Integrating the Healthcare Enterprise

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IHE Radiology
Technical Framework Supplement

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CT/MR Perfusion Imaging with Contrast (PERF)

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Trial Implementation

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Foreword

This is a supplement to the IHE Radiology Technical Framework V13.0. Each supplement
30 undergoes a process of public comment and trial implementation before being incorporated into the volumes of the Technical Frameworks.

This supplement is published on April 21, 2015 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
35 Framework. Comments are invited and may be submitted at 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.

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: www.ihe.net.

Information about the IHE Radiology domain can be found at: 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 and
50 http://ihe.net/Profiles.

The current version of the IHE Radiology Technical Framework can be found at: http://ihe.net/Technical_Frameworks.

CONTENTS

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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, a system can use more than one object to store the full series of images.

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

95   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)?

100   *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

105   requires the display to treat all related SOP instances as one.
Do we need additional text how the display locates the various SOP instances?

Answer: Storing the data in a single object is often not possible. Therefore, storage in multiple objects is accepted and is added to the possible cases.

110

Volume 1 – Integration Profiles

Glossary

115 *Add the following terms to the Glossary:*

None

1.7 History of Annual Changes

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.

120 ## 2.1 Dependencies among Integration Profiles

Add the following row to Table 2-1

CT/MR Perfusion Imaging with Contrast	none	none	-

Add the following section to Section 2.2

125 ### 2.2.23 CT/MR Perfusion Imaging with Contrast Integration Profile

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.

130 *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

135 *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]

Query Images [RAD-14]

Retrieve Images [RAD-16]
140 *Add Section 25*

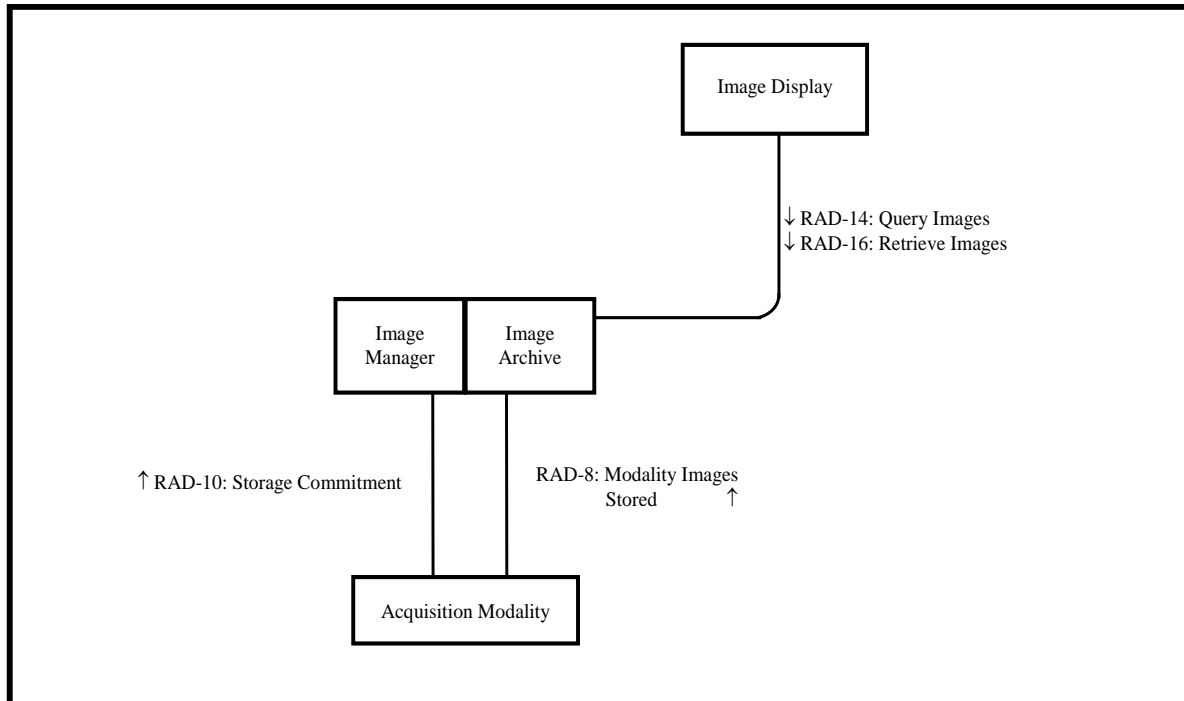## 25 CT/MR Perfusion Imaging with Contrast Integration Profile

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
145 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.

