UID and allow the user to perform the registration with those datasets. This avoids the ambiguity of defining a transform from one Frame of Reference to itself. This capability is not required to satisfy the Profile.

Identifying and obtaining an appropriate matching pair of datasets to register is necessary but is not defined by this profile. IHE ensures that some useful query parameters are available, but in the end this task is left to the implementer.

5.6.3 Resampling Datasets

After a Spatial Registation has been applied, the data in the two datasets is in the same coordinate system, but may still have different pixel resolution, pixel spacing, slice thickness, number of slices, slice positions or even slice orientations. Before display is possible, it is necessary to resample the registered dataset into the Registered Frame of Reference. Also, the Image Orientation Patient and Patient Position of the resampled dataset shall match that of the Base dataset.

Note that when resampling values, such as NM and PET counts, that are not normalized to the volume represented by the pixel, the resampled pixel value may be quite different from the original pixel value. For example, when creating a new image with twice the number of pixels in

the X and Y directions, 1 pixel in the original data is now 4 pixels in the resampled data, and the value of each of the new pixels would be expected to be roughly ¼ of the value of the original pixel. When resampling values that are not directly linked to the area/volume of the pixel (such as Hounsfield units), the new pixels will have values similar to the original pixel (partial volume effects notwithstanding).

The exact values produced by resampling also depends on the interpolation algorithm used. The specification of such algorithms is outside the scope of this profile.

In the Radiotherapy domain there will also be instances of RT Structure Set and RT Dose objects which exist in the same Frame of Reference as one of the datasets being registered. The structures described as contours in the RT Structure Sets will be subject to resampling prior to display. The resampling of the contours depends on the resampling algorithm used and is outside the scope of this profile.

Resampling of RT Dose objects is not supported within this profile.

The Registered Display actor is required to be able to perform any resampling needed for the display. Some Modalities or Registrators may choose to generate resampled datasets. The advantage is that such datasets might be useful to non-registration aware display stations, and even when provided to IHE Registered Display actors, might concievably provide improved display performance. In most cases, however, storing the resampled data will significantly increase bandwidth and storage costs. This capability is not required to satisfy this profile.

Note that the stepping interval when scrolling through slices may be of primary importance to users and care should be taken in that respect. Sometimes the user may wish to step in increments of the original slices of the underlying set, and sometimes in the increments of the original slice or pixel spacing of the superimposed data set.

5.6.4 Presenting Registered Datasets

Presentation of the Registered Datasets is performed by the Registered Display actor.

No Query transaction for Spatial Registration objects exists currently. For the purpose of this profile it will be assumed that the registered images and the required Spatial Registration objects will be made available to the Registered Display actor. The data will be transferred via C-STORE operations, but the initiation of the action is out of band for this profile.

The Registered Display transforms the datasets by applying the spatial registrations according to the DICOM specification, and resamples the datasets as necessary for display.

Simple registered display could involve presentation of a single frame at a time. For some clinical interpretation tasks, presentation of a registered MPR (Multi Planar Reconstructed) view is considered essential. Many users will also expect to be able to change the transparency of the fusion overlay (blending factor), the color map for the overlay, the Window Width/Level for

each data set, and other display parameters. For PET data, controls for upper & lower Window Level are valuable.

Appendix A Actors

A.1 Actor Descriptions

Actors are information systems or components of information systems that produce, manage, or act on information associated with operational activities in the enterprise.

Acquisition Modality – A system that acquires and creates medical images while a patient is present, e.g. a Computed Tomography scanner or Nuclear Medicine camera. A modality may also create other evidence objects such as Grayscale Softcopy Presentation States for the consistent viewing of images or Evidence Documents containing measurements.

ADT Patient Registration – A system responsible for adding and/or updating patient demographic and encounter information. In particular, it registers a new patient with the Order Placer and Department System.

Archive – A system that provides long term storage of evidence objects such as images, presentation states, Key Image Notes and Evidence Documents.

