

Integrating the Healthcare Enterprise



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**IHE Radiation Oncology
Technical Framework Supplement**

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**Deformable Registration in Radiation Oncology
(DRRO)**

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Revision 1.2 – Trial Implementation

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Please verify you have the most recent version of this document. See [here](#) for Trial Implementation and Final Text versions and [here](#) for Public Comment versions.

Foreword

30 This is a supplement to the IHE Radiation Oncology Technical Framework V4.0. Each supplement undergoes a process of public comment and trial implementation before being incorporated into the volumes of the Technical Frameworks.

This supplement is published on November 26, 2025 trial implementation and may be available for testing at subsequent IHE Connectathons. The supplement may be amended based on the results of testing. Following successful testing it will be incorporated into the Radiation
35 Oncology Technical Framework. Comments are invited and can be submitted at [Radiation Oncology Public Comments](#).

This supplement describes changes to the existing technical framework documents.

“Boxed” instructions like the sample below indicate to the Volume Editor how to integrate the relevant section(s) into the relevant Technical Framework volume.

40 *Amend Section X.X by the following:*

Where the amendment adds text, make the added text **bold underline**. Where the amendment removes text, make the removed text ~~**bold strikethrough**~~. When entire new sections are added, introduce with editor’s instructions to “add new text” or similar, which for readability are not bolded or underlined.

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General information about IHE can be found at [IHE.net](#).

Information about the IHE Radiation Oncology domain can be found at [IHE Domains](#).

Information about the organization of IHE Technical Frameworks and Supplements and the process used to create them can be found at [Profiles](#) and [IHE Process](#).

50 The current version of the IHE Radiation Oncology Technical Framework can be found at <https://profiles.ihe.net/RO/index.html>.

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Introduction to this Supplement

155 The DRRO Profile defines the content necessary for exchanging DICOM Deformable Spatial Registration (DSR) objects between radiation oncology systems. In addition to defining the data required to accomplish deformable image registration, it provides requirements on data elements so that DSR objects can be appropriately handled by radiation oncology systems that test to this profile.

160 Open Issues and Questions

#	Introduced in	Description
1		Is there a usage for (0064,0010) Post Deformation Matrix?
2		Use case “Dose compositor” partially overlaps with DCOM. The use case involves a Dose Actor and a Dose Compositor Actor. The latter is the same as in DCOM. Do we include this use case (as well the Dose Compositor Actor) in DRRO and how do we differentiate? Include, but make sure that it is reflected in the resulting RT Dose. 2019-03-19: There appear to be some limitations in the current DICOM standard preventing storage with relevant references for the Deformable Dose Compositor.
3		Should Use cases “Deformable registration creation” and “Deformable registration editing” be separate use cases or do we merge and use “optional” for consumption of Deformable Spatial Registration Object? 2018-02-04: Not clear if Use case “Deformable registration editing” corresponds to any current clinical product. The use case is retained as a placeholder.
4		Contourer Actor is described as propagation of structures but for the use cases also used to describe the action of contouring in fusion view. Should we introduce one more actor (Fusion View Contourer Actor)?
5		Do we introduce prerequisites on the RT Dose objects considered (axial)?
6		2019-03-18: Handling of Fiducial (0070,0314 “Used Fiducial Sequence”) was discussed. This is an Open Issue – could be handled as a Profile Option. The idea would be to use the reference structures (regions and/or points of interest) which have been used to guide the deformable registration algorithm.
7		2019-09-09: Deformable Dose Compositor Actor and deformable compositing planning are moved to later versions of the profile.
8		2020-10-07: Patient Position in the case of PET should be discussed. Expression of patient position in PET is different than the historical way of expressing it in MR and CT. Check this profile and dependent profiles on patient position restrictions
9		2020-10-09: Are differences in orientation to gravity properly handled in DSRO and deformed images?

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#	Introduced in	Description
10		<p>2020-10-09:</p> <ul style="list-style-type: none"> • Use cases not described above but which have been discussed: <ul style="list-style-type: none"> ○ Use case: Deformable Registration Comparison A device can display the differences between deformable registrations. The difference here between straight dose comparison is that it can accept the deformable registration and the data that composes it. The actors for this use case may not be different from actors suggested by other use cases (deformable dose compositing, displaying) except that it may have a comparison component and the ability to display deltas with side by side dose displays. ○ Surgery Use Case: Resection Cavity Correction (Intra-Op Update) • Any interest / relevance to add use case for diagnostic PET/CT planning CT contouring in fusion / contour propagation [deformable registration between diagnostic CT and planning CT, while diagnostic PET and planning CT used for fusion / propagation]? • Resampling (images, structures, and dose) is outside the scope of the DRRO Profile. This should be pointed out clearly in the description.

Closed Issues

#	Introduced in	Section #	Issue	Description
1	1.0, Public comments	7.4.1.7.1.1	This <u>should</u> be used for Registered RCS	Changed should to shall
2	1.0, Public comments	7.4.1.9.2.2	On the higher level we should describe what we are trying to achieve: the deformed structure set should reference both the non-deformed source structure set and the deformable registration that was used in the deformation.	With reference to TC meeting April 15, 2021: Additional requirements for derivation codes and referenced source instances in RT Structure Set have been removed (section 7.4.1.9.2.2) since they may not be applicable to all ROIs in the RT Structure Set.
3	1.0, Public comments	7.4.1.9.2.2	The codes are incorrect (according to the standard): (DCM, 125027, ‘Deformed for Registration’) is used for the derivation code for the deformed structure set (DCM, 125028, ‘Source Deformable Spatial Registration’) is used for the Purpose of Reference Code for the deformable registration used.	With reference to IHE-RO TC meeting April 15, 2021: Additional requirements for derivation codes and referenced source instances in RT Structure Set have been removed (section 7.4.1.9.2.2) since they may not be applicable to all ROIs in the RT Structure Set.

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#	Introduced in	Section #	Issue	Description
4	1.0, Public comments	7.4.1.9.2.2	Where do we put the source structure set? Should it also be in the Source Instance Sequence (0042,0013) or in the Predecessor Structure Set Sequence (3006,0018)?	With reference to TC meeting April 15, 2021: Additional requirements for derivation codes and referenced source instances in RT Structure Set have been removed (section 7.4.1.9.2.2) since they may not be applicable to all ROIs in the RT Structure Set.
5	1.0, Public comments	7.4.15.1.1.2	Frame of reference identity (125021) should be one of the registration type codes and <u>mandatory</u> for the identity registration sequence	With reference to TC meeting April 15, 2021: Agreement that Frame of Reference Identity code (125021) is to be used for the identity transformation. A CP to require this code for rigid registrations in the MMRO-* Profile is to be drafted as well
6	1.0, Public comments	7.4.15.1.1.2	What about 'NaN's in the Vector Grid Data? They should be explicitly not allowed.	With reference to TC meeting April 15, 2021: NaN values are to be allowed in the deformation map. Consuming actors must handle NaN values safely.
7	1.0, Public comments	7.4.15.1.1.2	Should Content Creator's Name (0070,0084) be mandatory?	With reference to TC meeting April 15, 2021: It is appropriate that Content Creator's Name attribute is Type 2 (accommodates automated use case).
8	1.0, Public comments	"general"	If deformable process involves objects (contours/ROI/points) that affect deformation, it can be difficult to analyze the deformable registration without this information.	With reference to TC meeting April 15, 2021: Metadata regarding deformation process and parameters is not adequately captured by the DICOM Standard. Conveying this meta-information is currently outside the scope of the DRRO Profile. See #6 under Open Issues.
9	4. Trial implementation	7.4.15.1.1.2	Clarification of which image instances should be referenced	With reference to the TC meeting July 3, 2024: Incorporate corresponding wording as for MMRO-III CP (Referenced Image Sequence)
10	4. Trial implementation	7.4.1.8.3.2	Image Type Attribute (0008,0008) clarified to apply only to values 1 and 2	Updates after IHE-RO connect-a-thon October 2024
11	4. Trial implementation	7.4.1.7.1	Clarification that Frame of reference module applies not only to Deformable registration but also to Deformed image and Deformed dose, including a rewording of the attribute note	Updates after IHE-RO connect-a-thon October 2024