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
150 single-frame objects are out of scope. This Profile does not cover workflow or post-processing capabilities.

25.1 Actors/Transactions

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

155

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

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"
160 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.

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

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.

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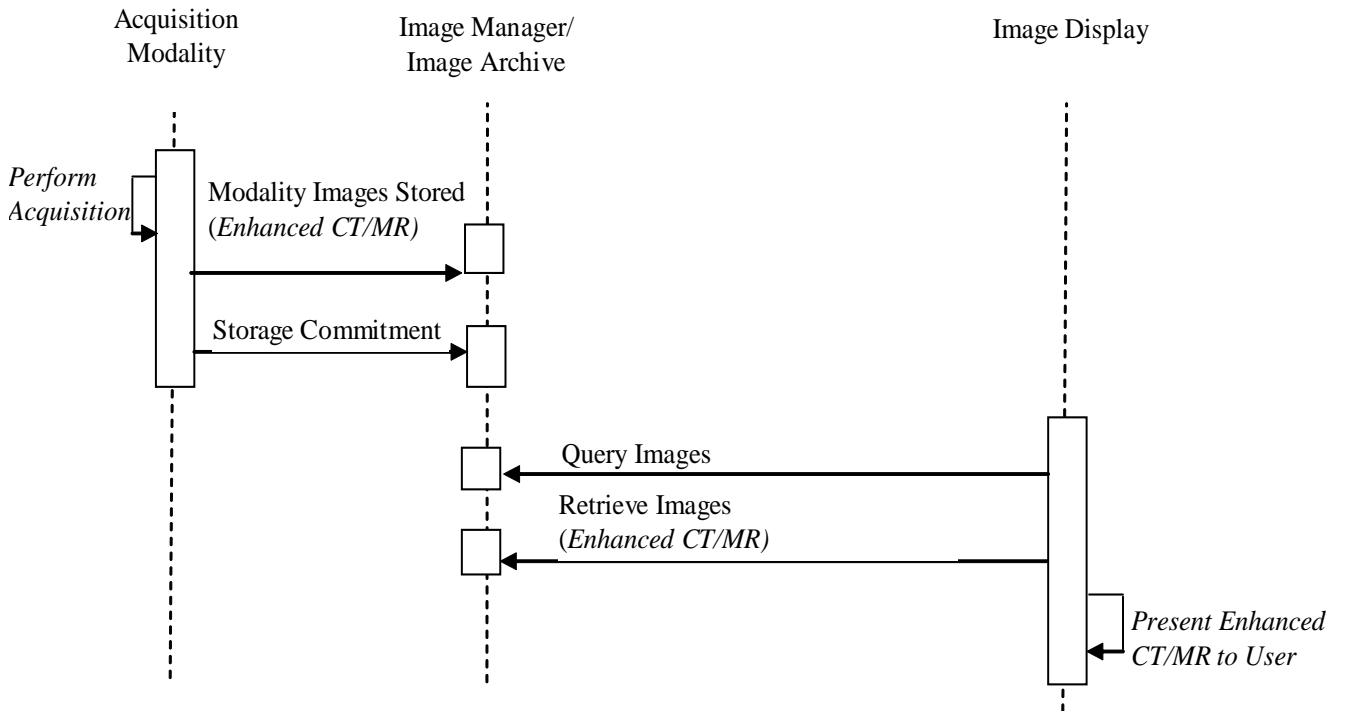**Table 25.2-1: CT/MR Perfusion Imaging with Contrast – Actors and Options**

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

The Acquisition Modality stores the complete set of images, either as one single Enhanced
175 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.

8

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.

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

Volume 2 - Transactions

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4.8.4.1.2.5.n CT/MR Contrast Perfusion

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

190 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	-	-

Note: Value 2 is, by definition, always PRIMARY

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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.