Audit Record Repository – A system unit that receives and collects audit records from multiple systems.

Charge Processor – Receives the posted charges and serves as a component of the financial system. Further definition of this actor is beyond current IHE scope.

Department System Scheduler/Order Filler – A department-based information system (for instance, Radiology or Laboratory) that provides functions related to the management of orders received from external systems or through the department system's user interface. Upon a defined workflow action, makes procedures available for charge posting. The action/event that actually causes charges to post is defined by the actor.

Display – Primary description for this actor can be found in ITI TF-1: Appendix A. The required capabilities for its use within the Radiology Technical Framework add the ability to view "web-viewable" diagnostic and therapeutic imaging information on interchange media.

Enterprise Report Repository – A system that receives Structured Report Export Transactions from the Report Manager and stores them.

Evidence Creator – A system that creates additional evidence objects such as images, presentation states, Key Image Notes, and/or Evidence Documents and transmits them to an Archive. It also makes requests for storage commitment to the Image Manager for the data previously transmitted. It may also retrieve worklist entries for post-processing steps from the Post-Processing Manager and provide notification of completion of the step, allowing the enterprise to track the status of post-processing work.

External Report Repository Access – A system that performs retrieval of clinical reports containing information generated outside the imaging department and presented as DICOM Structured Reporting Objects.

Image Display – A part of a system that can access imaging evidence objects (images, Presentation States, Key Image Notes, Evidence Documents) through network query/retrieve or reading interchange media and allow the user to view these objects.

Image Manager – A system that provides functions related to safe storage and management of evidence objects. It supplies availability information for those objects to the Department System Scheduler.

Master Patient Index (MPI) – A system that maintains unique enterprise-wide identifiers for patients. Note that this is not supported in the current scope of the IHE Technical Framework

Order Placer – A hospital or enterprise-wide system that generates orders for various departments and distributes those orders to the correct department.

Performed Procedure Step Manager – A system that re-distributes the Modality Performed Procedure Step information from the Acquisition Modality or Evidence Creator to the Department System Scheduler/Order Filler, Image Manager and Report Manager.

Portable Media Creator – This actor assembles the content of the media and writes it to the physical medium.

Portable Media Importer – This actor reads the DICOM information contained on the media, and allows the user to select DICOM instances, reconcile key patient and study attributes, and store these instances. The actor grouped with the Media Importer can then process the instances.

Post-Processing Manager – A system that provides functions related to post-processing worklist management. This involves the ability to schedule post-processing worklist items (scheduled procedure steps), provide worklist items to post-processing worklist clients, and update the status of scheduled and performed procedure steps as received from post-processing worklist clients.

Print Composer – A system that generates DICOM print requests to the Print Server. Print requests include presentation state information in the form of Presentation Look-Up Tables (Presentation LUTs). It may also read the DICOM information contained on interchange media.

Print Server – A system that accepts and processes DICOM print requests as a DICOM Print SCP and performs image rendering on hardcopy media. The system must support pixel rendering according to the DICOM Grayscale Standard Display Function.

Report Creator – A system that generates and transmits draft (and optionally, final) diagnostic reports, presenting them as DICOM Structured Reporting Objects. It may also retrieve worklist entries for reporting steps from the Report Manager and provide notification of completion of the step, allowing the enterprise to track the status of an awaited report.

Report Manager – A system that provides management and short-term storage of DICOM Structured Report objects during the reporting process then distributes text or structured reports to report repositories. It also manages the worklists and status of reporting.

Report Reader – A part of a system that can access reports through network query/retrieve or reading interchange media and allow the user to view reports presented as DICOM Structured Reporting Objects.

Report Repository – A system that provides long-term storage of diagnostic reports and their retrieval as DICOM Structured Reporting Objects.

Secure Node – A system unit that validates the identity of any user and of any other node, and determines whether or not access to the system for this user and information exchange with the other node is allowed. Maintains the correct time and sends audit records to Audit Record Repository.

