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**IHE Radiology  
Technical Framework Supplement**

10

**CT/MR Perfusion Imaging with Contrast  
(PERF)**

15

**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 Radiology Technical Framework V13.0. 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 July 30, 2014 for 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 Radiology Technical Framework. Comments are invited and may be submitted at  
35 [http://ihe.net/Radiology\\_Public\\_Comments](http://ihe.net/Radiology_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.

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<i>Amend section X.X by the following:</i>
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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: [www.ihe.net](http://www.ihe.net).

Information about the IHE Radiology domain can be found at: [http://ihe.net/IHE\\_Domains](http://ihe.net/IHE_Domains).

Information about the organization of IHE Technical Frameworks and Supplements and the process used to create them can be found at: [http://ihe.net/IHE\\_Process](http://ihe.net/IHE_Process) and  
50 <http://ihe.net/Profiles>.

The current version of the IHE Radiology Technical Framework can be found at: [http://ihe.net/Technical\\_Frameworks](http://ihe.net/Technical_Frameworks).

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## Introduction

This supplement adds a new profile to the IHE Radiology Technical Framework to address interoperability of Contrast Perfusion imaging data encoded as Enhanced CT/MR DICOM objects.

75 There are no new actors or transactions defined.

Additions are made to the following transactions:

- RAD-8 Modality Images Stored
- RAD-16 Retrieve Images

## Profile Abstract

80 The CT/MR Perfusion Imaging with Contrast Integration Profile facilitates the exchange of contrast enhanced images containing standard attributes for timing and position. The exchange of these attributes allow for correct and convenient display. Applications using the older single-frame DICOM image objects depended on proprietary assumptions about which timing attributes were expected to be present, and were not generally interoperable.

## 85 Open Issues and Questions

### Closed Issues

1. Which attribute should be used for the actual time: TemporalPositionIndex (is type 3) or Frame Reference DateTime (0018,9151)?

*Answer: TemporalPositionIndex will be made required.*

90 2. Can we assume all images will be frames in a single Enhanced CT or MR SOP Instance.

*Answer: No, there could be a need for multiple SOP Instances. E.g., the site might choose to acquire additional frames after the first acquisition is completed.*

*Answer: The committee decided to cover the 80 – 90% of situations where only one Perfusion object is allowed containing all original images, The object may potentially be split into multiple DICOM objects with the same Concatenation UID according to the DICOM rules.*

95

3. Is it necessary to display Contrast Usage attributes as listed in Table 4.16.4.2.2.n-1? Table 4.16.4.2.2.n-1 mandates a list of displayed attributes. Are more attributes required?

*Answer: TemporalPositionIndex, StackID and InStackPositionNumber*

100 4. Do we need to express image flavors other than PERFUSION?

Currently, the value of Image Type and Frame Type value 3 are both required to be PERFUSION. This excludes the use of values such as PRE\_CONTRAST and POST\_CONTRAST. In addition, DICOM WG-16 is working on PERFUSION\_ASL. Should Series Description Code Sequence to be used for indicating perfusion (CP-860)?

105 *Answer: No, the use case is limited to PERFUSION*

5. What should Display systems be required to do when there are frames for a single perfusion series in multiple Enhanced CT or MR SOP Instances?

In exceptional cases the clinician may decide to have additional images acquired after reviewing acquired images (the patient not having left the table). The current profile text requires the display to treat all related SOP instances as one.

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Do we need additional text how the display locates the various SOP instances?

*Answer: The IHE Radiology Technical Committee decided to cover the 80 – 90% of situations where the study will be completed with one single scan and all frames will be stored in one object. Thus the issue of multiple objects (other than Concatenation) is out of scope in this profile.*

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# Volume 1 – Integration Profiles

## Glossary

Add the following terms to the Glossary:

None

## 1.7 History of Annual Changes

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

- Added the CT/MR Perfusion Imaging with Contrast Integration Profile.

## 2.1 Dependencies among Integration Profiles

Add the following row to Table 2-1

CT/MR Perfusion Imaging with Contrast	none	none	-
---------------------------------------	------	------	---

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Add the following section to Section 2.2

### 2.2.23 CT/MR Perfusion Imaging with Contrast Integration Profile

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The CT/MR Perfusion Imaging with Contrast Integration Profile facilitates the exchange of contrast-enhanced images containing standard attributes for timing and position. The exchange of these attributes allows for correct and convenient display.