IHE Radiation Oncology Technical Framework Supplement – Deformable Registration in Radiation Oncology (DRRO)

#	Introduced in	Section #	Issue	Description
12	4. Trial implemenatation	7.4.15.1.1	Requirement that Referenced Image Sequence (0008,1140) be empty is inconsistent with DICOM requirement for this Sequence.	Correct Attribute Note to read: “Shall be empty absent or shall reference...”
13	4. Trial implemenatation	7.4.13.3.2	Tissue Heterogenity Correction (3004,0013) is Type 3. The requirement that it be present and have the same value as in the original RT Dose cannot be met if it is absent in the original RT Dose.	Correct Attribute Type to be “RC+” and Attribute Note to read: “If Attribute is present in the original RT Dose Instance, it shall be present and shall have the same value as in the original RT Dose Instance. Otherwise, shall be absent.”

IHE Technical Frameworks General Introduction

- 165 The [IHE Technical Frameworks General Introduction](#) is shared by all of the IHE domain technical frameworks. Each technical framework volume contains links to this document where appropriate.

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- 170 IHE technical documents refer to, and make use of, a number of standards developed and published by several standards development organizations. Please refer to the IHE Technical Frameworks General Introduction, [Section 9 - Copyright Licenses](#) for copyright license information for frequently referenced base standards. Information pertaining to the use of IHE International copyrighted materials is also available there.

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180 The [IHE Technical Framework General Introduction Appendices](#) are components shared by all of the IHE domain technical frameworks. Each technical framework volume contains links to these documents where appropriate.

185 *Update the following appendices to the General Introduction as indicated below. Note that these are **not** appendices to this domain’s Technical Framework (TF-1, TF-2, TF-3 or TF-4) but rather, they are appendices to the IHE Technical Frameworks General Introduction located [here](#).*

[Appendix A – Actors](#)

190 *Add the following **new or modified** actors to the [IHE Technical Frameworks General Introduction Appendix A](#):*

New (or modified) Actor Name	Description
Deformable Registrator	A system that consumes multi-modality images and generates deformable registrations.
Deformable Displayer	A system that consumes multi-modality images, structure sets and deformable registrations to display the registered information. The producer of the deformable registration is expected to be a Deformable Registrator .
Contour Deformer	A system that consumes multi-modality images, structure sets and deformable registrations to generate deformed structure sets in a Deformable Displayer .
Dose Deformer	A system that consumes multi-modality images, structure sets, dose and deformable registrations to generate deformed dose objects in a Deformable Displayer .
Image Deformer	A system that consumes multi-modality images, structure sets, and deformable registrations to generate deformed images in a Deformable Displayer .

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Appendix B – Transactions

Add the following **new or modified** transactions to the [IHE Technical Frameworks General Introduction Appendix B](#):

205

New (or modified) Transaction Name and Number	Definition
Deformable Registration Storage [RO-DRRO-1]	Storage of Deformable Registration Object instances.
Deformable Registration Retrieval [RO-DRRO-2]	Retrieval of Deformable Registration Object instances.

Appendix D – Glossary

210

Add the following **new or modified** glossary terms to the [IHE Technical Frameworks General Introduction Appendix D](#):

New (or modified) Glossary Term	Definition	Synonyms	Acronym/Abbreviation
No new terms			

Volume 1 – Profiles

Domain-specific additions

215 None

Add new Section 7

7 Deformable Registration for Radiation Oncology (DRRO) Profile

220 This Integration Profile specifies how images, RT Structure Sets, RT Doses, and associated deformable registration information can be exchanged, stored, processed, and displayed. The use of relevant DICOM objects (Deformable Spatial Registration) is clarified and constrained in order to avoid misinterpretations.

225 The *Deformable Registration for Radiation Oncology (DRRO) Profile* is a Workflow and Content Module profile. The focus is both on a registration workflow and content for image registration and deformation of structure sets and images.

7.1 DRRO Actors, Transactions, and Content Modules

230 Figure 7.1-1 shows the actors directly involved in the DRRO Profile and the relevant transactions between them. If needed for context, other actors that may be indirectly involved due to their participation in other related profiles are shown in dotted lines. Actors which have a mandatory grouping are shown in conjoined boxes.

