ACC, HIMSS and RSNA

Integrating the Healthcare Enterprise

IHE Radiology Technical Framework

Supplement 2006-2007

Image Fusion (FUS) Integration Profile

Trial Implementation Version

April 13, 2006

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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. IHE maintain formal relationships with several standards bodies including HL7, DICOM and refers recommendations to them when clarifications or extensions to existing standards are necessary.

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), Società Italiana di Radiologia Medica (SIRM), the European Institute for health Records (EuroRec), and the European Society of Cardiology (ESC). 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 invited to join in the expansion of the IHE process across disciplinary and geographic boundaries.

The IHE Technical Frameworks for the various domains (IT Infrastructure, Cardiology, Laboratory, Radiology, etc.) defines specific implementations of established standards to achieve integration goals that promote appropriate sharing of medical information to support optimal

patient care. It is 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 http://www.ihe.net/Technical_Framework/index.cfm or http://www.himss.org/IHE.

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.

This supplement to the IHE Radiology Technical Framework V6.0 is submitted for Trial Implementation.

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

2. Introduction

Creating and viewing of images which have been co-registered is becoming an increasingly important process in the clinical domains and Radiology in particular. This profile addresses the ability to convey registered data from one system to another for further processing, storage and display (which in itself is useful for multi-planar display, and other linked series display formats), and also the ability to present repeatable fused displays consisting of a grayscale underlying image and a pseudo color overlay image.

Currently, registration and image fusion can be performed on individual workstations designed for that purpose, but the results are not readily transferable to other systems, often due either to proprietary or inconsistent implementations. Further, for the results presented on different systems to appear the same, those systems must consistently and correctly handle issues such as identifying and retrieving the right datasets for the fusion display, matching data between single-slice and multi-slice datasets, performing spatial translations, and rendering the fused display. A collection of DICOM objects exists to address the problem. Their use is constrained and clarified to avoid misinterpretation and promote compatibility.

2.1. Open Issues and Questions

none

2.2. Closed Issues

1. It has been recognized that Grayscale display alone is not clinically sufficient and that the use of Color Display is necessary.

2. Additional “Spatial Registration Stored” transaction, which the Modality and the Evidence Creator support, was needed. Added Spatial Registration Stored and Retrieve transactions. Storage Commitment applies. Since the Blending Softcopy Presentation State (BSPS) is the defined access method for this profile (it provides explicit references to any needed Spatial Registration objects), no explicit Query for Spatial Registrations was defined.

3. Additional “Blending Softcopy Presentation State Stored” transaction, which the Modality and the Evidence Creator support, was needed. Query/Retrieve was done with existing presentation state transactions. Storage Commitment applies.

4. No changes were required in order to distribute Imaging Information on media. The transaction Distribute Imaging Information on Media supports all DICOM SOP

Classes as per the actor's DICOM Conformance Statement, so Blending Softcopy Presentation State (BSPS) and Spatial Registration objects can be "burned" or "read".

5. The Profile has not been limited to cross-sectional (volumetric) imaging. After discussion with WG-17, text was added to clarify how to handle other types of images such as projection (X-rays, Mammograms), unfixed (Ultrasound), Secondary Capture, etc.

6. The Profile has been reviewed with WG17/WG11 in regards to consistency with DICOM and terminology.

7. The Profile requires hybrid modalities be capable of storing Blending Presentation States when storing multiple datasets with the same Frame of Reference. However Image Displays have to be able to select two data sets without BSPS available (for example when dealing with old archived data)

8. The restriction for one of the datasets in a spatial registration to always stay unchanged (not transformed, i.e. has an identity transformation) has been removed.

9. As a result of removing the restriction for one of the datasets to stay unchanged, the terms "Base Data Set" and "Transformed Data Set" have been abandoned. "Original Dataset", "Resulting Dataset" and "Registered Space" terms are now used instead.

10. The semantics of Frame of Reference in DICOM and the rules for setting the same Frame of Reference in the Images Stored transactions have been recognized as clear and unambiguous. However to avoid misinterpretation the Acquisition Modalities are explicitly required not use the same Frame of Reference for multiple image datasets unless all the images are indeed in the same Reference Coordinate System

11. Since Evidence Creator had no defined method to obtain images it registers, it has been required to be grouped with another actor- Image Display or Image Importer for example.

12. Deformable registration will be added later when it is approved in the DICOM Standard.

13. The Profile requires IHE Image Fusion compliant displays to be able to apply transformations and resample the data before displaying them. It has been recognized that it is also useful if the Evidence Creator would be able to store transformed re-sampled image data in order to help non-Fusion image displays to present fused data side-by-side. However the Profile does not require this as a mandatory feature from the Evidence Creator.

14. If the Evidence Creator chooses to store a resampled version of a dataset, it is useful to be able to identify which dataset is resampled. The Derivation Code Sequence (0008,9215) shall be used with code DCM 113085 ("Spatial Resampling" according to DICOM CP520). "Derivation Description"may or may not be used.
15. Given that fused displays are generally resampled before display there has been a concern about whether it is useful to identify that fact to the user. It has been decided that this is not necessary. If local law requires it then implementations should follow those recommendations.
16. The requirements to perform spatial transformations and produce fused displays are attached as "expected behaviors" to the Retrieve Blending Presentation State transaction. It has been recognized as necessary to introduce a "Display transaction" to hold these Display requirements (internal behavior) instead of attaching image display requirements and spatial registration usage to the retrieve Blending Presentation State transaction. However this has not been addressed in the text of the Fusion Profile due to time constraints.
17. The profile requires an IHE Image Fusion compliant display to also support Side-by-side (i.e. non-fused) display of registered images.
18. The profile requires Image Displays be able to generate MPR (Multi-Planar Reconstruction) data and display it. It has been confirmed as clinically useful to have both- fused and non-fused display, but fused images may not necessarily be multi-planed at the same time.
19. Image data referenced by the BSPS might be stored on different PACS. The BSPS does not include Retrieve AE Titles. DICOM (PS 3.4 Section C.4.1.1.3.2) requires either or both the Retrieve AE Title or the Storage Media File-Set ID/Storage Media File Set UID to be supported by Storage SCP. Implementers of the Images Retrieve transaction are encouraged to use this mechanism for automatically directing the C-MOVE request to the right retrieve target. The profile does not add such text, nor does it require Image Displays and Image Managers to support the "multiple sources" option as mandatory.
20. A text has been added to insist attributes of image geometry that are type 2 for the NM object to be filled in by Evidence Creator.
21. The "Modalities In Study" attribute is often overlooked (both in terms of keeping it up to date, and taking advantage of it). It is technically required in the query for Blending Presentation States, through borrowing from the general Presentation State Query transaction, which in turn inherits the requirement by reference to the Query Images transaction requirement for both matching and return values on the SCU and SCP. It has been recognized that it would be useful to add a text to directly point out the requirement

on the Image Manager, its convenience to the Image Display. However, this issue has not been addressed in the Profile text because of time constraints.

22. Non-hybrid Modalities are allowed to claim the Image Fusion Profile. A text is added to stress that images shall only have same Frame of Reference UID if they are in the same space indeed. Also BSPS Storage is required when storing a pair of shared-Frame of Reference datasets for fusion (hybrid modality).

23. Registration and fusion depend on the images containing sufficient attributes for orientation, location and spatial scaling and on those attributes having reliably accurate values. Such constraints are normally required in relevant content profiles. Text added to require that images shall be compliant with the content profiles.

24. Display of SUV values for selected pixels is useful when reviewing PET images. However, it has been decided not to add a named option/extension to this Profile. A note has been added that this is an important future IHE work on new content profiles, namely PET Image.

25. An extension to the Key Image Note to deal with referencing BSPS specifically together with the relevant Images was not considered necessary- already covered for all composite objects (including Presentation States). However it has been recognized as useful to have a simple mechanism to reference regions inside selected, not only fused, images. This will be addressed in future IHE Profiles work. The intention is not to create another entry point.

26. A Registration Sequence in a Spatial Registration object may have both- a Frame of Reference and a Referenced Image Sequence. Text has been added to say that if images are referenced, then those that are not referenced shall not be transformed. Otherwise all having the referenced Frame of Reference shall be transformed.

27. The (overlooked but existing) requirement to support C-MOVE at the Series level in the Retrieve Images transaction is now emphasized.

28. DICOM (PS3.4- N.1.1) explicitly says that BSPS "is not defined in a pair wise image-by-image or frame-by-frame manner but rather the manner in which the two sets are combined is left to the discretion of the implementation.". It has been decided that the Profile should not overload the object with such semantics. A new DICOM SOP Class needs to be written to support more that 2 data sets for blending and possibly define a pair wise relationships. DICOM work group 11 has agreed to discuss this on its next meeting.

29. Fiducials which may be used to register the images for fusion are normally generated by the modality and used in earlier steps of the process flow, described in the profile. They

are seldom needed once the transformation is calculated, although some may store them on PACS for later use. The Profile does not currently define this part of the process. It could be added in later.

3. Profile Abstract

The Image Fusion Integration Profile specifies communications between systems creating and registering image sets and systems displaying fused images. It defines how DICOM objects for spatial registration, blended presentation and the images themselves are created, stored, queried, retrieved, processed and displayed.

4. 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 transversal data set.

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

Projection Dataset: A collection of images which do not have a completely defined location in space and whose pixels may not represent an exact location in the patient body. Although each image can have a normal vector describing the orientation of the image plane, they are not strictly planar since the "depth" of each pixel is undetermined. The image represents the (parallel or non-parallel) projection of volume data onto the image plane. Typical examples of projection data include Maximum Intensity Projection (MIP) images, projection images from an NM Gamma camera, most x-rays, mammograms, angio or fluoro series.