140

Add a column to Table 2.3-1 and place PERF in the header and an X in rows:

*Acq. Modality;*

*Image Archive;*

*Image Display;*

*Image Manager*

Add a column to Table 2.3-2 and place PERF in the header and an X in rows:

*Modality Images Stored [RAD-8]*

*Storage Commitment [RAD-10]*

145

*Query Images [RAD-14]*

*Retrieve Images [RAD-16]*

*Add Section 25*

## 25 CT/MR Perfusion Imaging with Contrast Integration Profile

150 CT/MR Perfusion Imaging with Contrast creates stacks of images at different timeslots, in order to demonstrate the uptake of a contrast agent over time.

This Integration Profile defines how these perfusion images are stored and archived into frames of one or more Enhanced DICOM (Multi-frame) object so that they can later be retrieved and displayed in an unambiguous way on image viewers supporting Enhanced DICOM objects.

155 This enables widespread and adequate review and interpretation of contrast-enhanced frames by radiologists in an IT environment where all Actors support the Enhanced CT or Enhanced MR DICOM objects; mixed environments that would need conversion of Enhanced objects into single-frame objects are out of scope. This Profile does not cover workflow or post-processing capabilities.

### 25.1 Actors/Transactions

160 Figure 25.1-1 diagrams the actors involved with this profile and the transactions between actors.

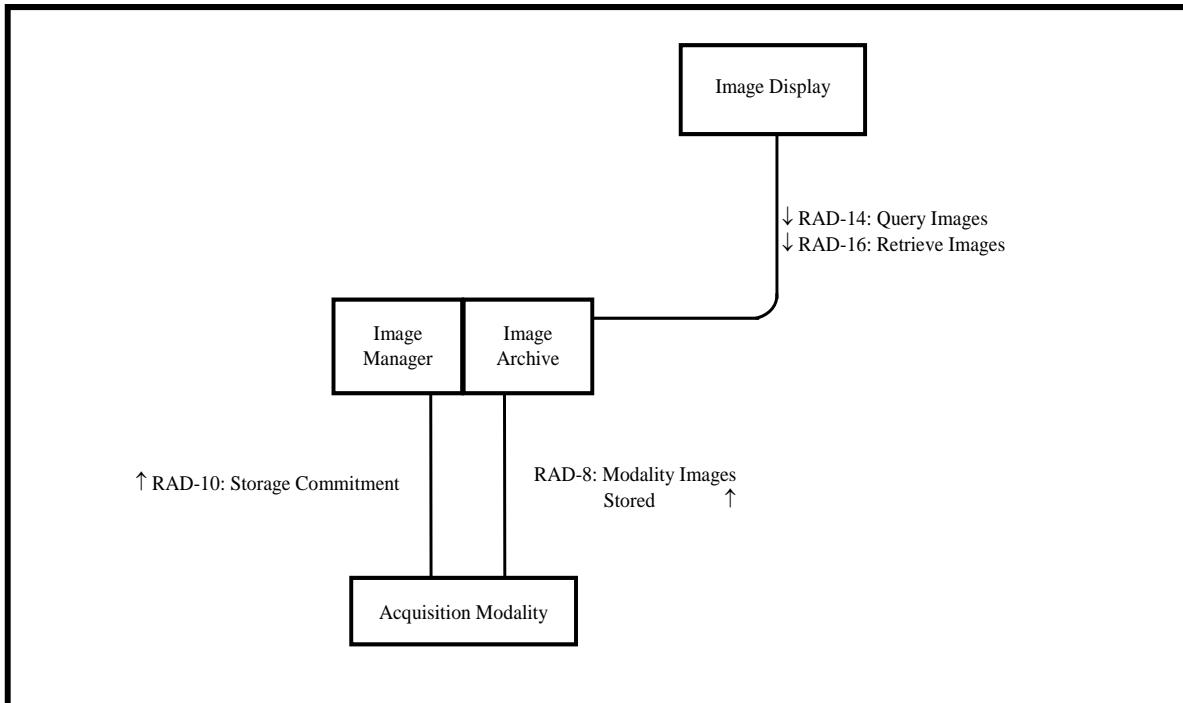


Figure 25.1-1: CT/MR Perfusion Imaging with Contrast Diagram

165 Table 25.1-1 lists the transactions for each actor directly involved in the CT/MR Perfusion Imaging with Contrast Integration Profile. 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 are listed in Section 25.2.