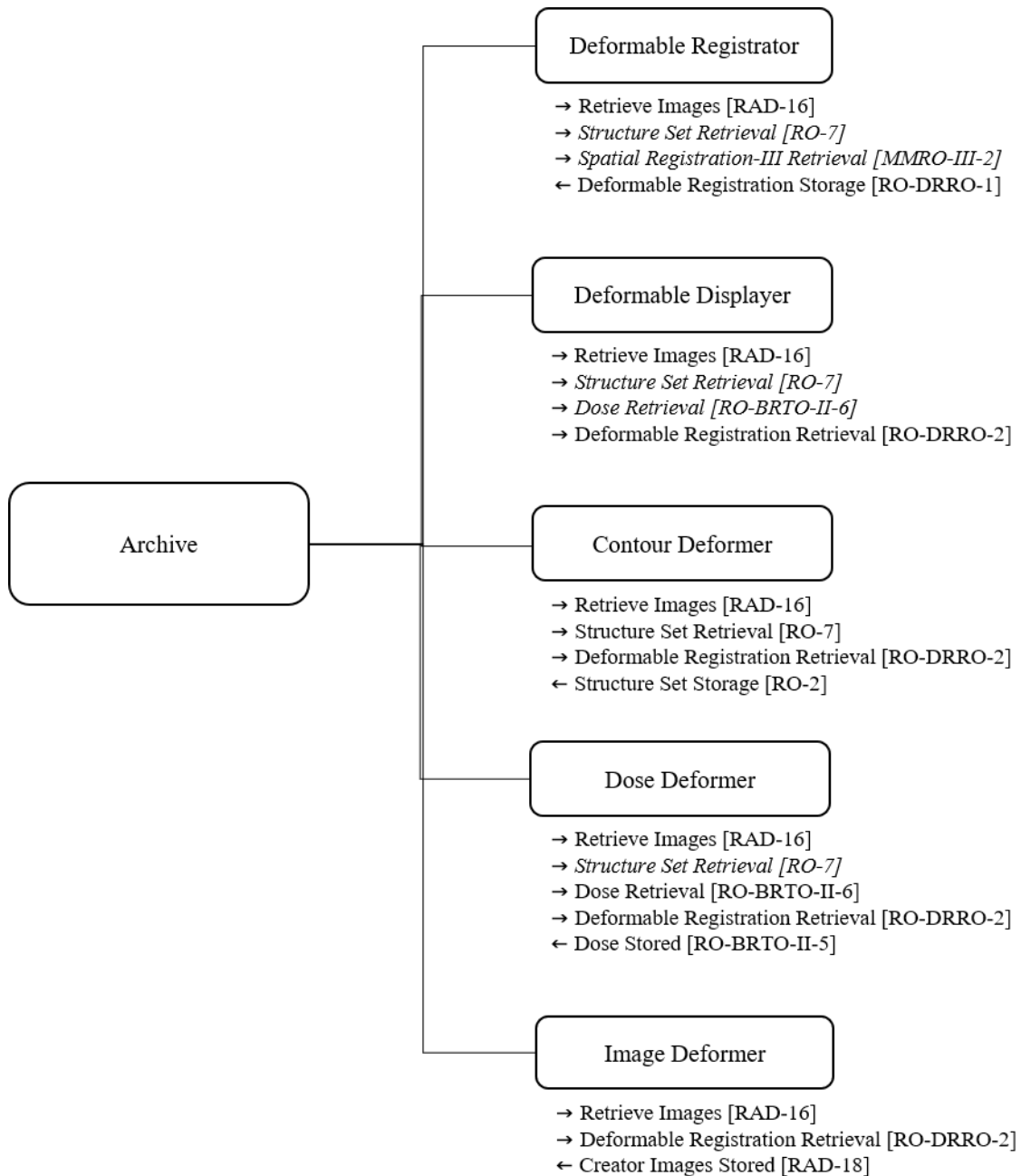


Figure 7.1-1: DRRO Actor Diagram

235 Table 7.1-1 lists the transactions for each actor directly involved in the DRRO Profile. In order to claim support for this profile, an implementation of an actor must perform the required transactions (labelled “R”) and may support the optional transactions (labeled “O”). Actor groupings are further described in Section 7.6.

Table 7.1-1: DRRO Profile – Actors and Transactions

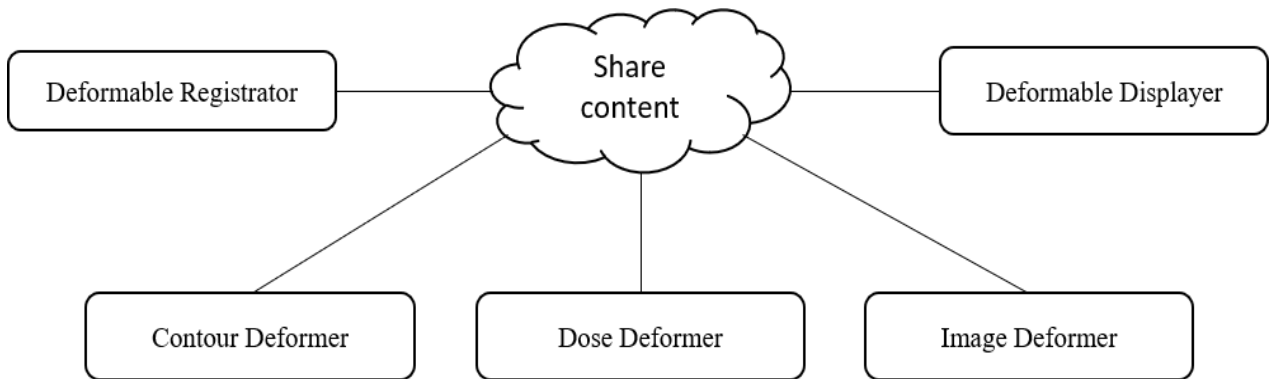
Actors	Transactions	Optionality	Reference
Deformable Registrator	Retrieve Images [RAD-16]	R	RAD TF-2: 4.16
	Structure Set Retrieval [RO-7]	O	RO TF-2: 3.7
	Spatial Registration-III Retrieval [MMRO-III-2]	O	RO TF-2: 3.18
	Deformable Registration Storage [RO-DRRO-1]	R	RO TF-2: 7.1
Deformable Displayer	Retrieve Images [RAD-16]	R	RAD TF-2: 4.16
	Structure Set Retrieval [RO-7]	O	RO TF-2: 3.7
	Dose Retrieval [RO-BRTO-II-6]	O	RO TF-2: 3.11
	Deformable Registration Retrieval [RO-DRRO-2]	R	RO TF-2: 7.2
Contour Deformer	Retrieve Images [RAD-16]	R	RAD TF-2: 4.16
	Structure Set Retrieval [RO-7]	R	RO TF-2: 3.7
	Deformable Registration Retrieval [RO-DRRO-2]	R	RO TF-2: 7.2
	Structure Set Storage [RO-2]	R	RO TF-2: 3.2
Image Deformer	Retrieve Images [RAD-16]	R	RAD TF-2: 4.8
	Deformable Registration Retrieval [RO-DRRO-2]	R	RO TF-2: 7.2
	Creator Images Stored [RAD-18]	R	RAD TF-2: 4.18
Dose Deformer	Retrieve Images [RAD-16]	R	RAD TF-2: 4.16
	Structure Set Retrieval [RO-7]	O	RO TF-2: 3.7
	Dose Retrieval [RO-BRTO-II-6]	R	RO TF-2: 3.11
	Deformable Registration Retrieval [RO-DRRO-2]	R	RO TF-2: 7.2
	Dose Stored [RO-BRTO-II-5]	R	RO TF-2: 3.3

240

Figure 7.1-1 shows the actors directly involved in the DRRO Profile and the direction that the content is exchanged.

245

A product implementation using this profile may group actors from this profile with actors from a workflow or transport profile to be functional. The grouping of the content module described in this profile to specific actors is described in more detail in Cross Profile Considerations Section 7.6.



250

Figure 7.1-2: DRRO Actor Diagram

Table 1-2 lists the content modules defined in the DRRO Profile. To claim support with this profile, an actor shall support all required content modules (labeled “R”) and may support optional content modules (labeled “O”).

Table 7.1-2: DRRO – Actors and Content Modules

Actors	Content Modules	Optionality	Reference
Deformable Registrator	Deformable Spatial Registration IOD for General Use	R	RO TF-3: 7.3.11.1
	Frame of Reference Module for Deformable Registrations	R	RO TF-3: 7.4.1.7.1
	Deformable Spatial Registration Module Base Content	R	RO TF-3: 7.4.15.1.1
Deformable Displayer	-	-	-
Contour Deformer	-	-	-
Image Deformer	General Image Module in Deformed Image	R	RO TF-3: 7.4.1.8.3
	General Reference Module in Deformed Image	R	RO TF-3: 7.4.1.9.1
Dose Deformer	RT Dose in Deformed Dose	R	RO TF-3: 7.4.13.3.2

255

7.1.1 Actor Description and Actor Profile Requirements

No additional requirements are needed.

7.2 DRRO Actor Options

Options that may be selected for this profile are listed in Table 7.2-1 along with the actors to which they apply. Dependencies between options when applicable are specified in notes.

260

Table 7.2-1: DRRO – Actors and Options

Actor	Options	Reference
Deformable Registrator	Structure Set Retrieval [RO-7]	RO TF-2: 3.7
	Spatial Registration-III Retrieval [MMRO-III-2]	RO TF-2: 3.18
Deformable Displayer	Structure Set Retrieval [RO-7]	RO TF-2: 3.7
	Dose Retrieval [RO-BRTO-II-6]	RO TF-2: 3.11
Contour Deformer	No options defined	-
Image Deformer	No options defined	-
Dose Deformer	Structure Set Retrieval [RO-7]	RO TF-2: 3.7

7.3 DRRO Required Actor Groupings

None.