Time Server – A system unit that knows, maintains and distributes the correct time in the enterprise.

A.2 RT Specific Actors

Contourer – A system that consumes CT and creates RT Structure Set. If the Contourer consumes multiple series CT or has an internal requirement for resampling, it also will generate a single series CT to which the RT Structure Set maps.

Geometric Planner – A system that consumes (single series) CT and RT Structure Set and creates a Geometric Plan

Dosimetric Planner – A system that consumes (single series) CT, an RT Structure Set, a Geometric Plan, and creates a Dosimetric Plan and an RT Dose.

Archive (including RT) – A system that stores the RT SOP Classes in addition to the CT images and is capable of transmitting them.

Dose Displayer – A system that consumes a Dosimetric Plan, CT, Structure Set and an RT Dose and displays the dose.

Patient Positioning System (PPS) – A system responsible for determining patient positioning prior to treatment, determining any adjustment required, and then adjusting it such that the patient is then in a position appropriate for treatment. A PPS is a combination of the future PAD, PRD, and PMD devices described below. The PPS fulfils the role of a UPS-Pull 'Pull Performer' SCU as described in DICOM Supplement 96 Part 17 Table Z.1-1.

Positioning and Delivery System (PDS) – A system that determines and corrects patient position then delivers therapeutic radiation. A PDS is a combination of a PPS and TDD described above. The PDS fulfils the role of a UPS-Pull 'Pull Performer' SCU as described in DICOM Supplement 96 Part 17 Table Z.1-1.

Registrator – A system that consumes multi-modality images and generates 1 or more Spatial Registration objects.

Registered Display – A system that consumes multi-modality images, RT Structure Set objects, and Spatial Registration objects and allows the user to display the registered information.

Registered Dose Display – A system that consumes multi-modality images, RT Structure Set objects, RT Dose objects and Spatial Registration objects and allows the user to display the registered information.

Registered Contourer – A system that consumes multi-modality images, RT Structure Set objects, and Spatial Registration objects and allows the user to contour images in a registered display.

Treatment Delivery Device (TDD) – A system that delivers therapeutic radiation to a correctly positioned patient. The TDD fulfils the role of a UPS-Pull 'Pull Performer' SCU as described in DICOM Supplement 96 Part 17 Table Z.1-1.

Treatment Management System (TMS) – An information system that manages oncology information and is responsible for the scheduling of radiotherapy activities (i.e. is a workflow manager). The TMS fulfils the role of a UPS-Pull 'Worklist Manager' SCP as described in DICOM Supplement 96 Part 17 Table Z.1-1. Note that a specific product implementation could potentially fulfill the role of both a TMS and an Archive, in which case the supplied AE Title in Input and Output Sequences may be an AE Title managed by that implementation.

Note that the Acquisition Modality (CT) is not included as an RT Specific actor in the profile - it is assumed that it will have performed its function within the scope of RAD-8 (Modality images stored).

The following table (Table A.2-1) shows which transactions are required to be supported by the actors in the **RT Objects Profile** (the letter "R" in the Optionality column means the transaction is required. There are no optional transactions in the RT Objects Integration Profile).

Table A.2-1 RT Objects Profile Supported Transactions

Actors	Transactions	Optionality	Section in Vol.2
Archive	Single/Contoured Series Image Retrieval [RO-1]	R	3.1
	Structure Set Storage [RO-2]	R	3.2
	Geometric Plan Storage [RO-3]	R	3.3
	Dosimetric Plan Storage [RO-4]	R	3.4
	Dose Storage [RO-5]	R	3.5
	Multi-Series Image Retrieve [RO-6]	R	3.6
	Structure Set Retrieval [RO-7]	R	3.7
	Geometric Plan Retrieve [RO-8]	R	3.8
	Dosimetric Plan Retrieve [RO-9]	R	3.9
	Dose Retrieve [RO-10]	R	3.10
	Resampled/Combined CT Series Storage [RO-11]	R	3.11