170 **Table 25.1-1: CT/MR Perfusion Imaging with Contrast - Actors and Transactions**

Actors	Transactions	Optionality	Section in Vol. 2
Acquisition Modality	Modality Images Stored [RAD-8]	R	4.8
	Storage Commitment [RAD-10]	R	4.10
Image Manager/Archive	Modality Images Stored [RAD-8]	R	4.8
	Creator Images Stored [RAD-18]	R	4.18
	Storage Commitment [RAD-10]	R	4.10
	Query Images [RAD-14]	R	4.14
	Retrieve Images [RAD-16]	R	4.16
Image Display	Query Images [RAD-14]	R	4.14
	Retrieve Images [RAD-16]	R	4.16

## 25.2 CT/MR Perfusion Imaging with Contrast Integration Profile Options

175 Options that may be selected for this Integration Profile are listed in Table 25.2-1 along with the Actors to which they apply. Dependencies between options when applicable are specified in notes.

**Table 25.2-1: CT/MR Perfusion Imaging with Contrast – Actors and Options**

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

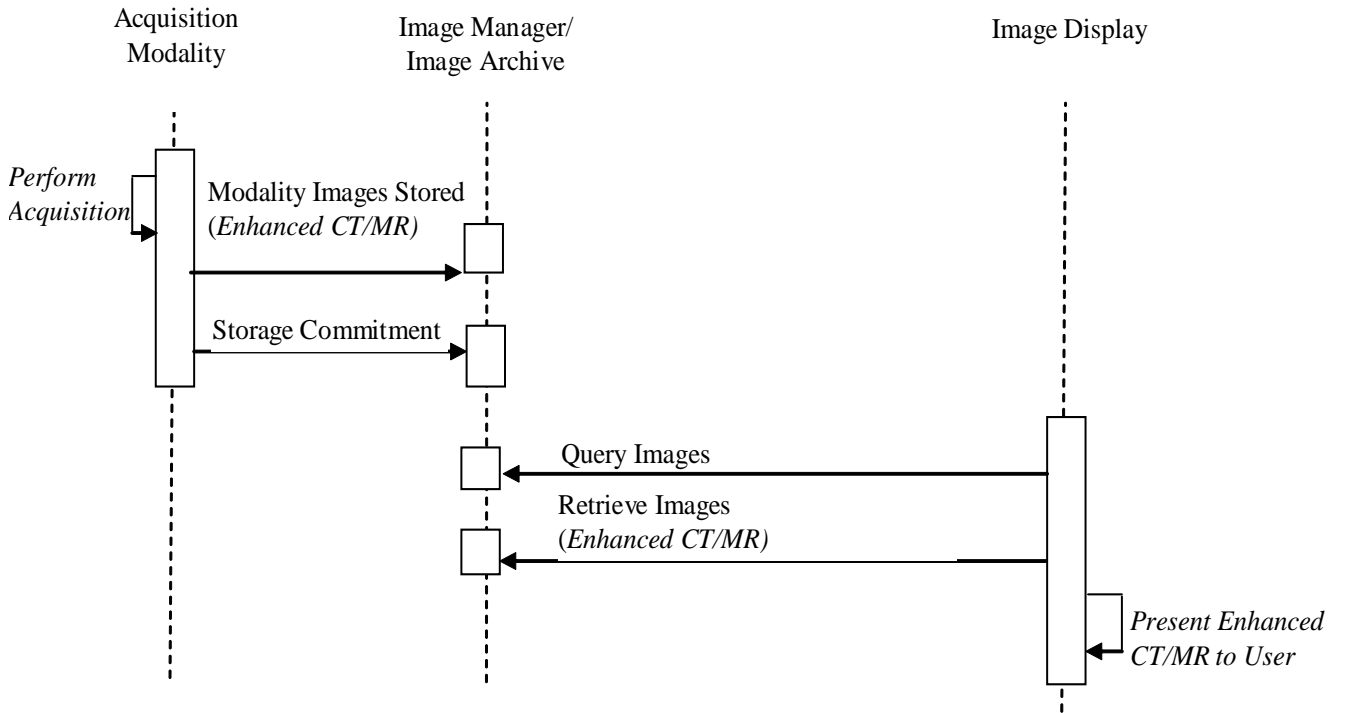
## 25.3 CT/MR Perfusion Imaging with Contrast Process Flow

180 The Acquisition Modality stores the complete set of images, either as one single Enhanced DICOM object or as a set of Enhanced DICOM objects belonging to the same series, to the Image Manager/ Archive so that it can be retrieved later for viewing and interpretation.

This use case does not describe additional use of the newly acquired image set, e.g., how to transfer or use it for quality assurance, post-processing or timely display at other workstations.