200 **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)

205 3. Temporal Position Index (0020,9128)

10

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.

210   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.
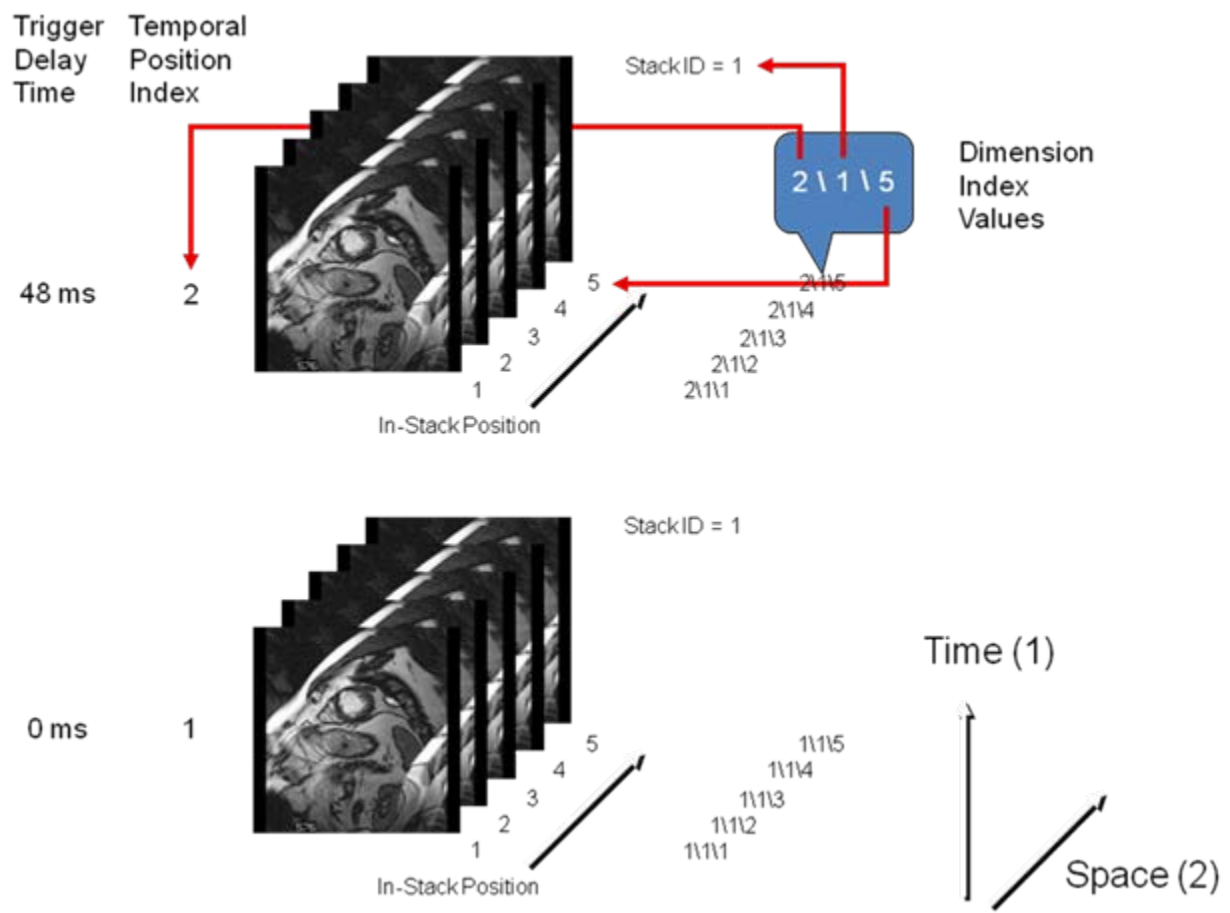
215   **Figure 4.8.4.1.2.5.n-1: Example of Dimension Organization**

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.

220   *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
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
…	

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

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

225

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

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

235

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.

240 *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.

245   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.

In a single viewport in stack mode, the Image Display shall provide the user with a choice
250   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).

255   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.

260   - 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.

265   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.

270   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)

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:

- 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

- 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

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
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)

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

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

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

305   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.

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
310   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.