Registered Space: The space to which the datasets are being registered. Typically this will be the space of one of the Original Data Sets. The Registered Space 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.

Unfixed Dataset: A set of images which are planar, with a defined "depth", but due to the nature of the modality the relative positions of each frame in the set is undetermined and so they do not technically define a volume. The most typical example of an unfixed dataset is a set of conventional ultrasound images.

4.1. DICOM Terms

Blending Softcopy Presentation State SOP Class: See DICOM 2004 Final Text Supplement 100.

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

Volume 1 – Integration Profiles

1 Changes to Sections 1 – 1.X

1.7 History of Annual Changes

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

- Added the Image Fusion Profile which specifies communications between systems acquiring and creating registered image data, systems displaying registered fused images as well as systems storing such data.

2 Integration Profiles

Add this row to table 2-1

Table 2-1. Integration Profiles Dependencies

Integration Profile	Depends on	Dependency Type	Comments
Image Fusion	***None***	***None***	-

Add the following section to the end of 2.1

2.1.20 Image Fusion (FUS)

The Image Fusion Integration Profile specifies communications between systems creating and registering image sets and systems displaying fused images. It defines how the related image data sets, registration and presentation information is stored, so that it can reliably be retrieved and applied by Image Displays.

Change the Actor Descriptions in 2.2 as follows:

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.

In table 2.2-1:

Add a column with the heading "FUS" at the end of the table.

Add "20" in this columns' cells for these actors: Acquisition Modality, Evidence Creator, Image Display, Image Manager, Image Archive.

Change or add the following transaction descriptions in 2.3:

10. **Storage Commitment –** A requestor (Acquisition Modality or Evidence Creator) requests that the Image Manager confirm ownership for the specified DICOM objects (images, ~~**GSPS**~~ **Presentation State** objects, Key Image Notes, Evidence Documents or any combination thereof) that the requestor stored in the Image Archive, thus allowing the sender to delete those objects now owned by the Image Manager.

15. **Query Presentation States –** An Image Display queries the Image Archive for a list of entries representing image Grayscale Softcopy Presentation States (GSPS) **or Blending Softcopy PresentationStates (BSPS)** by patient, study, series, or instance.

17. **Retrieve Presentation States –** An Image Display requests and retrieves the Grayscale Softcopy Presentation State (GSPS) **or Blending Softcopy Presentation State (BSPS)** information for a particular image or image set.

56. **Spatial Registrations Stored** – An Acquisition Modality or Evidence Creator stores transformation information for registering two image data sets in the same coordinate system for further processing or fused display.

57. **Blending Presentation States Stored** - An Acquisition Modality or Evidence Creator stores presentation information on registered image data sets for fused display.

58. **Retrieve Spatial Registrations** – An Image Display retrieves from an Image Archive the transformation information to be applied to image data sets for further processing or fused display.

In table 2.3-1:

Add a column with the heading "FUS" at the end of the table. Add "20" in this columns' cells for these transactions: Modality Images Stored [RAD-8], Storage Commitment [RAD-10], Query Images [RAD-14], Query Presentation States [RAD-15], Retrieve Images [RAD-16], Retrieve Presentation States [RAD-17], Creator Images Stored [RAD-18], Spatial Registrations Stored [RAD 56], Blending Presentation States Stored [RAD 57], Retrieve Spatial Registrations [RAD 58].

2.4 Product Implementations

Add a new bulet point for Evidence Creator Actor of the Image Fusion Profile to the lsit in 2.4:

- **Evidence Creator Actor of the Image Fusion Profile shall be grouped with another suitable actor to access the data it is intended to process. For example Image Display or Image Importer are suitable actors for such groupings.**

Add a new section 20 for Image Fusion Profile

20 Image Fusion Integration Profile

This Integration Profile specifies how images and associated spatial registration and blending information can be exchanged, stored, queried, retrieved, processed and displayed. For a blended display, it is essential that a workstation correctly identifies and retrieves the corresponding image sets, matches data from single-slice and multi-slice datasets, performs spatial translations, and renders the fused display. The use of relevant DICOM objects (Blending Softcopy Presentation State, Spatial Registration) is clarified and constrained in order to avoid misinterpretation.

Image Fusion Integration Profile focuses on content for image fusion 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 Fusion Integration Profile currently only handles rigid registration. The intention is to add deformable registration as an extension to the Profile when the Deformable Registration IOD is approved for inclusion in the DICOM Standard.

The Image Fusion 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 prodovide SUV capability even though not required under this Profile.

20.1 Actors/ Transactions

Figure 20.1-1 shows the actors directly involved in the Image Fusion 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 Fusion

Integration Profile does not define new actors. Rather it specialises existing actors in Radiology, and other domains.

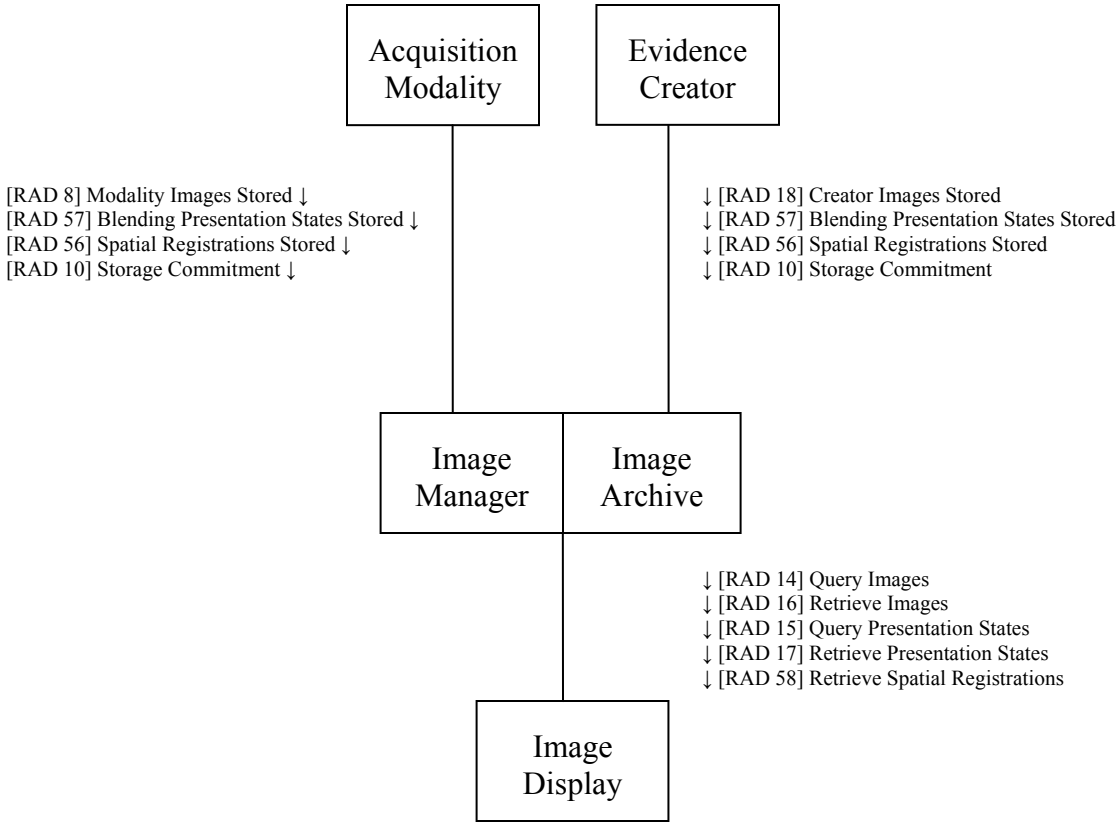


Figure 20.1-1. Image Fusion Profile Actors Diagram

Table 20.1-1 lists the transactions for each actor directly involved in the Image Fusion Profile. In order to claim support of this Integration Profile, an implementation must perform the required transactions (labeled "R"). Transactions labeled "O" are optional. A complete list of options defined by this Integration Profile and that implementations may choose to support is listed in Volume I, Section 20.2.

Table 20.1-1. Image Fusion Integration Profile - Actors and Transactions

Actors	Transactions	Optionality	Section in Vol. 2
Evidence Creator	Creator Images Stored	O	4.18
	Blending Presentation States Stored	R	4.57
	Spatial Registrations Stored	R	4.56

	Storage Commitment	R	4.10
Image Display	Query Images	R	4.14
	Query Presentation States	R	4.15
	Retrieve Images	R	4.16
	Retrieve Presentation States	R	4.17
	Retrieve Spatial Registrations	R	4.58
Acquisition Modality	Modality Images Stored	R	4.8
	Blending Presentation States Stored	R (see Note 1)	4.57
	Spatial Registrations Stored	O	4.56
	Storage Commitment	R	4.10
Image Manager/Archive	Modality Images Stored	R	4.8
	Creator Images Stored	R	4.18
	Blending Presentation Stored	R	4.57
	Spatial Registrations Stored	R	4.56
	Query Images	R	4.14
	Query Presentation States	R	4.15
	Retrieve Images	R	4.16
	Retrieve Presentation States	R	4.17
	Retrieve Spatial Registrations	R	4.58
	Storage Commitment	R	4.10

Note 1: Acquisition Modalities that store two acquired image datasets with the same Frame of Reference shall be capable of storing a Blending Softcopy Presentation State for the datasets (See RAD 20.2 Blending Presentation States Stored).

20.2 Image Fusion Integration Profile Options

Options that may be selected for this Integration Profile are listed in the table 20.2-1 along with the Actors to which they apply. Dependencies between options, when applicable, are specified in notes.