Contourer	Single/Contoured Series Image Retrieval [RO-1]	R	3.1
	Structure Set Storage [RO-2]	R	3.2
	Multi-Series Image Retrieve [RO-6]	R	3.6
	Structure Set Retrieval [RO-7]	R	3.7
	Resampled/Combined CT Series Storage [RO-11]	R	3.11
Geometric Planner	Geometric Plan Storage [RO-3]	R	3.3
	Structure Set Retrieval [RO-7]	R	3.7
	Single/Contoured Series Image Retrieval [RO-1]	R	3.1
Dosimetric Planner	Dosimetric Plan Storage [RO-4]	R	3.4
	Dose Storage [RO-5]	R	3.5
	Dosimetric Plan Retrieve [RO-9]	R	3.9
	Geometric Plan Retrieve [RO-8]	R	3.8
	Structure Set Retrieval [RO-7]	R	3.7
	Single/Contoured Series Image Retrieval [RO-1]	R	3.1
Dose Displayer	Dose Retrieve [RO-10]	R	3.10
	Dosimetric Plan Retrieve [RO-9]	R	3.9
	Structure Set Retrieval [RO-7]	R	3.7
	Single/Contoured Series Image Retrieval [RO-1]	R	3.1

The following table (Table A.2-2) shows which transactions are required to be supported by the actors in the **Image Registration Profile.**

Table A.2-2 Image Registration Profile Supported Transactions

Actors	Transactions	Optionality	Section in Vol. 2
Archive	Modality Images Stored	R	RAD 4.8
	Creator Images Stored	R	RAD 4.18
	Registered Structure Set Storage	R	3.14
	Spatial Registrations Stored	R	3.12
Registrator	Modality Images Stored	R	RAD 4.8
	Creator Images Stored	O	RAD 4.18
	Utilize Spatial Registrations	O	3.13
	Spatial Registrations Stored	R	3.12
Registered Display	Modality Images Stored	R	RAD 4.8
	Registered Structure Set Retrieval	R	3.15

	Utilize Spatial Registrations	R	3.13
Registered Dose Display	Modality Images Stored	R	RAD 4.8
	Registered Structure Set Retrieval	R	3.12
	Registered Dose Retrieve	R	3.16
	Utilize Spatial Registrations	R	3.13
Registered Contourer	Modality Images Stored	R	RAD 4.8
	Registered Structure Set Storage	R	3.14
	Registered Structure Set Retrieval	R	3.15
	Utilize Spatial Registrations	R	3.13

Future Actors

In future IHE-RO frameworks, the subcomponents of a PPS will be modeled separately in some profiles. These subcomponents are as follows:

- **Position Acquisition Device (PAD)** – A device that obtains information regarding the location of the patient prior to undergoing radiation therapy. The data obtained from such a process may include projection images, 3D image sets, fiducial information, or some other data that can be used to determine or infer the position of the patient.
- **Position Registration Device (PRD)** – A device that uses the information obtained by a PAD in order to determine the relationship between the actual and desired patient position. An example of the output from this actor would be a six-dimensional vector indicating the translational and rotational offsets that need to be applied to the patient position in order that the patient is positioned correctly for the treatment.
- **Position Modification Device (PMD)** – A device that uses the information generated by a PRD in order to modify patient position. Such a device could modify treatment couch parameters, for example. In some use cases, a human operator may act in the role of a PMD (e.g. when couch position is adjusted manually, or when the patient is moved relative to the couch).

In addition, future profiles could potentially address monitoring of patient position during treatment (especially for gated deliveries). This may require new actors such as a Position Monitoring System that detect changes in patient or tumor position and notify other actors of these changes.

Appendix B Transactions

B.1 Transaction Descriptions

Transactions are interactions between actors that transfer the required information through standards-based messages. The following are the transactions defined by IHE and referenced throughout the rest of this document.