185



**Figure 25.3-1: CT/MR Perfusion Imaging with Contrast Process Flow**

## Volume 2 - Transactions

190 *Append section 4.8.4.1.2.5 with the following subsection and substitute .n with the appropriate serial number*

*Note to the editor: The MR Diffusion Imaging supplement should be processed first!*

### 4.8.4.1.2.5.n CT/MR Contrast Perfusion

195 Systems supporting the CT/MR Perfusion Imaging with Contrast Profile shall comply with the requirements in this section.

In the context of the CT/MR Perfusion Imaging with Contrast Profile, objects shall have Image Type and Frame Type values as shown in Table 4.8.4.1.2.5.n-1.

**Table 4.8.4.1.2.5.n-1: Image Type and Frame Type values**

	Image Type	Frame Type
Value 1	ORIGINAL	ORIGINAL
Value 3	PERFUSION	PERFUSION
Value 4	-	-

200 Note: Value 2 is, by definition, always PRIMARY

In addition to the required attributes described in the MR Diffusion Imaging (DIFF) Trial Implementation supplement in Section 4.8.4.1.2.5, the attributes in Table 4.8.4.1.2.5.n-2 shall also be supported.

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**Table 4.8.4.1.2.5.n-2: Enhanced CT/MR Object Attributes for Contrast Perfusion**

Attribute Name	Tag	Requirement
Frame Content functional group macro		
Frame Content Sequence	(0020,9111)	
>Temporal Position Index	(0020,9128)	R+
Temporal Position Time Offset	(0020,930D)	R+ (for MR only)

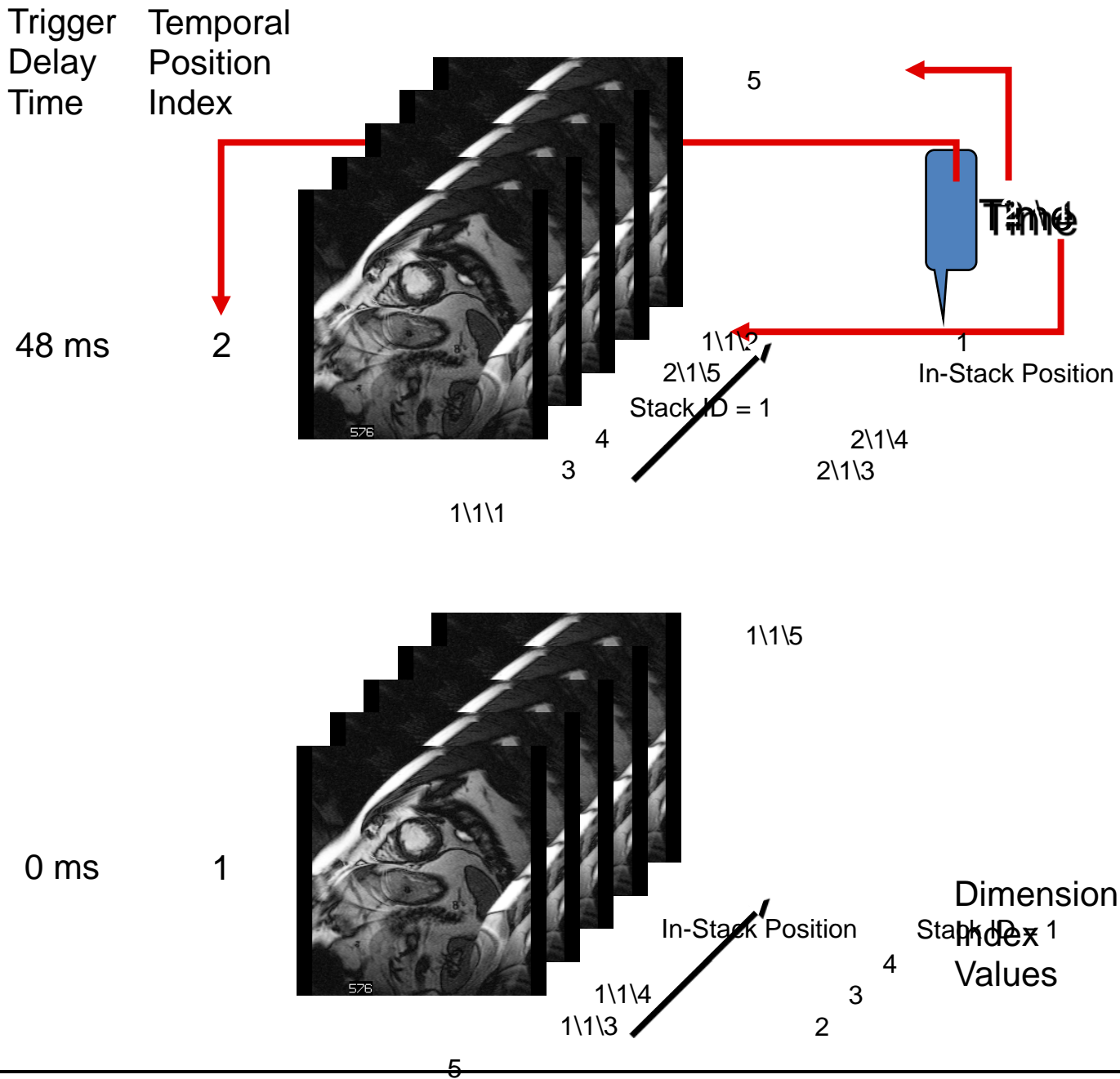
The Dimension Index Pointer shall be populated with the:

1. Stack ID (0020,9056)
2. In-Stack Position Number (0020,9057)
3. Temporal Position Index (0020,9128)

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All acquired contrast perfusion images belonging to the same series shall be stored in one or more Enhanced CT or Enhanced MR SOP Instances in the same series. The Series Instance UID (0020,000E) shall be equal for all the Enhanced CT or Enhanced MR SOP Instances.

- 215 A single Dimension Organization UID (0020,9164) value shall be used for all items of the Dimension Index Sequence (0020,9222) in all instances of the set. All frames with the same Temporal Position Index value shall be stored in the same Instance. An Instance may contain more than one Temporal Position.



**Figure 4.8.4.1.2.5.n-1: Example of Dimension Organization**

Note: The example shown above will result in a *maximum* of two objects: either a single object containing all frames, or a pair of objects where one object contains all frames that have a Temporal Position Index value of 1 and one object contains all frames that have a Temporal Position Index value of 2.

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Add the following row to Table 4.8.-1

**Table 4.8-1: Suggested Image SOP Classes**

SOP Class UID	SOP Class Name
...	
1.2.840.10008.5.1.4.1.1.2	CT Image Storage
<b><u>1.2.840.10008.5.1.4.1.1.2.1</u></b>	<b><u>Enhanced CT Image Storage</u></b>
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
...	

Add the following text and table to the end on Section 4.8.4.1.3.1

230 Note to the editor: The MR Diffusion Imaging supplement should be processed first!

Acquisition Modality Actors claiming the CT/MR Perfusion Imaging with Contrast Profile are required to support at least one of the SOP classes listed in Table 4.8-6 below.

Image Manager/Image Archive Actors claiming the CT/MR Perfusion Imaging with Contrast Profile are required to support both of the SOP classes listed in Table 4.8-6 below.

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**Table 4.8-6: Contrast Perfusion**

SOP Class UID	SOP Class Name
1.2.840.10008.5.1.4.1.1.4.1	Enhanced MR Image Storage
1.2.840.10008.5.1.4.1.1.2.1	Enhanced CT Image Storage

Append Section 4.16.4.1.3 with the following subsection

240 Note to the editor: The MR Diffusion Imaging supplement should be processed first

**4.16.4.1.3.5 CT/MR Perfusion Imaging with Contrast Profile**

Image Display and Image Manager/Image Archive Actors that claim the CT/MR Perfusion Imaging with Contrast Profile shall support all the SOP Classes specified in Table 4.8-6 in section 4.8.

245 Append section 4.16.4.2.2 with the following subsection

**4.16.4.2.2.7 Display of CT/MR Perfusion Imaging with Contrast objects**

The contents of this section are required for Image Displays claiming the CT/MR Perfusion Imaging with Contrast Profile.

The following requirements are intended to establish a baseline level of capabilities.

250 The Image Display shall present all SOP Instances belonging to the same Series as one set of frames.

The Image Display shall be capable of using the information from the Dimension Index Values (0020,9157) to separately display frames in different viewports.

255 In a single viewport in stack mode, the Image Display shall provide the user with a choice between ordering the frames to:

- Scroll by Temporal Position Index (0020,9128) then Stack ID (0020, 9056) / In-Stack Position Number (0020,9057).
- Scroll by Stack ID (0020,9056) / In-Stack Position Number (0020,9057) then Temporal Position Index (0020,9128).