Currently there are no options defined in this profile.

Table 20.2-1 Image Fusion- Actors and Options

Actor	Options	Vol & Section
Evidence Creator	*No options defined*	- -
Image Display	*No options defined*	- -

Actor	Options	Vol & Section
Image Manager/Archive	*No options defined*	- -
Acquisition Modality	*No options defined*	- -

20.3 Image Fusion Integration Profile Process Flow

Image Fusion presents a blended display of two datasets. The basic process steps to image fusion are:

- Creation of each of the two datasets
- Registration (if necessary) to find the transformation that spatially aligns one dataset with the other
- Creation of a Presentation State defining display parameters such as the transparency (blending) and color map for the overlayed dataset as well as initial window level for each dataset.
- Application of the registration transformation and presentation parameters to the two datasets to create the fused display

The fused display might be viewed by a Radiologist reading and interpreting the images, used by an Oncologist preparing a Radiation Therapy Plan or reviewed by a Referring Physician.

20.3.1 General Case

This case uses the Image Fusion mechanisms in the most generic way.

- Two series of images (data sets), for example a CT or MR series and a PET or SPECT series, are acquired and reconstructed on two different Acquisition Modalities (see Figure 20.3-1).
- The image datasets, each with a different Frame of Reference, are stored to the Image Manager/Archive.
- An Evidence Creator obtains the two datasets and determines the transformation for mapping data from second Frame of Reference into the first Frame of Reference and records the transformation in a Spatial Registration object.
- The Evidence Creator creates a Blending Softcopy Presentation State object which identifies the two datasets, a spatial registration object that relates them spatially, and

a number of display parameters such as the window settings for the underlying data, and the transparency and color map for the superimposed data.

- The Evidence Creator stores the Blending Presentation object and Spatial Registration object to the Image Manager/Archive.
- An Image Display retrieves the Blending Presentation object from the Image Manager/Archive and also retrieves the two referenced datasets and the referenced Spatial Registration.
- To render the fused display, the Image Display uses the transformation in the Spatial Registration to translate the superimposed data into the same space as the underlying data, re-samples the two datasets to the same resolution and uses the parameters in the Blending Presentation State to prepare, blend and display the pixels.

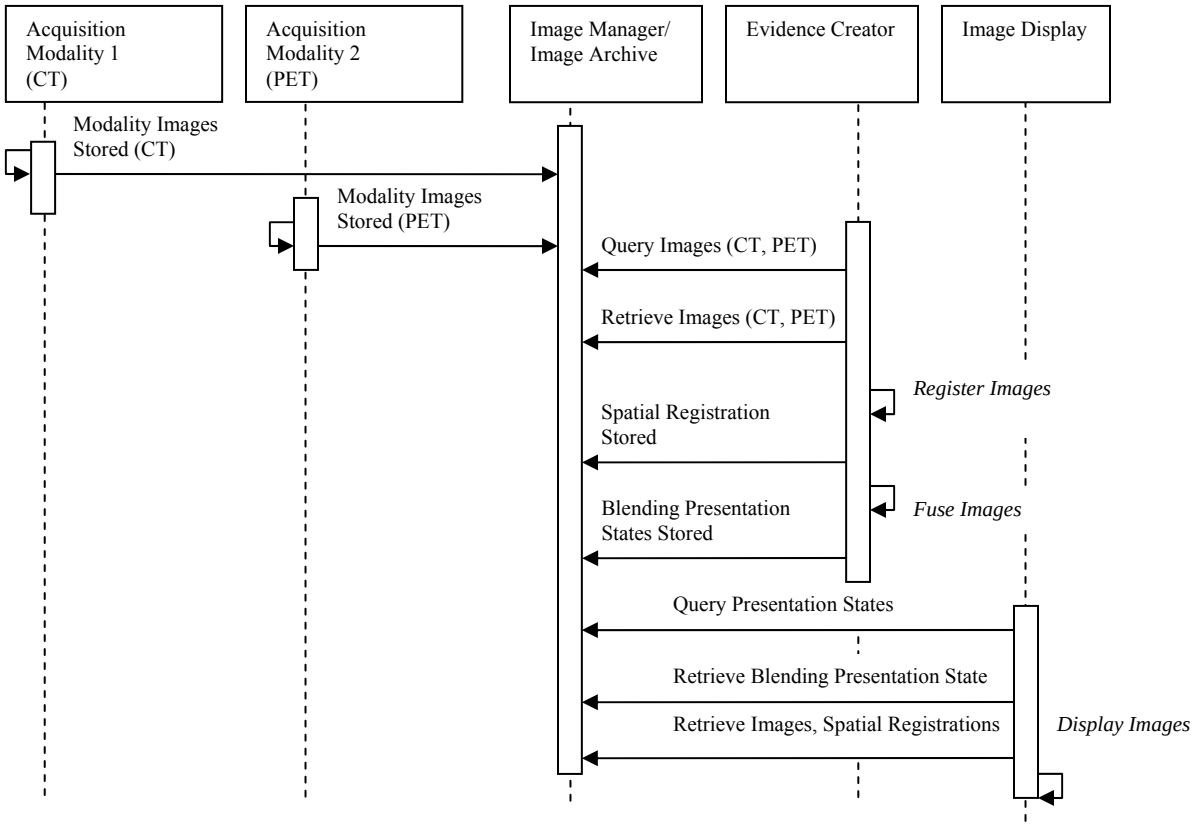


Figure 20.3-1. Image Fusion - General Case

20.3.2 Hybrid 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.

- 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 20.3-2).

- The image datasets, each with the ***same*** Frame of Reference, are stored to the Image Manager/Archive. A common Frame of Reference implies that the two datasets are already in the same coordinate system and no transformation is required.

- A Blending Presentation object will be created and stored to the Image Manager/Archive.

- An Image Display retrieves the Blending Presentation object from the Image Manager/Archive, retrieves the two referenced datasets and observes that no Spatial Registration object is referenced. It also observes that the two datasets share the same Frame of Reference.

  Note: It is possible that neither a Modality nor an Evidence Creator has created a Blending Presentation object- for example when dealing with archived data from an old hybrid scaanner. In such a case, the Image Display will have to help the user locate the two datasets and set initial blending parameters.

- To render the fused display, the Image Display re-samples one or both datasets, if necessary to match resolution. It then uses the blending parameters to prepare, blend and display the pixels. No spatial registration transformation is required.

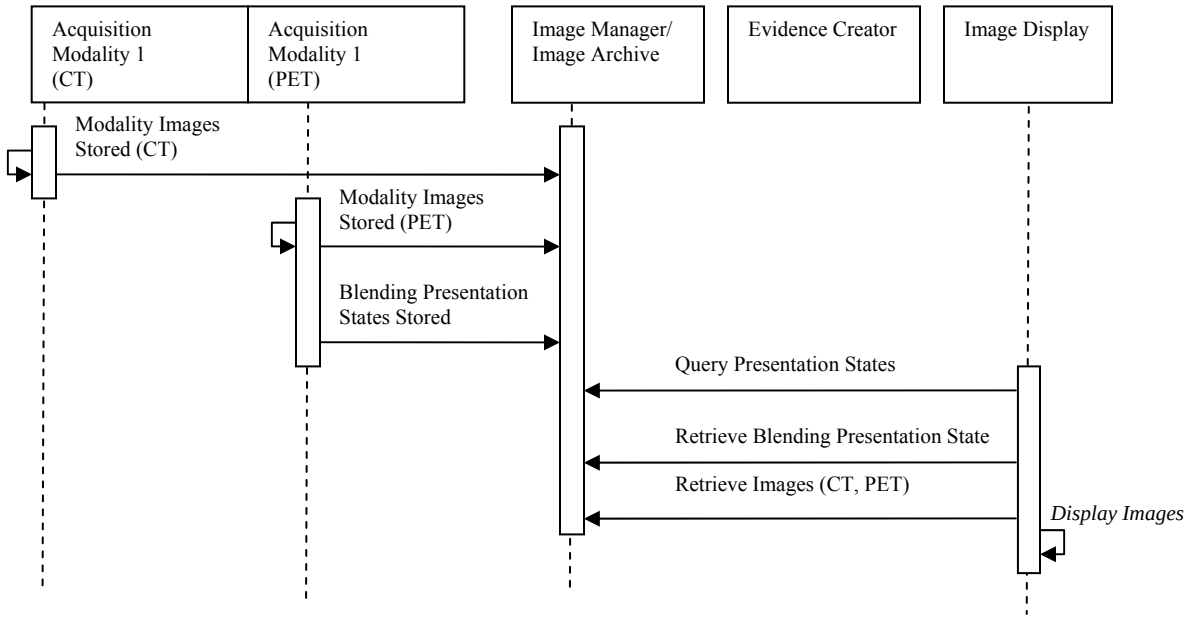


Figure 20.3-2. Image Fusion - Hybrid Case

20.3.3 Hybrid Case with Registration

The Hybrid Case is based on some calibrations and assumptions. In some cases, users may decide to perform a registration anyway to adjust the data alignment.

- Two series of images (data sets), for example a CT series and a PET series, are acquired and reconstructed on a single hybrid system (see Figure 20.3-3).
- The image datasets, each with the ***same*** Frame of Reference, are stored to the Image Manager/Archive.
- An Evidence Creator obtains the two datasets. The Evidence Creator determines the transformations (one of which may be the identity transform) for mapping instances from the first dataset to the second dataset. However since both original datasets have the same Frame of Reference, mapping a Frame of Reference to itself is ambiguous. A new Frame of Reference UID defined by the Evidence Creator is used to identify the Registered Space. It then records the transformations in a Spatial Registration object.