265 7.4 DRRO Overview

7.4.1 Concepts

7.4.1.1 Deformable Image Registration (DIR)

270 Deformable image registration (DIR) is the process of defining a mapping between the positions in one scan and their corresponding positions in another scan. This permits point-wise merging of information in scans acquired of the same subject at different time points or of different subjects and is of high relevance in many aspects of radiation therapy treatments.

275 DIR allows for alignment that accounts for changes such as organ deformation, patient weight loss, or tumor shrinkage. DIR has the perspective of being widely integrated into many different steps of the radiotherapy process including planning, delivery and accumulated dose from radiotherapy. For example, inter-fractional registration can be used to match an image acquired at one treatment fraction to an image from another fraction to improve patient positioning, and to evaluate organ motion relative to bony anatomy. Another particular use is data transfer between images to propagate contours from the planning images or from an atlas to newly acquired images as well as between images of different modalities. Intra-fractional registration is used to match images acquiring during a single treatment fraction. For example, this process is used to track respiratory motion and can be used to generate a model of organ motion across a patient population.

285 Once the registration is complete, the result is recorded in a Deformable Spatial Registration object which is typically stored in the study with the image data. The registration is described through a rigid transform, for initial coarse alignment, and a deformation vector field, for subsequent detailed alignment, see Section 7.4.1.2.

290 Many different deformable image registration algorithms exist. The specific algorithm used may be of interest to the user (especially when several different registrations exist between the same datasets). It is therefore relevant that the Deformable Spatial Registration object stores information on the type of algorithm used, for instance if the driving force is image information or fiducial markers in terms of POIs or ROIs.

7.4.1.2 Rigid transform and deformation vector field

295 Deformations and transformations describe how to sample data from the *Source* Reference Coordinate System (RCS) into the *Registered* RCS. The deformable spatial registration is applied to the Registered RCS coordinates by:

1. First, transforming the coordinates using a pre deformation matrix; and
2. Then, applying the deformation offsets to the resulting coordinates.

The resulting coordinate addresses the corresponding point within the Source RCS. In other words,

- 300
- Each vector describes the displacement of a point in the Registered RCS to spatially align with the corresponding point in the Source RCS, after having been rigidly aligned through a pre deformation matrix; and
 - The vector field is defined on the Registered image.

Expressed as an equation, a source coordinate can be calculated as:

305

$$\begin{bmatrix} X_{Source} \\ Y_{Source} \\ Z_{Source} \\ 1 \end{bmatrix} = M_{pre} \begin{bmatrix} X_{Start} + i \cdot X_R \\ Y_{Start} + i \cdot Y_R \\ Z_{Start} + i \cdot Z_R \\ 1 \end{bmatrix} + \begin{bmatrix} \Delta X_{ijk} \\ \Delta Y_{ijk} \\ \Delta Z_{ijk} \\ 0 \end{bmatrix},$$

310 where $(X \ Y \ Z)_{Source}$ is the spatial coordinate in the Source RCS; $(X \ Y \ Z)_{Start}$ the start coordinate in the Registered RCS of the deformation grid; $(i \ j \ k)$ the index in the deformation grid in the X , Y , and Z dimension; $(X \ Y \ Z)_R$ the resolution of the deformation grid in the X , Y , and Z dimension; $(\Delta X_{ijk} \ \Delta Y_{ijk} \ \Delta Z_{ijk})$ the deformation at index (i, j, k) in the deformation grid; and M_{pre} the pre deformation matrix.

Note that a deformation vector field is not, in general, invertible. This is a difference with respect to Spatial Registration object which can be used for rigid alignment in both directions.

7.4.1.3 Deforming Images, Contours and Dose

A deformable image registration can be used to create deformed objects.

315 Contours on the Registered image can be deformed to the Source image following the vector field.

The Source image can be deformed to the Registered image and stored as a Deformed image. This allows for instance visualization of the two images fused.

320 A RT Dose defined on the Source image can be deformed to the Registered image and stored as a Deformed Dose. This allows for instance summation of doses on different images.

7.4.2 Use Cases

7.4.2.1 Use Case #1: Deformable Registration Creation

A deformable registration is created based on two images in the system.

7.4.2.1.1 Deformable Registration Creation Use Case Description

325 The Deformable Registrator and some data source (e.g., an Archive) retrieves data and stores a deformable registration.

- Received:
 - Two series of images are retrieved.
 - *Optional A structure set is retrieved.*
- 330 • Action:
 - A deformable registration is created from Image R to Image S.
 - Structures (regions and points of interest) can optionally be used in the creation of the deformable registration
- Stored:
 - 335 ○ A Deformable Spatial Registration Object is stored.