RO-1: Single/Contoured Image Series Retrieval

In the Single/Contoured Image Series Retrieve transaction, the Archive sends a series of CT-Images to the ***Contourer***, ***Geometric Planner***, or ***Dosimetric Planner***.

RO-2: Structure Set Storage

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

RO-3: Geometric Plan Storage

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

RO-4: Dosimetric Plan Storage

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

RO-5: Dose Storage

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

RO-6: Multi-Series Image Retrieve

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

RO-7: Structure Set Retrieval

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

RO-8: Geometric Plan Retrieve

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

RO-9: Dosimetric Plan Retrieve

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

RO-10: Dose Retrieve

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

RO-11: Resampled/Combined CT Series Storage

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.

RO-12: Spatial Registrations Stored

In the Spatial Registrations Stored transaction, the Registrator sends Spatial Registration instances to the Archive. Spatial registration objects define how the pixel coordinates of one image data set are transformed to another coordinate system (for example to a coordinate system defined by another image data set thus allowing each dataset to be spatially aligned).

RO-13: Utilize Spatial Registrations

A Registration Display receives from an Archive one or more Spatial Registration objects carrying the transformation information to be applied to two image data sets intended for further processing or registered display.

RO-14: Registered Structure Set Storage

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

RO-15: Registered Structure Set Retrieval

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

RO-16: Registered Dose Retrieve

In the Registered Dose Retrieve Transaction, the requested Dose is transferred from the Archive to the Registered Dose Display actors.

RO-17: Worklist Query for Positioning and Delivery

In the Worklist Query for Positioning and Delivery transaction, a PDS requests and receives a patient positioning and treatment delivery worklist from a TMS.

RO-18: Retrieve Workitem Input Objects from Archive

In the Retrieve Workitem Input Objects from Archive transaction, a PPS, PDS, or TDD requests and receives from the Archive any SOP Class Instances required for performing desired procedure steps returned by a previous query. Each SOP instance must have been supplied in the Input Information Sequence of one or more of the returned worklist items.

RO-19: UPS in Progress

In the UPS in Progress transaction, a PPS, PDS, or TDD signals to the TMS that responsibility has been taken for the performing of the selected work item.

RO-20: Retrieve Workitem Input Objects from TMS

In the Retrieve Workitem Input Objects from TMS transaction, a PDS or TDD requests and receives requests and receives SOP Class instances from the TMS, in order to support execution of the requested work item. These requested instances are of a "transient" nature, typically generated 'on-the-fly' by the TMS.

RO-21: UPS Final Update

In the UPS Final Update transaction, a PPS, PDS, or TDD signals to the TMS changes in the properties of the work item that is currently in progress, prior to the UPS being signaled as completed or canceled.

RO-22: Store Position Acquisition Results to Archive

In the Store Position Acquisition Results to Archive transaction, when a patient position acquisition workitem has been completed by a PPS or PDS, the results of the acquisition are stored to the Archive. These results may subsequently be referenced in the Output Information Sequence of the corresponding Unified Procedure Step.

RO-23: Store Position Registration Results to Archive

In the Store Position Registration Results to Archive transaction, when a patient registration workitem has been completed by a PPS or PDS, the results of the registration operation are stored to the Archive. These results may subsequently be referenced in the Output Information Sequence of the corresponding Unified Procedure Step.

RO-24: Store Delivery Results to Archive

In the Store Position Registration Results to Archive transaction, when a treatment delivery workitem has been completed by a PDS or TDD, the results of the treatment delivery operation are stored to the Archive. These results may subsequently be referenced in the Output Information Sequence of the corresponding Unified Procedure Step.

RO-25: UPS Completed/Canceled

In the UPS Completed/Canceled transaction, a PPS, PDS, or TDD signals to the TMS that the selected work item has either been completed or canceled.