260 The following display views shall be provided:

- The Image Display shall provide at least one viewport for displaying frames with the same Stack-ID/In-Stack-Position-Number (scrolling through Temporal Positions). More viewports may be used for displaying frames with other Stack-ID/In-Stack-Position-Number values.

265 • The Image Display shall provide at least one viewport for displaying frames with the same Temporal Position Index (scrolling through Stack-ID/In-Stack-Position-Number). More viewports may be used for displaying frames with other Temporal Position Index values.

It is not required that both viewports be presented at the same time.

270 Determining the display order of frames involves the use of two sequences. The Dimension Index Sequence (0020,9222) can be used to retrieve the attribute tags which define the dimensions of the dataset. The Frame Content Sequence (0020,9111) values will give per-frame the corresponding values for the attribute tags defined in the Dimension Index Sequence.

This usage is described in more detail in the following example.

275 For purposes of the example the Frame Content Sequence will contain, in addition to other required attributes, the following:

Frame Content Sequence	(0020,9111)
>Dimension Index Values	(0020,9157)
>Temporal Position Index	(0020,9128)
>Stack ID	(0020,9056)
>In-Stack Position Number	(0020,9057)

280 The frames can have the following values for the different tags including the Dimension Index Values (0020,9157):

**Table 4.16.4.2.2.7-1: Dimension Index Values**

Frame Number	Temporal Position Index	Stack ID	In-Stack Position Number	Dimension Index Values (0020,9157)
1	1	1	1	1\1\1
2	1	1	2	1\1\2
3	1	1	3	1\1\3
4	1	1	4	1\1\4
5	1	1	5	1\1\5
6	2	1	1	2\1\1
7	2	1	2	2\1\2
8	2	1	3	2\1\3
9	2	1	4	2\1\4
10	2	1	5	2\1\5

Depending on the dimension preferred for sorting/viewing, the applicable index (column) in the attribute Dimension Index Values (0020,9157) would be used to order the frames.

The two possible frame orders described with the example would be as follows:

- 285
- Scroll by Temporal Position Index (0020,9128) then Stack ID (0020,9056) / In-Stack Position Number (0020,9057).
    - Frame 1 to 5 for Temporal Position Index = 1
    - Frame 6 to 10 for Temporal Position Index = 2
- 290
- Scroll by Stack ID (0020,9056) / In-Stack Position Number (0020,9057) then Temporal Position Index (0020,9128)
    - Frame 1 and 6 for In Stack Position Number = 1
    - Frame 2 and 7 for In Stack Position Number = 2
    - Frame 3 and 8 for In-Stack Position Number = 3
    - Frame 4 and 9 for In-Stack Position Number = 4
    - Frame 5 and 10 for In-Stack Position Number = 5
- 295

Image Display Actors supporting the CT/MR Perfusion Imaging with Contrast Profile shall be able to display all of the attributes listed in Table 4.16.4.2.2.7-2.

**Table 4.16.4.2.2.7-2: Perfusion Display Attributes**

Attribute Name	Tag
----------------	-----

Attribute Name	Tag
Enhanced Contrast/Bolus Module	
Contrast/Bolus Agent Sequence	(0018,0012)
>Contrast/Bolus Administration Route Sequence	(0018,0014)
Frame Type Value 3	(0008,9007)
Frame Content Sequence	(0020,9111)
>Stack ID	(0020,9056)
>InStackPositionNumber	(0020,9057)
Temporal Position Time Offset	(0020,930D)

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This requirement is in addition to any display of slice offset in mm and frame number.

#### **4.16.4.2.2.7.1 Inclusion of Other Dimensions**

There could be other dimensions associated with the frames of ORIGINAL Perfusion objects (for example Effective Echo Time (0018,9082) for MR).

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In this case the Dimension Organization UIDs for the extra dimensions will be different from the Dimension Organization UID associated with the Temporal Position Index.

#### **4.16.4.2.2.7.2 Derived Objects**

The organization of frames for DERIVED objects may be different from the organization of frames of the corresponding ORIGINAL objects. For example frames may be spread over 2 ORIGINAL objects but the corresponding frames may be stored into a single DERIVED object.

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The Temporal Position Index in DERIVED objects shall have the same Dimension Organization UID as the ORIGINAL objects from which they were derived if the Temporal Position is the same. It is up to the application to determine if the Temporal Position Index of the result is meaningful and, if so, what Temporal Position Index to use. For example, subtraction of a non-contrast frame (Temporal Position = 1) and contrast frame (Temporal Position > 1) to show the uptake of the contrast could include the Temporal Position Index of the frame of the higher Temporal Position Index.

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