7.4.2.1.2 Deformable Registration Creation Process Flow

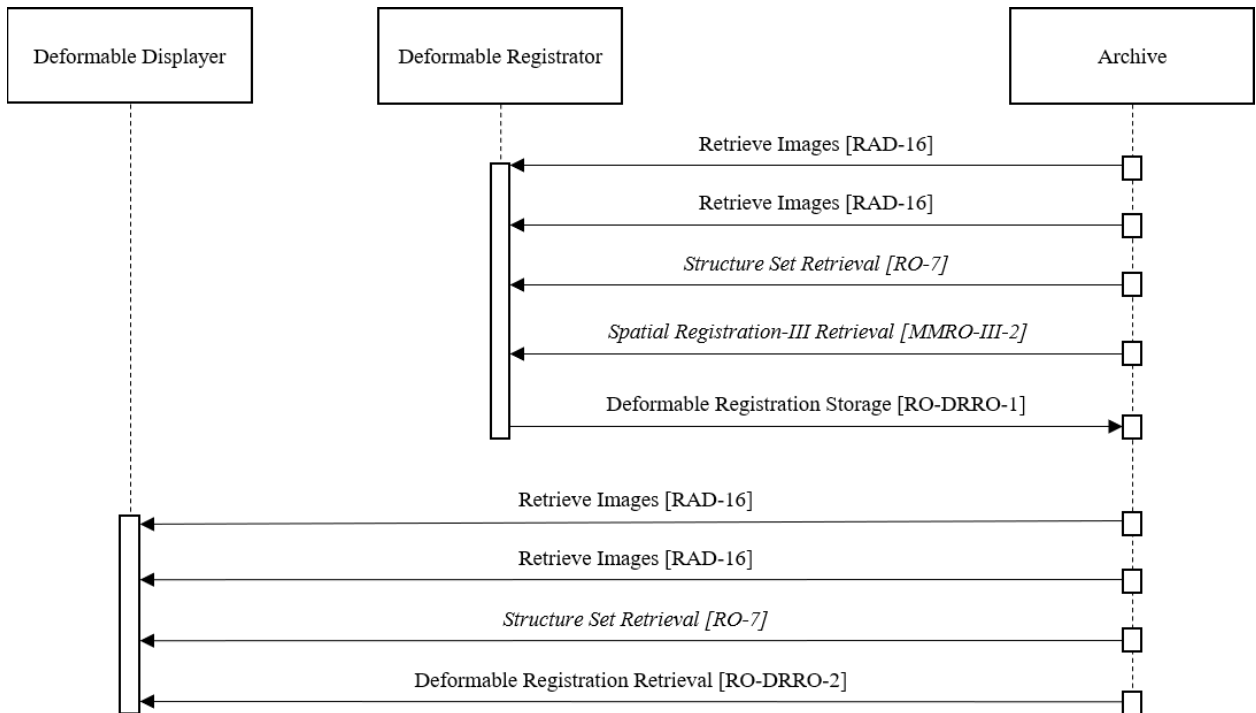


Figure 7.4.2.1.2-1: Process Flow for Deformable Registration Creation

7.4.2.2 Use Case #2: Multimodality Contouring I

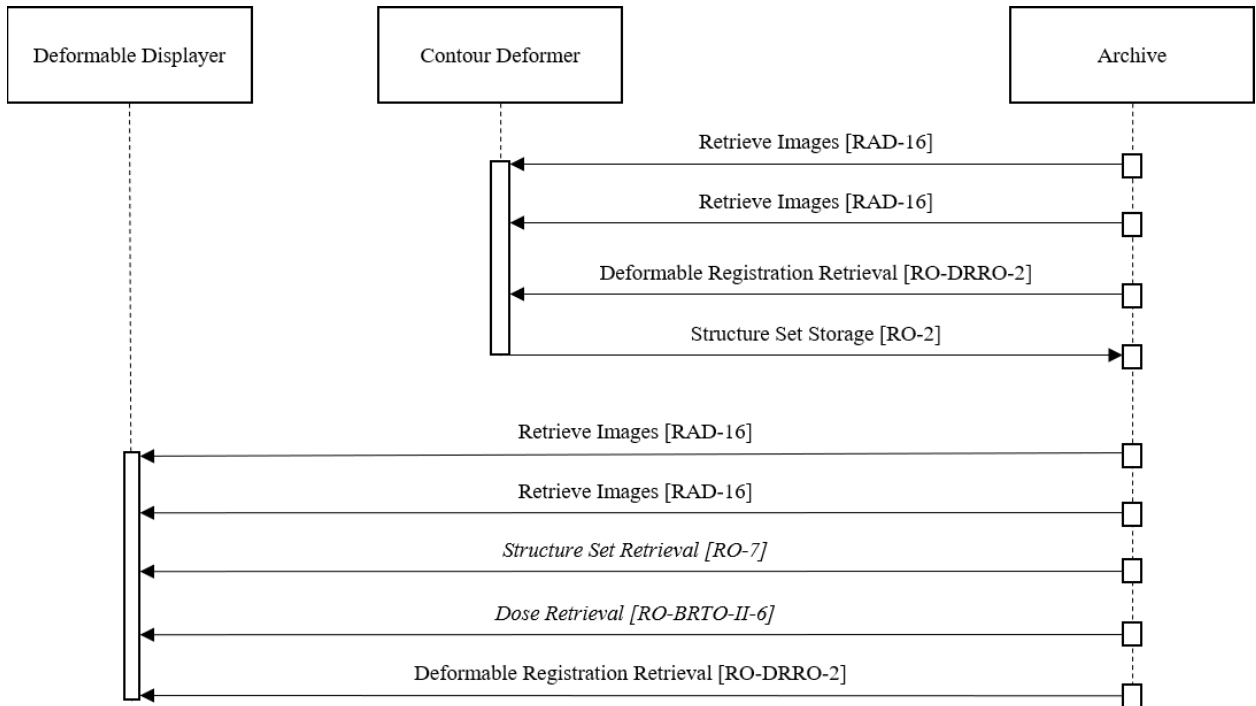
340 The images are visualized in a fusion view (based on the deformable image registration) and used to identify structures (regions and points of interest) in the system.

7.4.2.2.1 Multimodality Contouring I Use Case Description

- Received:
 - Two series of images (Image R and Image S) are retrieved.
 - 345 ○ A deformable registration from Image R to Image S is retrieved.
- Action:
 - Deformable Displayer displays a fusion of Image R and Image S using the deformable registration.
 - Deformable Displayer allows identification of structures (regions and points of interests) in the fusion view.
 - 350

- Stored:
 - The structures in Image R are stored.

7.4.2.2.2 Multimodality Contouring I Process Flow



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Figure 7.4.2.2.2-1: Process Flow for Multimodality Contouring I

7.4.2.3 Use Case #3: Multimodality Contouring II

The deformable image registration is used to propagate structures between images in the system.

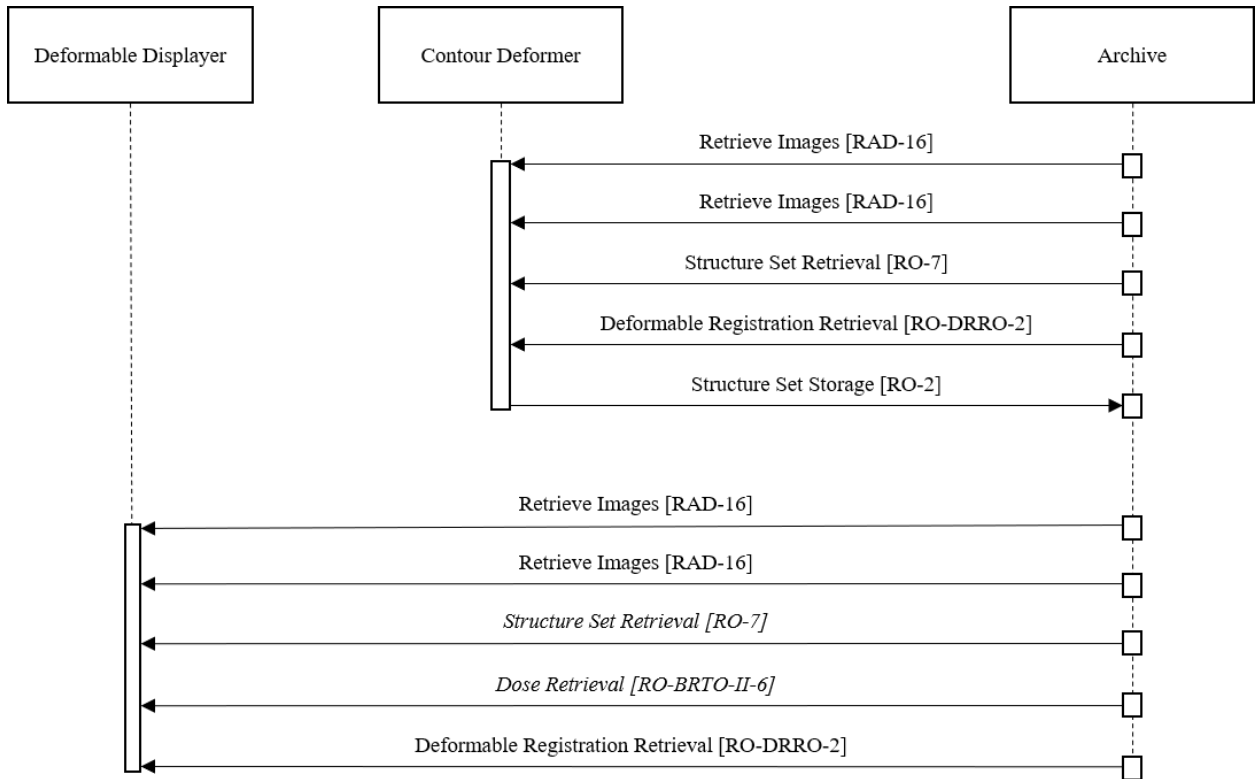
7.4.2.3.1 Multimodality Contouring II Use Case Description

- Received:
 - Two series of images as CT/MR/PET Image Objects – registered Image R and source Image S.
 - Structures (regions and points of interests) as RT Struct on Image R
 - A deformable image registration from Image R to Image S as Deformable Spatial Registration Object.
- Action: A Contour Deformer Actor allows propagation of the structures from Image R to Image S based on the deformable image registration.