- The Evidence Creator creates a Blending Presentation State object which identifies the two datasets, a spatial registration object, and a number of display parameters such as the window settings for the CT data, and the transparency and color map for the PET data.
- The Evidence Creator stores the Blending Presentation object and Spatial Registration object to the Image Manager/Archive.
- An Image Display retrieves the Blending Presentation object from the Image Manager/Archive and also retrieves the two referenced datasets and the referenced Spatial Registration.
- To render the fused display, the Image Display uses the transformation in the Spatial Registration to translate the PET data and the CT data into the same space, re-samples the PET data and the CT data to the same resolution, and uses the parameters in the Blending Presentation State to prepare, blend and display the pixels.
- The Image Display may observe that the two original datasets share the same Frame of Reference and may also offer the user the option of displaying the datasets without the transformation from the Spatial Registration object.

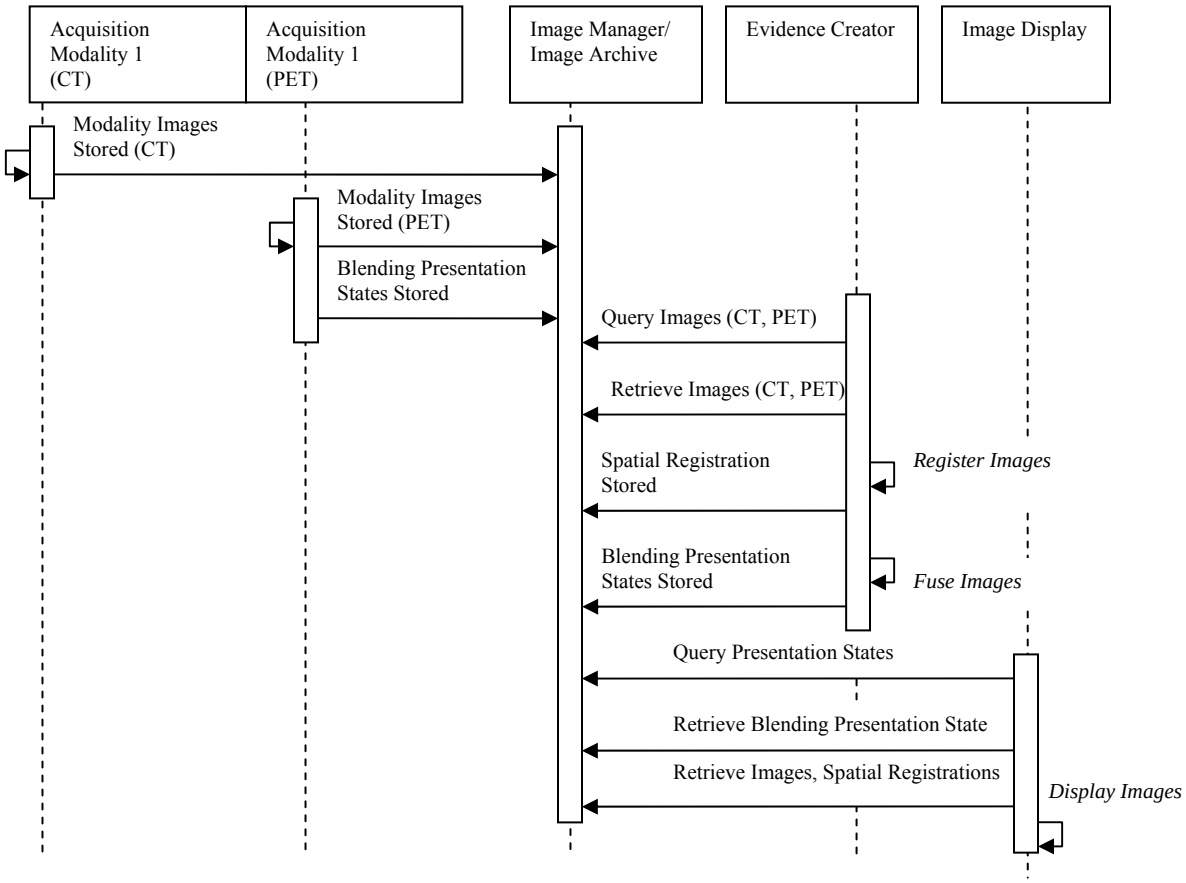


Figure 20.3-3. Image Fusion – Hybrid with Registration Case

Note that it is also valid for a Hybrid modality to choose to store the two original datasets with ***different*** Frames of Reference. The situation is then similar to the General Case above. The Hybrid modality can communicate the initial presumed registration by storing a Spatial Registration object for the two Frames of Reference with an Identity transform. When an Evidence Creator then creates a another Spatial Registration, both are still available in the study for later use. Both Spatial Registration objects should clearly record the registration method used and/or the registration purpose for later differentiation.

20.3.4 Pre-processed Case

It is always preferable for the Evidence Creator to store the transformation from the first step together with references to the original images in a Spatial Registration object, and store an appropriate Blending Presentation State referencing the registration and those original images. The objects are small, and would allow more sophisticated workstations to provide additional functionality as described in this profile. However some display workstations may not be capable

of performing the transformations, re-sampling and color blending described above. Although such a workstation would not qualify as an Image Display in this profile, some Evidence Creators or Modalities may allow the user to create a version of the dataset which is already transformed and re-sampled so such a workstation could display the two data sets side-by-side allowing visual correlation of the features. Note that this profile does not require such support from Evidence Creators and Acquisition Modalities as a mandatory feature.

- An Evidence Creator obtains the two datasets (for example an MR and a CT), and determines a transformation for mapping data from MR Frame of Reference into the CT Frame of Reference.
- The Evidence Creator transforms the MR data, re-samples it to match the resolution and frame positions of the CT data, and assigns the new data the same Frame of Reference UID as the CT data. The new derived MR images are stored to the Image Manager/Archive.
- A non-IHE Image Fusion Display somehow locates the CT and the re-sampled MR datasets, observes that they have the same Frame of Reference, resolution and frame positions, and does whatever co-display it is capable of (e.g. side-by-side).

Whether an Evidence Creator stores the resulting datasets in their original resolution or re-samples the lower resolution dataset to match the higher resolution datasets, or vice-versa, or chooses to resample both datasets to some intermediate resolution, will depend on the application, local disk storage constraints, local bandwidth constraints and other factors.

Evidence Creators may also store secondary capture images of the fused display to allow users of workstations without fusion capabilities to have visual access to the results of the fusion operation.

20.4 Image Fusion Steps

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

20.4.1 Creating datasets

The Image Fusion 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 on an Evidence Creator actor.

Three main types of datasets used are Volumetric, Projection and Unfixed.

Volumetric Datasets

Volumetric datasets refer to a collection of planar images which spans a volume and each image has a defined location in space. Typical examples include a set of CT transverse slices, MR slice stacks and reconstructed tomographic NM or PET volumes.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 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 means 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)

Projection Datasets

Projection datasets refer to images which do not have a completely defined location in space. Although each image can have a normal vector describing the orientation of the image plane, they are not strictly planar since the "depth" of each pixel is undetermined. The image represents the projection of volume data onto the image plane. Projection datasets are often missing a Frame of Reference.

The projection may be parallel or non-parallel. Typical examples of parallel projection data include Maximum Intensity Projection (MIP) images, and projection images from an NM

Gamma camera with a parallel collimator. Typical examples of non-parallel projection images include most x-rays, mammograms, angio or fluoro series, and many visible light images.

Unfixed Datasets

Unfixed datasets refer to sets of images which are planar, with a defined "depth", but due to the nature of the modality, the relative positions of each frame in the set is undetermined and so they do not technically define a volume. In a sense, each frame may be considered to be in its own Frame of Reference, although they may be stored without any Frame of Reference information.

The most typical example of an unfixed dataset is a set of conventional ultrasound images.

20.4.2 Registering Datasets

To perform fusion when datasets do not share a Frame of Refence, it is necessary to define a relationship between them. That process is called registration. 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 regsitration is complete, the resulting transformation is recorded in a 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 Evidence Creator actors; however in some situations an Acquisition Modality actor may choose to create them, and 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 two datasets, using operator input to help align the data, correlating the information content in the two 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.

In some cases, it is conceivable that an Evidence Creator 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 Evidence Creator could use those transforms to produce a new registration for dataset A and B.

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

When registering volumetric datasets that share a Frame of Reference with each other, the registration defines a new Frame of Reference for the resulting space. This avoids the ambiguity of defining a transform from one Frame of Reference to itself.

When registering projection datasets, the datasets likely have no Frame of Reference since they have no fixed depth. In that case the transform in the registration is for the specific images registered.

When registering unfixed datasets each image essentially has its own Frame of Reference, although none may be recorded. It will likely require separate registration transforms for each image. It is also conceivable that one or more unfixed frames could each be registered with a volumetric dataset.

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.

20.4.3 Setting Blending Parameters

Setting the blending parameters is probably the simplest part of the chain. It includes setting the contrast/window settings for the underlying grayscale dataset, setting the windowing and colormap to use for the overlay dataset, and setting the alpha blending (i.e. transparency) for the overlay dataset. These details are stored in a Blending Presentation State which, more importantly, also contains references to the two datasets, and any spatial registration objects required to align them.

Note that in the case where the Frame of Reference of a dataset is selected by a Spatial Registration to be the resulting space, that dataset is not necessarily going to be the underlying dataset in the fused display. It could instead be the overlayed dataset.

Blending Presentation State objects will generally be created by the Evidence Creator that also generates the Spatial Registration object. They may also be created by an Acquisition Modality actor that is storing datasets with shared Frames of Reference (See 20.4.1).