RO-26: UPS Progress Update

In the UPS Progress Update transaction, a PDS or TDD signals to the TMS changes in the progress of the work item that is currently in progress.

The following table (**Table B.1-1**) shows which transactions are used in which Integration Profiles.

Table B.1-1 IHE-RO Profile Transactions

	Profiles		
Transactions	**RT Objects**	**(Multi-Modality) Image Registration**	**Integrated Positioning and Delivery Workflow**
RO-1 Single/Contoured Image Series Retrieve	X		
RO-2 Structure Set Storage	X		
RO-3 Geometric Plan Storage	X		
RO-4 Dosimetric Plan Storage	X		
RO-5 Dose Storage	X		
RO-6 Multi-Series Image Retrieve	X		
RO-7 Structure Set Retrieve	X		
RO-8 Geometric Plan Retrieve	X		
RO-9 Dosimetric Plan Retrieve	X		
RO-10 Dose Retrieve	X		
RO-11 Resampled/ Combined CT Series Storage	X		
RO-12 Spatial Registrations Stored		X	
RO-13 Utilize Spatial Registrations		X	
RO-14 Registered Structure Set Storage		X	
RO-15 Registered Structure Set Retrieval		X	
RO-16 Registered Dose Retrieve		X	
RO-17 Worklist Query for Positioning and Delivery			X

RO-18 Retrieve Workitem Input Objects from Archive			X
RO-19 UPS in Progress			X
RO-20 Retrieve Workitem Input Objects from TMS			X
RO-21 UPS Final Update			X
RO-22 Store Position Acquisition Results to Archive			X
RO-23 Store Position Registration Results to Archive			X
RO-24 Store Delivery Results to Archive			X
RO-25 UPS Completed/Canceled			X
RO-26 UPS Progress Update			X
RAD-8 Modality Images Stored		X	
RAD-18 Creator Images Stored		X	

Appendix C Glossary

Data Set: A series of images or set of frames.

Frame of Reference (FoR): Identifies the coordinate system that conveys spatial and or temporal information of composite instances in a series. The identified Coordinate System typically includes an origin, orientation and dimension scaling. Data with the same Frame of Reference are inherently using coordinate systems with the same origin, orientation and dimension scaling.

Image Fusion: The process of superimposing (overlaying) data sets for display. This is typically done so that corresponding features of the data sets can be seen at once. Fusion typically requires that the datasets be registered. This would normally involve two data sets- one underlying and one superimposed.

Image Registration: Spatially aligning datasets. This is done by mapping the pixel spatial coordinates of the Original Data Sets to the Registered Space and may include translations or rotations between the coordinate systems. The primary purpose is to support display of correlated features in two images. Typically the Registered Space is defined by one of the datasets, and the other is aligned with it.

Image Re-sampling: Synthesizing a new image dataset where the number of pixels, resolution, number of slices, slice locations and slice orientations may differ from the original, but the frame of reference is preserved (i.e. the pixel value at a given spatial location in the new dataset corresponds to the value at the same spatial location in the old dataset).

MPR: Multi-Planar Reconstruction. Creating orthogonal images from a data set, e.g. creating coronal and sagittal images from a transverse data set.

Original Dataset: Either of the data sets that are to be transformed and blended.

Registered Frame of Reference: The Frame of Reference to which the datasets are being registered. Typically this will be the space of one of the Original Data Sets. The Registered Frame of Reference is identified by the Frame of Reference UID of the Spatial Registration object.

Resulting Dataset: The data set created by applying a Registration Transformation to an Original Dataset.

Volumetric Dataset: A collection of planar (cross-sectional) images which spans a volume and each image has a defined location in space. Typical examples include a set of CT transversal slices, MR slice stacks, reconstructed tomographic NM or PET volumes or volumes re-constructed from projection X-ray images.

DICOM Terms

Spatial Registration SOP Class**: See DICOM PS 3.3 Section A.39**