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- Stored: The structures in Image S are stored as a RT Struct Object.

7.4.2.3.2 Multimodality Contouring II Process Flow



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Figure 7.4.2.3.2-1: Process Flow for Multimodality Contouring II

7.4.2.4 Use Case #4: Dose Deformation

The deformable image registration is used to map the dose from one image to another in the system.

7.4.2.4.1 Dose Deformation Use Case Description

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- Received:
 - Two series of images as CT/MR/PET Image Objects – registered Image R and source Image S
 - A deformable image registration from Image R to Image S as Deformable Spatial Registration Object.

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- A dose on Image S as RT Dose Object.

- Action: A Dose Actor allows mapping of the dose on Image S to Image R based on the deformable image registration.
- Stored: The deformed dose is stored as a RT Dose Object in the frame-of-reference and patient orientation as Image R.

385 **7.4.2.4.2 Dose Deformation Process Flow**

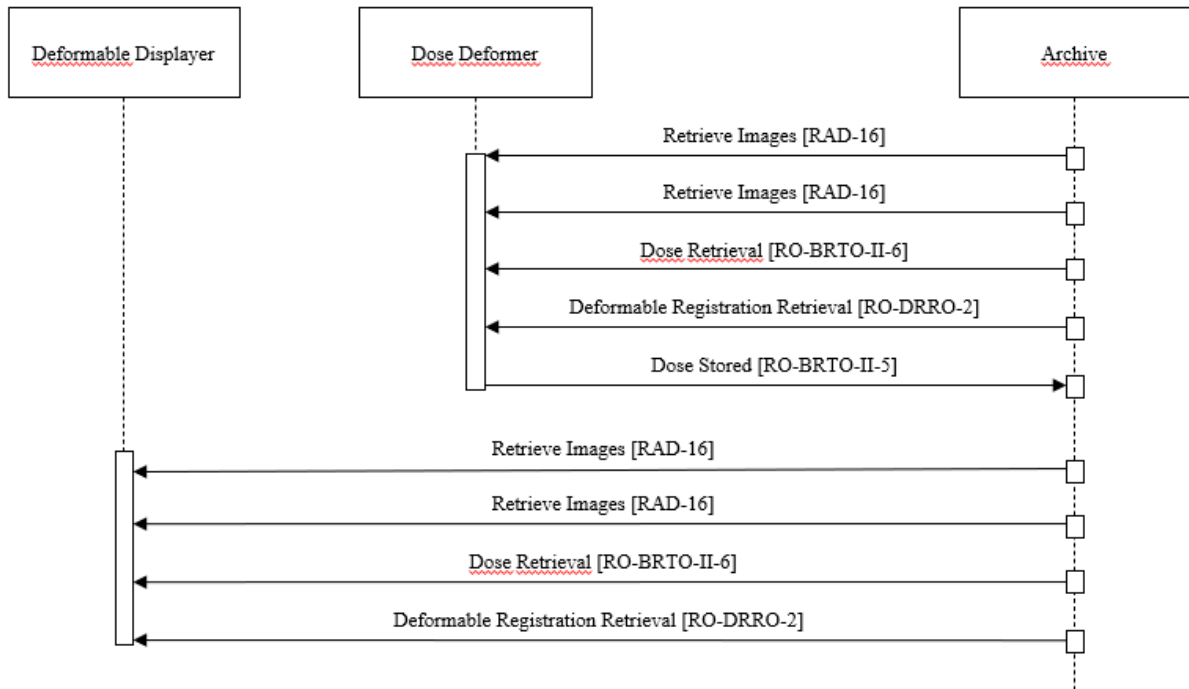


Figure 7.4.2.4.2-1: Process Flow for Dose Deformation

7.4.2.5 Use Case #5: Image Deformation

The deformable image registration is used to deform an image in the system.

390 **7.4.2.5.1 Image Deformation Use Case Description**

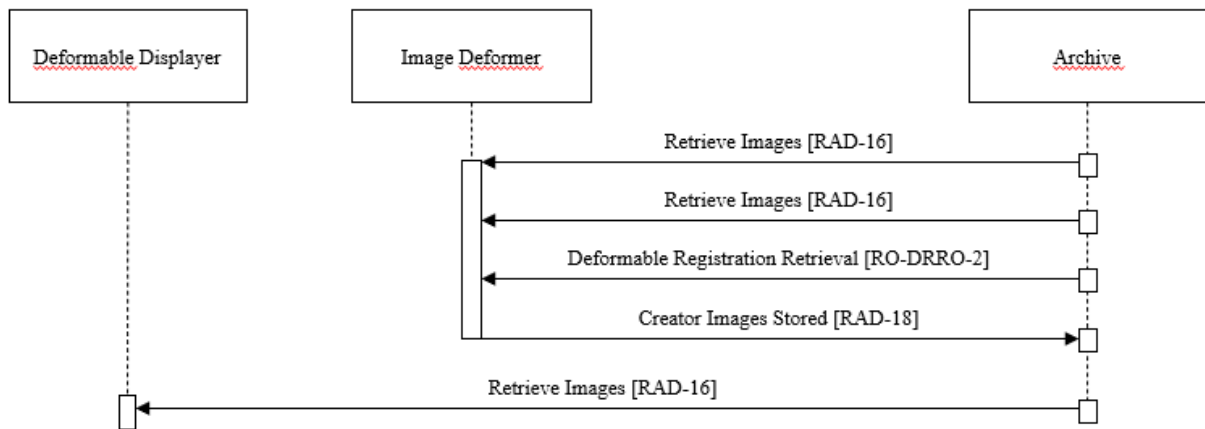
- Received:
 - Two series of images as CT/MR/PET Image Objects – registered Image R and source Image S
 - A deformable image registration from Image R to Image S as Deformable Spatial Registration Object.

395

- Action: An Image Actor allows deforming Image R to Image S based on the deformable image registration.
- Stored: The deformed image is stored as a CT/MR/PET Image Object, where the geometrical information corresponds to Image R:
 - Image acquisition information corresponds to Image S.
 - Reference to Deformable Spatial Registration Object
 - Referenced Image (Image S)
 - Dates and time taken from Image S

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7.4.2.5.2 Image Deformation Process Flow



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Figure 7.4.2.5.2-1: Process Flow for Image Deformation

7.4.2.6 Use Case #6: Image Distortion Correction

The deformable image registration is used to deform an image in the system. Applicable, e.g., for phantom based geometrical correction of MRI images where a displacement field which may not be patient-specific is used.