20.4.4 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 one or the other dataset so that the x, y, z (and perhaps temporal) resolutions will match.

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 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.

The Image Display actor is required to be able to perform any resampling needed for the fused display. Some Modalities or Evidence Creators may choose to generate resampled datasets. The advantage is that such datasets might be useful to non-Fusion display stations, and even when provided to IHE Image Display actors, might concievably provide improved display performance. In most cases, however, storing the resampled data will significantly increase bandwidth and storage costs.

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.

20.4.5 Presenting Fused Datasets

Presentation of the Fused Datasets is performed by the Image Display actor.

In the general case, the Image Display actor will start from a Blending Presentation State. That object will contain references to the two datasets to be fused. Usually it will also contain a reference to a Spatial Registration object, although in the case of datasets with the same Frame of Reference, this might not be present.

No Query transaction for Spatial Registration objects exists currently. It is expected the Image Display will retrieve it based on the reference in a presentation state.

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

Lastly, the fused display will be generated from the resampled datasets and blending parameters according to the pipeline defined in DICOM for the Blending Presentation State object.

Simple fused display could involve presentation of a single frame at a time. For some clinical interpretation tasks, presentation of a fused 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 NM or PET data, controls for upper & lower Window Level are valuable.

Note that it is possible that neither the Modality nor an Evidence Creator has created a Blending Presentation object. Image Display that can identify two datasets with the same Frame of Reference could assume default blending parameters and, without using a Blending Presentation State, present a fused display to the user for interaction. The user may have to manually locate the two datasets and set initial blending parameters. The Display may have to pay close attention to the region spanned by the datasets since it is possible that the datasets have the same Frame of Reference but none of the actual data overlaps.

20.4.6 Consistency between Blending States and Spatial Registrations

Spatial Registration instances created for this profile would typically be stored in a new series in the same Study as the Blending Softcopy Presentation State instance which references them.

When a Spatial Registration object is created, it must provide registration information for all image instances referenced in the parent Blending Softcopy Presentation State object.

Volume II - Transactions

4 IHE Transactions

4.8 Modality Images Stored

Add/ replace the following text in the section "4.8.4.1.3.1 DICOM Image Storage SOP Classes"

4.8.4.1.3.1 DICOM Image Storage SOP Classes

The DICOM Standard (2004~~3~~) defines a number of image specific storage SOP classes. It is expected that Image Archive will support multiple storage SOP classes as defined in table 4.8-1 below. **It is expected that all SOP classes that the actor supports are documented in the corresponding DICOM Conformance Statement (referenced in the IHE Integration Statement, see appendix D).**

Table 4.8-1. Suggested Image SOP Classes

SOP Class UID	SOP Class Name
1.2.840.10008.5.1.4.1.1.1	Computed Radiography Image Storage
1.2.840.10008.5.1.4.1.1.2	CT Image Storage
1.2.840.10008.5.1.4.1.1.2.1	Enhanced CT Image Storage
1.2.840.10008.5.1.4.1.1.4	MR Image Storage
1.2.840.10008.5.1.4.1.1.4.1	Enhanced MR Image Storage
1.2.840.10008.5.1.4.1.1.20	Nuclear Medicine Image Storage
1.2.840.10008.5.1.4.1.1.128	Positron Emission Tomography Image Storage
1.2.840.10008.5.1.4.1.1.481.1	RT Image Storage
1.2.840.10008.5.1.4.1.1.7	Secondary Capture Image Storage
1.2.840.10008.5.1.4.1.1.6.1	Ultrasound Image Storage
1.2.840.10008.5.1.4.1.1.3.1	Ultrasound Multi-frame Image Storage
1.2.840.10008.5.1.4.1.1.12.1	X-Ray Angiographic Image Storage
1.2.840.10008.5.1.4.1.1.12.2	X-Ray Radiofluoroscopic Image Storage
1.2.840.10008.5.1.4.1.1.1.1	Digital X-Ray Image Storage – For Presentation
1.2.840.10008.5.1.4.1.1.1.1.1	Digital X-Ray Image Storage – For Processing
1.2.840.10008.5.1.4.1.1.1.2	Digital Mammography Image Storage – For Presentation
1.2.840.10008.5.1.4.1.1.1.2.1	Digital Mammography Image Storage – For Processing
1.2.840.10008.5.1.4.1.1.1.3	Digital Intra-oral X-Ray Image Storage – For Presentation
1.2.840.10008.5.1.4.1.1.1.3.1	Digital Intra-oral X-Ray Image Storage – For Processing
1.2.840.10008.5.1.4.1.1.77.1.1	VL Endoscopic Image Storage

1.2.840.10008.5.1.4.1.1.77.1.2	VL Microscopic Image Storage
1.2.840.10008.5.1.4.1.1.77.1.3	VL Slide-Coordinates Microscopic Image Storage
1.2.840.10008.5.1.4.1.1.77.1.4	VL Photographic Image Storage

4.8.4.1.2 Message Semantics

Acquisition Modalities shall not use the same Frame of Reference for multiple image datasets unless all the images are in the same Reference Coordinate System.

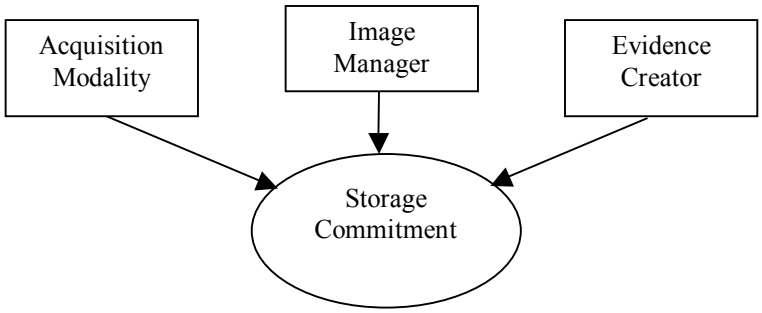
4.10 Storage Commitment

Replace the existing text in sections 4.10.1, 4.10.2, 4.10.4.1.3 by the following text:

4.10.1 Scope

After the Acquisition Modality or Evidence Creator has sent images, Presentation States, **Spatial Registration objects,** or Key Image Notes to the Image Archive, it requests that the Image Manager/Image Archive accept responsibility for them. The objective of this transaction is to provide a formal release of storage responsibility to the Acquisition Modality or Evidence Creator, allowing it to reuse its internal resources allocated to the study.

4.10.2 Use Case Roles



Actor: Acquisition Modality

Role: Make requests for storage commitment to the Image Manager for the images, Presentation States, **Spatial Registration objects,** Key Image Notes, and Evidence Documents previously transmitted.

Actor: Evidence Creator

Role: Make requests for storage commitment to the Image Manager for the images, Presentation States, **Spatial Registration objects,** Key Image Notes, and Evidence Documents previously transmitted.

Actor: Image Manager.

Role: **Receive requests for storage commitment and a**ssume**s** responsibility for reliable storage, retrieval, and validity of images, Presentation States, **Spatial Registration objects**, Key Image Notes, and Evidence Documents.

4.10.4.1.3 Expected Actions

The Image Manager in coordination with the Image Archive accepts responsibility for the safe storage of the transferred image data, **~~or~~** Presentation States **or Spatial Registration objects.** (The form of the cooperation is beyond the scope of the IHE Technical Framework.) Ownership of data transfers from the Acquisition Modality **or Evidence Creator** to the Image Manager. The Acquisition Modality **or Evidence Creator** is then free to manage its own internal resources accordingly.

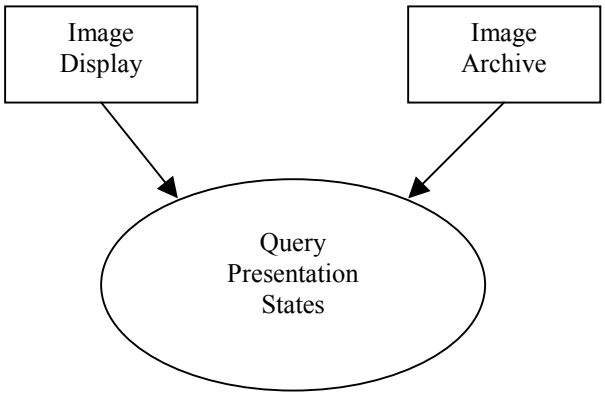
4.15 Query Presentation States

Make changes to Section 4.15.1, 4.15.2, 4.15.3. 4.15.4. to include also Blending Presentation States IODs defined in DICOM Supplement 100, as follows.

4.15.1 Scope

This section describes the sequence of messages required for the Image Display to query the Image Archive for instances of **~~Grayscale~~** Softcopy Presentation States. The Image Display will query and then retrieve Presentation State objects together with the image data **or other instances** referenced in the return keys supplied in the response from the Image Archive or referenced in the Presentation State object. The transformations will be applied by the Image Display to the image data to assure the image display is consistent with the device that originally created and stored the Presentation State. The Image Display **~~will be~~is** required to support all transformations defined in DICOM **for the Softcopy Presentation State Class supported~~2003 PS 3.4: Grayscale Softcopy Presentation State Storage~~**. In addition, multiple Presentation States may exist that reference the same image data.

4.15.2 Use Case Roles



Actor: Image Display

Role: Query for ~~**Grayscale**~~ Softcopy Presentation State objects together with the referenced image data **and other instances,** and apply the transformations specified by the Presentation State. ~~**This actor must support pixel rendering according to the Grayscale Standard Display Function (GSDF) defined in DICOM 2003 PS 3.14.**~~ This ~~**device**~~ **actor** ~~**will**~~ implements the Query/Retrieve SOP Classes in the role of SCU.

Actor: Image Archive

Role: Respond to queries from the Image Display for ~~**Grayscale**~~ Softcopy Presentation States objects. This **actor** ~~**device will**~~ implements the Query/Retrieve SOP Classes in the role of SCP.

4.15.3 Referenced Standards

DICOM 200~~3~~**4** PS 3.4: Query/Retrieve Service Class

DICOM 2004 PS 3.4: Storage SOP Classes, including Softcopy Presentation State Storage (Final Text Supplement 100)

DICOM 200~~3~~**4** PS 3.14: Grayscale Standard Display Function

4.15.4.1 Query for ~~Grayscale~~ Softcopy Presentation States

The Query (Study Root – FIND and optionally Patient Root – FIND) SOP Classes will be supported. Refer to DICOM 200~~3~~**4** PS 3.4: Query/Retrieve Service Class for detailed descriptive semantics.

4.15.4.1.1 Trigger Events

The user of the Image Display wishes to query instances of ~~Grayscale Softcopy~~ Presentation States.

4.15.4.1.2 Message Semantics

The message semantics are defined by the DICOM Query/Retrieve SOP Classes: A C-FIND Request from the DICOM Study Root Query/Retrieve Information Model – FIND SOP Class or the optional DICOM Patient Root Query/Retrieve Information Model – FIND SOP Class. The C-FIND request shall be sent from the Image Display to the Image Archive.

The matching keys and return keys to be supported by the Image Display (SCU) and the Image Archive (SCP) at the Study and Series level are defined in table 4.14-1. **Note that the SCU may find the SOP Class UID (a required matching key for the SCP) is a useful way to limit responses to queries for Grayscale Softcopy Presentation States, or Blending Softcopy Presentation States.**

Table 4.15-1 below specifies for both the Query SCU (Image Display) and the Query SCP (Image Archive), additional Matching Keys (keys used as matching criteria in the Query request) and Return Keys (keys used to request attributes to be returned in the query responses) that are Required ("R") or Optional ("O"), specific (or pertaining) to Presentation State. See section 2.2 for more information.

Table 4.15-1. Presentation State Specific Query Matching and Return Keys

Attribute Name	Tag	Query Keys Matching		Query Keys Return	
		SCU	SCP	SCU	SCP
Presentation Label	(0070,0080)	O	O	R+	R+
Presentation Description	(0070,0081)	O	O	O	R+
Presentation Creation Date	(0070,0082)	O	O	R+	R+
Presentation Creation Time	(0070,0083)	O	O	R+	R+
Presentation Creator's Name	(0070,0084)	O	O	R+	R+
Referenced Series Sequence	(0008,1115)				
>Series Instance UID	(0020,000E)	O	O	O	R+
>Referenced Image Sequence	(0008,1140)				
>>Referenced SOP Class UID	(0008,1150)	O	O	O	R+
>>Referenced SOP Instance UID	(0008,1155)	O	O	O	R+

4.15.4.1.3 Expected Actions

The Image Archive receives the C-FIND request, matches on the provided keys and sends the list of matching records back to the Image Display via C-FIND responses. It is the responsibility of the Image Manager to ensure that the patient and procedure information is current in the images and Softcopy Presentation State objects when they are retrieved from the Image Archive. The patient and procedure information is updated through transactions RAD-12 and RAD-13.

This means the Image Display may receive patient data inconsistent with those received from a previously issued query or retrieve operation. For example, in the event that a patient has been renamed, the Image Display will receive Softcopy Presentation State objects with the same Study Instance UID, Series Instance UID and SOP Instance UIDs, but with a different patient name. The Image Display shall use the just queried information or the most recently received instances to ensure that the most recent patient data from the Image Manger/Archive is displayed.

4.16 Retrieve Images

4.16.3 Referenced Standards

DICOM 2004~~3~~ PS 3.4: Storage Service Class

DICOM 2004~~3~~ PS 3.4: Query/Retrieve Service Class

4.16.4.1 Retrieve Images

The Retrieve (Study Root – MOVE and optionally Patient Root – MOVE) SOP Classes shall be supported. **This requires that C-MOVE also be supported at the Series Level.** The DICOM Image Storage SOP Classes will be supported by the Image Archive as an SCU. Refer to DICOM 2004~~3~~ PS 3.4, Annex C, for detailed descriptive semantics.

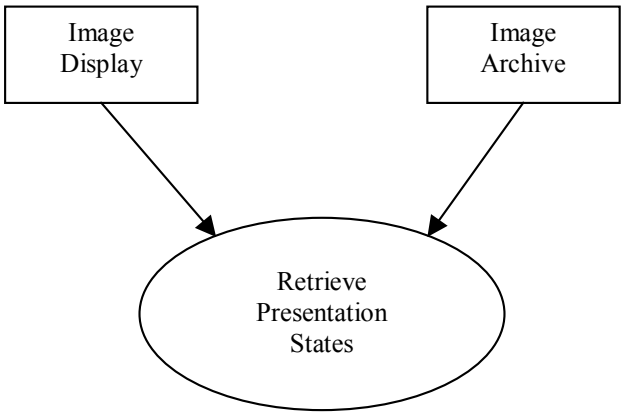
4.17 Retrieve Presentation States

Make changes to Sections 4.17.1, 4.17.2, 4.17.3 to include also Blending Presentation States IODs defined in DICOM Supplement 100. Add new sub-section to 4.17.4.2 for FUS Profile specifics on expected actions inImage Display

4.17.1 Scope

This section describes the sequence of messages required for the Image Display to retrieve ~~**Grayscale**~~ Softcopy Presentation State Instances from the Image Archive. The Image Display will query and then retrieve Presentation State objects. The transformations will be applied by the Image Display to the image data to assure the ~~**image**~~ display **of the images** is consistent with the device that originally created and stored the Presentation State. The Image Display ~~will be~~**is** required to support all transformations defined in DICOM 200~~3~~**4** PS 3.4 **for the Softcopy Presentation State Class supported~~: Grayscale Softcopy Presentation State Storage~~.** In addition, multiple Presentation States may exist that reference the same image data.

4.17.2 Use Case Roles



Actor: Image Display

Role: Retrieve ~~**Grayscale**~~ Softcopy Presentation State objects together with the referenced image data and **other instances, such as Spatial Registration objects, and** apply the transformations specified by the Presentation State. ~~**This actor must support pixel rendering according to the Grayscale Standard Display Function (GSDF) defined in DICOM 2003 PS 3.14.**~~ This ~~device~~**actor** ~~**will**~~ implements the Query/Retrieve SOP Classes in the role of an SCU.

Actor: Image Archive

Role: Respond to retrieve requests from the Image Display for ~~**Grayscale**~~ Softcopy Presentation States objects. Transmit requested ~~**Grayscale**~~ Softcopy Presentation State object(s) to the Image Display. This ~~**device will**~~ **actor** implements the Query/Retrieve SOP Classes in the role of an SCP.

4.17.3 Referenced Standards

DICOM 200~~3~~**4** PS 3.4: Query/Retrieve Service Class

DICOM 2004~~3~~ PS 3.14: Grayscale Standard Display Function

DICOM 2004~~3~~ PS 3.4: Softcopy Presentation State Storage (Final Text Supplement 100)

4.17.4.1 Retrieve ~~Grayscale~~ Softcopy Presentation State

This transaction refers to the "C-MOVE" and "C-STORE" messages between the Image Display and Image Archive in the above interaction diagram. The Retrieve (Study Root – MOVE and optionally Patient Root – MOVE) SOP Classes are supported. Refer to the DICOM 2004 PS 3.4 for detailed descriptive semantics.

4.17.4.1.1 Trigger Events

The Image Display selects specific ~~Grayscale~~ Softcopy Presentation State objects to retrieve from the Image Archive.

4.17.4.1.3 Expected Actions

The Image Archive receives the C-MOVE request, and establishes a DICOM association with the Image Display, and uses the **appropriate** DICOM ~~**Grayscale**~~ Softcopy Presentation State Storage SOP Class **(Grayscale or Blending)** to transfer the requested Presentation State objects.

4.17.4.2 View Presentation States

This transaction relates to the "View Presentation States" event in the above interaction diagram. Presentation States cannot be viewed separately, but ~~must be~~**are** applied to ~~an~~ image**s referenced in the Presentation State**.

4.17.4.2.1 Trigger Events

The Image Display receives Presentation State instances from the Image Archive.

4.17.4.2.2 Invocation Semantics

This is a local invocation of functions resident within the Image Display. The method used by the Image Display to present images for viewing by the user after the Presentation State transformations have been applied is outside the scope of the IHE Technical Framework.

4.17.4.2.3 Expected Actions

If not already present, any images or spatial registration objects referenced in the Presentation State shall be retrieved by the Image Display. Refer to RAD TF-2, 4.16 (to retrieve referenced images) and RAD TF-3, 4.58 (to retrieve referenced Spatial Registration objects).

The Image Display applies the transferred ~~**Grayscale**~~ Softcopy Presentation State to image data and renders it for viewing. The Image Display may receive patient data inconsistent with those received from a previously issued query or retrieve operation. For example, in the event that a patient has been renamed, the Image Display will receive Softcopy Presentation State objects with the same Study Instance UID, Series Instance UID and SOP Instance UIDs, but with a different patient name. The Image Display shall use the just queried information or the most recently received instances to ensure that the most recent patient data from the Image Manger/Archive is displayed.

4.17.4.2.3.1 Grayscale Softcopy Presentation States

Image Display actors claiming the Consistent Presentation of Images Profile or Access to Radiology Information Profile shall be able to apply any transforms specified in the Grayscale Softcopy Presentation State Storage SOP Class and shall support pixel rendering according to the Grayscale Standard Display Function (GSDF) defined in DICOM.