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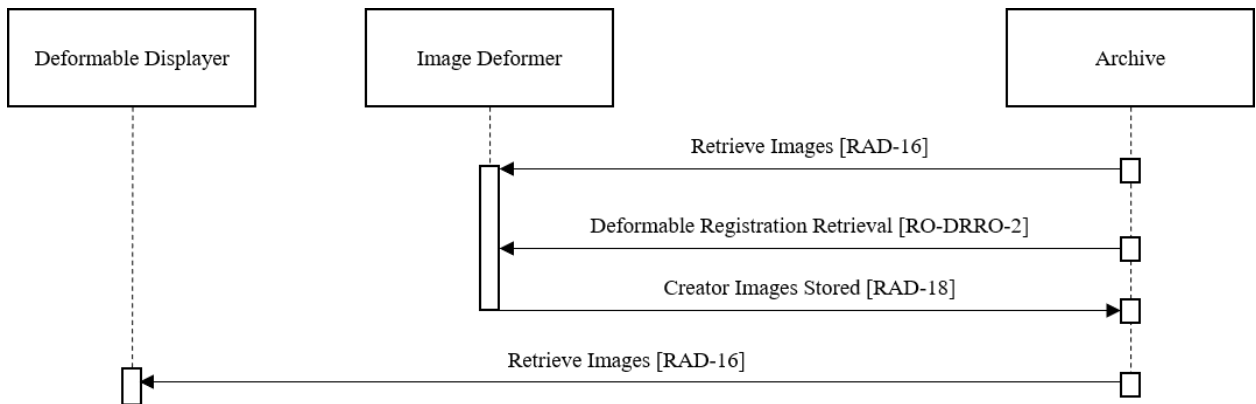
7.4.2.6.1 Image Distortion Correction Use Case Description

- Received:
 - One series of images as CT/MR/PET Image Object – source Image S
 - A displacement field to Image S as Deformable Spatial Registration Object.
- Action: An Image Actor deforms Image S based on the displacement field.
- Stored: The deformed image is stored as a CT/MR/PET Image Object, where:

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- Image acquisition information corresponds to Image S.
- Reference to Deformable Spatial Registration Object
- Referenced Image (Image S)
- 420 ○ Dates and time taken from Image S

7.4.2.6.2 Image Distortion Process Flow



425 **Figure 7.4.2.6.2-1: Process Flow for Image Deformation**

7.5 DRRO Security Considerations

There are no explicit security considerations in this profile.

7.6 DRRO Cross Profile Considerations

430 Consistent Presentation of Images (CPI) – Consistent Presentation of Images Integration Profile

Actors of the DRRO Profile uses the Retrieve Images [RAD-16] and Creator Images Stored [RAD-18] transactions defined by the CPI Profile (RAD TF-1: 5).

BRTO-II – Basic Radiation Therapy Objects Integration Profile II

435 A Contourer in BRTO-II might be grouped with a Deformed Contourer to support a rich suite of contouring tools.

MMRO-III - Multimodality Image Registration for Radiation Oncology 2018

- 440 A Registrator in MMRO-III might be grouped with a Deformable Registrator to support both spatial registration and deformable registration.
- A Registered Display in MMRO-III might be grouped with a Deformable Displayer to support display of spatial registrations and deformable registrations.
- A Registered Dose Display in MMRO-III might be grouped with a Deformable Displayer to support display of registered dose.
- 445 A Registered Contourer in MMRO-III might be grouped with a Deformable Contourer to support spatial registration of contours and deformable registration of contours.

Volume 2 – Transactions

3.X Deformable Registration Storage [RO-DRRO-1]

450 **3.X.1 Scope**

3.X.2 Actor Roles

Actor:	Deformable Registrator
Role:	Create and transmit Deformable Spatial Registration Objects

3.X.3 Referenced Standards

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3.X.4 Messages

455 **3.X.4.1 Storage of Deformable Registration**

3.X.4.1.1 Trigger Events

The Deformable Registrator retrieves images (Images S and Images R) and creates a Deformable Spatial Registration instance.

3.X.4.1.2 Message Semantics

460 The following actions and transmissions are expected:

1. Retrieve image series Images S
2. Retrieve image series Images R
3. Process images and create deformable registration
4. Store deformable registration

465 The content of the deformable registration shall conform to the content module definition 7.3.11 Deformable Spatial Registration IOD in RO TF-3.

3.X.4.1.3 Expected Actions

The Deformable Registrator processes the image series Images S and Images R and creates a Deformable Spatial Registration instance.

470 **3.Y Deformable Registration Retrieval [RO-DRRO-2]**

3.Y.1 Scope

3.Y.2 Actor Roles

Actor:	Deformable Displayer
Role:	Retrieve Deformable Spatial Registration Objects For Display
Actor:	Contour Deformer
Role:	Retrieve Deformable Spatial Registration Objects To Deform Contours
Actor:	Image Deformer
Role:	Retrieve Deformable Spatial Registration Objects To Deform Images
Actor:	Dose Deformer
Role:	Retrieve Deformable Spatial Registration Objects To Deform Dose

3.Y.3 Referenced Standards

475 DICOM 2020d Edition PS 3.3

3.Y.4 Messages

3.Y.4.1 Retrieval of Deformable Registration

3.Y.4.1.1 Trigger Events

480 The Deformable Displayer retrieves Images (Images S, Images R), Structure Set (optional), Dose (optional), and a Deformable Spatial Registration instance.

3.Y.4.1.2 Message Semantics

The following actions and transmissions are expected:

1. Retrieve image series Images S
2. Retrieve image series Images R
- 485 3. Retrieve Structure Set (optional)
4. Retrieve Dose (optional)
5. Retrieve Deformable Spatial Registration

3.Y.4.1.3 Expected Actions

- 490 The Deformable Displayed processes the image series Images S and Images R and Deformable Spatial Registration instance. Optionally it applies the registration on the retrieved structure set and dose.

Volume 3 – Content Modules

495 7 Radiation Oncology DICOM Content Definitions

7.3 IOD Definitions

7.3.11 Deformable Spatial Registration IOD

7.3.11.1 Deformable Spatial Registration IOD for General Use

7.3.11.1.1 Deformable Spatial Registration IOD Base Content

500 7.3.11.1.2 Referenced Standards

DICOM 2020d PS 3.3

7.3.11.1.3 IOD Definition

IE	Module	Reference	Usage	IHE-RO Usage
Patient	Patient	C.7.1.1	M	M
	Clinical Trial Subject	C.7.1.3	U	U
Study	General Study	C.7.2.1	M	M
	Patient Study	C.7.2.2	U	U
	Clinical Trial Study	C.7.2.3	U	U
Series	General Series	C.7.3.1	M	M
	Clinical Trial Series	C.7.3.2	U	U
	Spatial Registration Series	C.20.1	M	M
Frame of Reference	Frame of Reference	C.7.4.1	M	R See Section 7.4.1.7.1
Equipment	General Equipment	C.7.5.1	M	M
	Enhanced Frame of Reference	C.7.5.2	M	M
Spatial Registration	Deformable Spatial Registration	C.20.3	M	R See Section 7.4.15.1
	Common Instance Reference	C.12.2	M	M
	General Reference	C.12.4	U	U
	SOP Common	C.12.1	M	M

7.4 Module Definitions

7.4.1 General Modules

505 7.4.1.7 Frame of Reference Module

7.4.1.7.1 Frame of Reference Module for Deformable Registrations, Deformed Image, and Deformed Dose

7.4.1.7.1.1 Reference Standards

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510 7.4.1.7.1.2 Module Definition

Attribute	Tag	Type	Attribute Note
Frame of Reference UID	(0020,0052)	R	Shall be the Frame of Reference UID of the Registered RCS.
Position Reference Indicator	(0020,1040)	-	

7.4.1.8 General Image Module

This Module Content must be present for any instance of the following SOP Classes that is used in adherence to the Deformable Registration in Radiation Oncology Profile:

- 515 • CT Image Storage (1.2.840.10008.5.1.4.1.1.2)
- MR Image Storage (1.2.840.10008.5.1.4.1.1.4)
- Positron Emission Tomography Image Storage (1.2.840.10008.5.1.4.1.1.128)

7.4.1.8.3 General Image Module in Deformed Image

7.4.1.8.3.1 Reference Standards

520 DICOM 2020d Edition PS 3.3

7.4.1.8.3.2 Module Definition

Attribute	Tag	Type	Attribute Note
Image Type	(0008,0008)	R	The first value shall be DERIVED. The second value shall be SECONDARY.