4.17.4.2.3.2 Blending Softcopy Presentation States

The contents of this section are required for Image Display actors claiming the Image Fusion Integration Profile.

The Image Display shall be able to:

- **Display two fused image sets with any transformations specified by the Blending Softcopy Presentation State (including any referenced Spatial Registration Object(s)). See DICOM 2004 PS3.4, Annex N.**
- **Use the registration transformations in a Spatial Registration referenced by the Blending Softcopy Presentation State even if the images share a Frame of Reference, although the workstation may give the user the choice of seeing the fused images with no registration transformation applied.**
- **Choose an initial viewpoint and let the user navigate the various dimensions of the image data to their desired viewpoint in space/time.**
- **Perform any resampling needed to correlate the pixels from the two datasets despite differing pixel sizes, slice spacing, slice thickness, etc. of the registered data**
- **Display the two individual image sets side-by-side to enable reading of the individual volumes with corresponding slices next to each other. It is also very usefull to display the fused images at the same time so that all the three displays are present.**

- **Provide user interaction for adjusting the transparency of the fusion overlay (blending factor). Users may wish to modify color lookup tables, if several are available.**
- **Display MPR (Multi Planar Reconstructed) planes of fused data. Note that by adjusting the blending factor the user may view the unfused data sets. It is recommended that a fused MIP display also be available.**
- **Provide direct independent control over the Upper Window Level and the Lower Window Level display parameters for all images with a modality type of NM or PET. For details regarding Upper and Lower Window levels and how they relate to Window Center and Width, refer to RAD TF-1, E.5.1 NM Intensity and Color Mapping.**
- **Display the values of Series Description (0008,103E) and Derivation Code Sequence (0008,9215)**
- **Image Displays are not required to be able to fuse projection images with non-projection images.**

4.18 Creator Images Stored

Make changes to Section 4.18.4 for derived re-sampled images after registration

4.18.4.1.2 Message Semantics

The Evidence Creator uses the DICOM C-STORE message to transfer the images. The Evidence Creator is the DICOM Storage SCU and the Image Archive is the DICOM Storage SCP.

Per the DICOM Standard, the Evidence Creator shall create a new series for its created images and not extend series containing source images.

The Evidence Creator derives images from source images, and the derived images may or may not have the same Image SOP Class as the source images. **The images the Evidence Creator stores may be referenced from other instances, e.g. from Presentation State or Spatial Registration objects.**

The source images may include Performed Procedure Step relationship information. This information will include Scheduled Procedure Step information for the procedure performed at an Acquisition Modality. When present in the source images, the Evidence Creator shall extract appropriate Scheduled Procedure Step information and include it with PPS information produced by the Evidence Creator.

See Appendix A for rules on how to use the source image information in the derived image objects.

4.18.4.1.2.5 Storage of Derived Images

Evidence Creators claiming the Image Fusion Profile may support storage of resulting data sets, which are in the Registered Space i.e have the Frame of Reference of the registration.

It is not required that the two resulting datasets have a one-to-one relationship of frames nor that the frames are with the same pixel resolutions and span the same space.

When storing resulting data sets Evidence Creator shall store Derivation Code Sequence (0008,9215) with a value of DCM 113085 (Spatial Resampling).

When storing resulting data sets of the NM Image Storage SOP Class, the Evidence Creator is also required to fill the attributes Frame of Reference UID (0020,0052), Image Orientation (0020,0037), Image Position (0020,0032) (both in Detector Information Sequence (0054,0022)) and Spacing Between Slices (0018,0088).

All image data sets stored by Evidence Creator shall be compliant with the requirements of the relevant IHE image content profiles.

Volume III – Transactions (Continued)

Add the following chapter 4.56 to the end of the RAD transaction chapter.

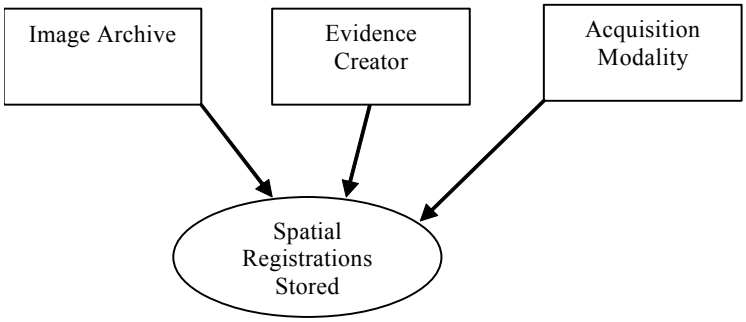
4.56 Spatial Registrations Stored

This section corresponds to Transaction RAD-56 of the IHE Technical Framework. Transaction RAD-56 is used by the Image Archive, Evidence Creator and Acquisition Modality actors.

4.56.1 Scope

In the Spatial Registrations Stored transaction, the Evidence Creator or Acquisition Modality sends Spatial Registration instances to the Image 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 both datasets to be spatially aligned).

4.56.2 Use Case Roles



Actor: Image Archive

Role: Accept and store Spatial Registration instances from Evidence Creator or Acquisition Modality actors.

Actor: Evidence Creator

Role: Transmit Spatial Registration instances to an Image Archive.

Actor: Acquisition Modality

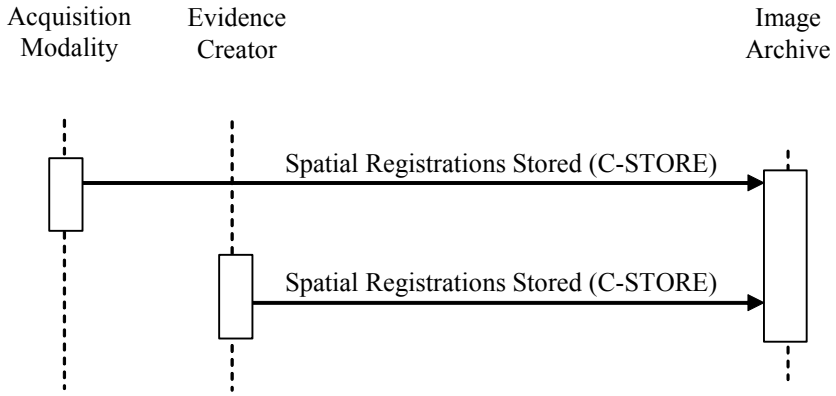
Role: Transmit Spatial Registration instances to an Image Archive.

4.56.3 Referenced Standard

DICOM 2004 PS 3.4: Storage Service Class

DICOM 2004 PS 3.4: Spatial Registration Storage

4.56.4 Interaction Diagram



4.56.4.1 Spatial Registrations Stored

4.56.4.1.1 Trigger Events

An Acquisition Modality or Evidence Creator chooses to transfer one or more Spatial Registration objects to the Image Archive. This may follow creation of the Spatial Registration object as part of a registration process.

4.56.4.1.2 Message Semantics

The Acquisition Modality or Evidence Creator uses the DICOM C-STORE message to transfer the Spatial Registration objects. The Acquisition Modality or Evidence Creator are the DICOM Storage SCU and the Image Archive is the DICOM Storage SCP.

The Spatial Registration shall contain one or more Registration Sequences. Refer to DICOM 2004 PS 3.17 Figure O.4-1 for informative details on the structure of the Registration Sequences.

When registering volumetric datasets with different Frames of Reference, each Registration Sequence shall define the transformation of the corresponding Original Dataset into the Registered Space. Typically, one of the Registration Sequences will contain an IDENTITY transform, indicating that the corresponding original dataset was used as the basis for the Registration Space. In that case the Frame of Reference of the Registration object may be the same as the Frame of Reference of that Original Dataset.

When registering volumetric datasets with the same Frame of Reference, the Frame of Reference of the Spatial Registration object shall be different than that of the original datasets. The transformation in the Registration Sequence of one or the other or both datasets may still be an identity transform.

A Registration Sequence item shall contain either:

- a Frame of Reference and no list of images, in which case the transformation is applicable to all images within that Frame of Reference
- a Frame of Reference and a list of images, in which case the transformation is applicable to only the listed images, and not other images that may claim to share the same Frame of Reference
- a list of images without any Frame of Reference specified, in which case the transformation is applicable to only the listed images.

When storing a registration of projection or unfixed images, in each Registration Sequence (0070,0308) the image instance UIDs registered in that Registration Sequence shall be explicitly listed in the Referenced Image Sequence (0008,1140) and the Frame of Reference UID (0020,0052) shall not be present. The Frame of Reference UID for the Spatial Registration object itself is unconstrained.

Modifying an existing Spatial Registration Object shall result in a new instance with a new instance UID.

The Spatial Registration object shall be stored:

- in the most recent of the Studies containing the registered images.
- in a different series from images and presentation states.

4.56.4.1.3 Expected Actions

The Image Archive will store the received Spatial Registration objects. The Spatial Registration objects shall be stored such that they can be later retrieved (See 4.58 Retrieve Spatial Registrations) in a fashion meeting the requirements defined for a DICOM Level 2 Storage SCP (see DICOM PS 3.4 B.4.1).

Add the following chapter 4.20 to the end of the RAD transaction chapter.

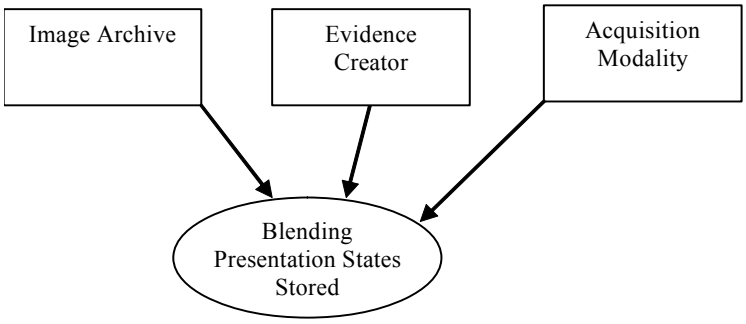
4.57 Blending Presentation States Stored

This section corresponds to Transaction 4.57 of the IHE Technical Framework. Transaction 4.57 is used by the Evidence Creator, Acquisition Modality and Image Archive actors.

4.57.1 Scope

The Evidence Creator or Acquisition Modality actors send Blending Softcopy Presentation States for storage to the Image Archive. Afterwards, these objects can be used for the fused display of the two image data sets referenced in the Presentation State object.

4.57.2 Use case Roles



Actor: Evidence Creator

Role: Generate Blending Softcopy Presentation States to be applied to image data, and send it to an Image Archive.

Actor: Acquisition Modality

Role: Generate Blending Softcopy Presentation States to be applied to image data, and send it to an Image Archive.

Actor: Image Archive

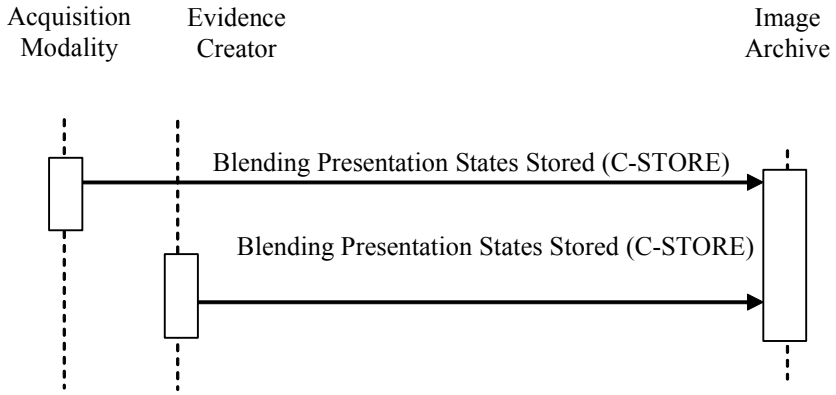
Role: Accept and store Presentation State Instances received from the Evidence Creator or Acquisition Modality.

4.57.3 Referenced Standards

DICOM 2004 PS 3.4: Storage Service Class

DICOM 2004 PS 3.4: Blending Softcopy Presentation State Storage (Final Text Supplement 100)

4.57.4 Interaction Diagram



4.57.4.1 Blending Presentation State Stored

An Acquisition Modality or an Evidence Creator stores presentation information referencing two co-registered image data sets that are intended for fused display, and potentially referencing one Spatial Registration object.

4.57.4.1.1 Trigger Events

The Evidence Creator or Acquisition Modality generates a Blending Softcopy Presentation State instance and chooses to send it to the Image Archive for storage.

4.57.4.1.2 Message Semantics

The Evidence Creator or Acquisition Modality uses the DICOM C-STORE message to store a Blending Softcopy Presentation State (BSPS) instance. The Evidence Creator or Acquisition Modality are the DICOM Storage SCU and the Image Archive is the DICOM Storage SCP.

The BSPS defines the fused presentation of an underlying grayscale image set and a superimposed color-coded image set.

The Presentation State Relationship Macro in the Blending Sequence (0070, 0402) shall list all the images or frames to which blending shall be applied. The BSPS may reference the data to blend by study/series and if desired, specific instances by their image UIDs (or the frames in the case of a multiframe object).

Note that Image Displays are not required to be able to handle fusion of projection images with non-projection images.

The Referenced Spatial Registration Sequence (0070, 0404) shall be present unless the referenced images all share the same Frame of Reference, in which case it may be present.

If Referenced Spatial Registration Sequence is absent, no transformation needs to be applied to register the referenced images. An empty sequence shall not be used to indicate "unknown" transformation.

If Referenced Spatial Registration Sequence is present, it shall contain a reference to a single Spatial Registration instance which registers all images referenced by the Blending Presentation State. Multiple alternative registrations for the same set of image data shall be referenced in separate Blending Presentation States.

Modifying an existing Blending Softcopy Presentation State shall result in a new instance with a new instance UID.

The color space encoded in ICC Profile (0028, 2000) shall be the default ICC space (sRGB).

The Blending Softcopy Presentation State object shall be stored:

- in the most recent of the Studies containing the regferenced images.
- in a different series from images and Spatial Registration Objects.

4.57.4.1.3 Expected Actions

The Image Archive will store the received Blending Softcopy Presentation State objects.

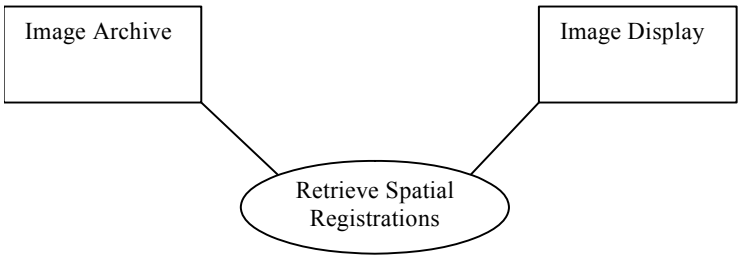
4.58 Retrieve Spatial Registrations

This section corresponds to Transaction 4.58 of the IHE Technical Framework. Transaction 4.58 is used by the Image Display and Image Archive actors.

4.58.1 Scope

An Image Display retrieves from an Image Archive the transformation information to be applied to two image data sets intended for further processing or fused display.

4.58.2 Use Case Roles



Actor: Image Archive

Role: Sends requested Spatial Registrations to the Image Display Actor.

Actor: Image Display

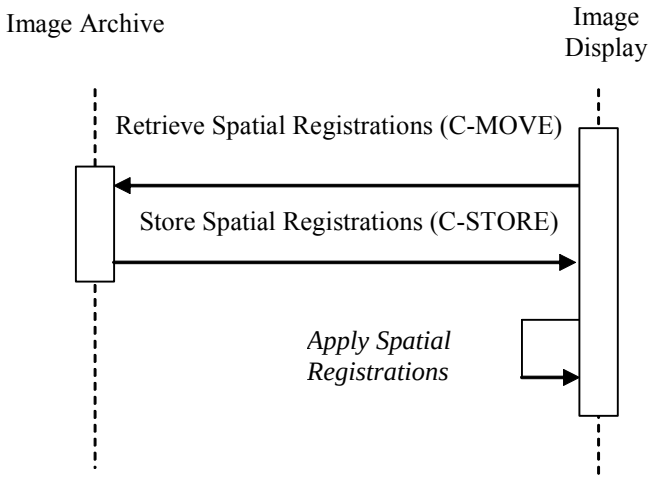
Role: Receives requested Spatial Registrations from the Image Archive Actor.

4.58.3 Referenced Standards

DICOM 2004 PS 3.4: Query/Retrieve Service Class

DICOM 2004 PS 3.4: Spatial Registration Storage

4.58.4 Interaction Diagram



4.58.4.1 Retrieve Spatial Registrations

The Retrieve (Study Root – MOVE and optionally Patient Root – MOVE) SOP Classes at Study and Series level shall be supported.

4.58.4.1.1 Trigger Events

The Image Display selects specific Spatial Registration objects to retrieve from the Image Archive. This may be based on the Spatial Registration being referenced in a previously retrieved Blending Softcopy Presentation State.

4.58.4.1.2 Message Semantics

The message semantics are defined in the DICOM Query/Retrieve Service Class. The Evidence Creator or Acquisition Modality are the DICOM Storage SCU and the Image Archive is the DICOM Storage SCP.

It is the responsibility of the Image Manager to assure that the patient and procedure information is current in the images and Spatial Registration objects when they are retrieved from the Image Archive.

It is the responsibility of the Image Display to apply the Spatial Registration as defined in DICOM. Refer to DICOM 2004 PS 3.4, Annex C, for detailed descriptive semantics.

A Registration Sequence item in the Spatial Registration may contain either:

- a Frame of Reference and no list of images, in which case the transformation shall be applied to all images within that Frame of Reference;

- a Frame of Reference and a list of images, in which case the transformation shall be applied only to the listed images, and not other images that may claim to share the same Frame of Reference;
- a list of images without any Frame of Reference specified, in which case the transformation shall be applied only to the listed images.

4.58.4.1.3 Expected Actions

The Image Archive receives the C-MOVE request, establishes a DICOM association with the Image Display, and uses the DICOM Spatial Registration Storage SOP Class to transfer the requested Spatial Registration objects.

The Image Display may receive patient data inconsistent with those received from a previously issued query or retrieve operation, e.g. if a patient has been renamed. The Image Display shall use the just queried information or the most recently received instances to ensure that the most recent patient data from the Image Manager/ Image Archive is displayed.

Add the following rows to the end of the table 5.1-2 in the Radiology Audit Trail Option to ITI-ATNA:

IHE Radiology Transaction	ATNA Trigger Event(s)	Actor(s) that shall be able to record audit event
Spatial Registrations Stored [RAD-56]	Begin-storing-instances	Sender (Evidence Creator, Acq. Mod) shall audit
	Instances-Stored	Receiver (IM/IA) shall audit
Blending Presentation States Stored [57]	Begin-storing-instances	Sender (Evidence Creator, Acq. Mod) shall audit
	Instances-Stored	Receiver (IM/IA) shall audit
Retrieve Spatial Registrations [58]	Instances-Stored	Sender (IM/IA) shall audit
	Study-used	Image Display shall audit