7.4.1.9 General Reference Module

525 This Module Content must be present for any instance of the following SOP Classes that is used in adherence to the Deformable Registration in Radiation Oncology Profile:

- CT Image Storage (1.2.840.10008.5.1.4.1.1.2)
- MR Image Storage (1.2.840.10008.5.1.4.1.1.4)
- Positron Emission Tomography Image Storage (1.2.840.10008.5.1.4.1.1.128)

7.4.1.9.1 General Reference Module in Deformed Image

530 7.4.1.9.1.1 Referenced Standards

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7.4.1.9.1.2 Module Definition

Attribute	Tag	Type	Attribute Note
Derivation Description	(0008,2111)	R+	Shall be present
Derivation Code Sequence	(0008,9215)	R+	Shall be present
>Code Value	(0008,0100)	R+*	Shall be '125027'
>Code Scheme Designator	(0008,0102)	R+*	Shall be 'DCM'
>Code Meaning	(0008,0104)	R+	Shall be 'Deformed for Registration' or localized version
Source Instance Sequence	(0042,0013)	R+	Shall be present
>Referenced SOP Class UID	(0008,1150)	R+	Shall be '1.2.840.10008.5.1.4.1.1.66.3' for Deformable Spatial Registration Storage
>Referenced SOP Instance UID	(0008,1155)	R+	
>Purpose of Reference Code Sequence	(0040,A170)	R+	Shall be present
>>Code Value	(0008,0100)	R+*	Shall be '125028'
>>Code Scheme Designator	(0008,0102)	R+*	Shall be 'DCM'
>>Code Meaning	(0008,0104)	R+	Shall be 'Source Deformable Spatial Registration' or localized version

7.4.13 Dose-Related Modules

535 7.4.13.3 RT Dose Module

7.4.13.3.2 RT Dose in Deformed Dose

This Module Content must be present for any instance of the following SOP Classes that is used in adherence to the Deformable Registration in Radiation Oncology Profile:

- RT Dose Storage (1.2.840.10008.5.1.4.1.1.481.2)

540 The following table lists redefinitions of attributes within the Deformable Registration in Radiation Oncology, which extend the definitions of RT Dose Module Base Content.

7.4.13.3.2.1 Reference Standards

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7.4.13.3.2.2 Module Definition

Attribute	Tag	Type	Attribute Note
Dose Type	(3004,0004)	R	Shall be the same as the original dose.
Spatial Transform of Dose	(3004,0005)	R+	Shall be NON_RIGID.
Referenced Spatial Registration Sequence	(0070,0404)	R+	Shall reference the Deformable Spatial Registration SOP Instance used to deform the dose.
<i>Start Include Table 10-11 "SOP Instance Reference Macro Attributes"</i>			
>Referenced SOP Class UID	(0008,1150)	R+	Shall be '1.2.840.10008.5.1.4.1.1.66.3' for Deformable Spatial Registration Storage
>Referenced SOP Instance UID	(0008,1155)	R+	
<i>End Include Table 10-11 "SOP Instance Reference Macro Attributes"</i>			
Tissue Heterogeneity Correction	(3004,0014)	RC+	If Attribute is present in the original RT Dose Instance, it shall be present and shall have the same value as in the original RT Dose Instance. Otherwise, shall be absent.

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7.4.15 Deformable Spatial Registration Modules in Planning

7.4.15.1 Deformable Spatial Registration Module

7.4.15.1.1 Deformable Spatial Registration Module Base Content

7.4.15.1.1.1 Referenced Standards

550 DICOM 2020a Edition PS 3.3

7.4.15.1.1.2 Module Definition

Attribute	Tag	Type	Attribute Note
Content Date	(0008,0023)	-	
Content Time	(0008,0033)	-	
<i>Start Include of Table 10-12 "Content Identification Macro Attributes"</i>			
Instance Number	(0020,0013)	-	

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Attribute	Tag	Type	Attribute Note
Content Label	(0070,0080)	R+	Label used to distinguish registration instances. Shall not be empty
Content Description	(0070,0081)	R+	Description used to distinguish registration instances. Shall not be empty.
<i>End Include of Table 10-12 "Content Identification Macro Attributes"</i>			
Deformable Registration Sequence	(0064,0002)	R+*	Exactly two Item shall be present. One Item shall represent the Registered Image (with no Deformable registration grid sequence). The other Item shall represent the Source Image and shall have a Deformable Registration Grid Sequence
>Source Frame of Reference UID	(0064,0003)	-	Identifies a Frame of Reference that may or may not be an image set. Shall be present.
>Referenced Image Sequence	(0008,1140)	O+*	Identifies the set of images registered in this sequence item. Shall be absent or shall reference all image instances within the specified Source Frame of Reference UID (0064,0003) available to the Registrator at the time of deformable registration
>>Include 'Image SOP Instance Reference Macro' Table 10-3			
>Frame of Reference Transformation Comment	(3006,00C8)	-	
>Registration Type Code Sequence	(0070,030D)	R+	Shall be present and include one of the items in CID 7100 RCS Registration Method Type.
>Code Value	(0008,0100)	R+*	Shall be one of '125022' (Fiducial Alignment), '125024' (Image Content-based Alignment) or '125026' (Image Content and Fiducial Based Alignment) for the Source Image. Shall be '125021' (Frame of Reference Identity) for the Registered Image.
>Code Scheme Designator	(0008,0102)	R+*	Shall be 'DCM'
>Code Meaning	(0008,0104)	R+*	Shall be the Code Meaning corresponding to the value in Code Value (0008,0010) as specified in CID 7100
>Pre Deformation Matrix Registration Sequence	(0064,000F)	RC+	Shall include one Item for the Source Image in case a matrix transformation needs to be applied prior to deformation. In case this Item is absent the identity transformation matrix shall be applied. Shall be absent for the Registered Image
>>Frame of Reference Transformation Matrix	(3006,00C6)	-	
>>Frame of Reference Transformation Matrix Type	(0070,030C)	R+	Shall be RIGID
>Post Deformation Matrix Registration Sequence	(0064,0010)	R+	If present shall be the identity transformation matrix.
>Deformable Registration Grid Sequence	(0064,0005)	RC+	Shall be present for Source Image and shall be absent for Registered Image.
>>Image Orientation (Patient)	(0020,0037)	R	

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Attribute	Tag	Type	Attribute Note
>>Image Position (Patient)	(0020,0032)	R	
>>Grid Dimensions	(0064,0007)	R	
>>Grid Resolution	(0064,0008)	R	
>>Vector Grid Data	(0064,0009)	R*	'NaN' values shall be allowed. Consuming actors must handle 'NaN' values safely.
>Used Fiducials Sequence	(0070,0314)	-	