Digital Imaging and Communications in Medicine (DICOM)

Supplement 49:

Enhanced MR Image Storage SOP Class

Prepared by:

DICOM Standards Committee, Working Group 16

1300 N. 17th Street, Suite 1847

Rosslyn, Virginia 22209 USA

VERSION: Final Text (49) 26 March, 2002

Please send comments to Howard Clark, NEMA (how_clark@nema.org)

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Foreword

The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee to develop a standard for Digital Imaging and Communication in Medicine (DICOM). This DICOM Standard was developed according to the NEMA procedures.

This Standard is developed in liaison with other standardization organizations including CEN TC251 in Europe and JIRA in Japan, with review also by other organizations including IEEE, HL7 and ANSI in the USA.

The DICOM Standard is structured as a multi-part document using the guidelines established in the following document:

- ISO/IEC Directives, 1989 Part 3: Drafting and Presentation of International Standards.

This document is a Supplement to the DICOM Standard. It is an extension to Part 3, 4, 5, 6 and 16 of the published DICOM Standard which consists of the following parts:

PS 3.1	-	Introduction and Overview
PS 3.2	-	Conformance
PS 3.3	-	Information Object Definitions
PS 3.4	-	Service Class Specifications
PS 3.5	-	Data Structures and Encoding
PS 3.6	-	Data Dictionary
PS 3.7	-	Message Exchange
PS 3.8	-	Network Communication Support for Message Exchange
PS 3.9	-	Point-to-Point Communication Support for Message Exchange
PS 3.10	-	Media Storage and File Format for Data Interchange
PS 3.11	-	Media Storage Application Profiles
PS 3.12	-	Media Formats and Physical Media for Data Interchange
PS 3.13	-	Print Management Point-to-Point Communication Support
PS 3.14	-	Grayscale Standard Display Function
PS 3.15	-	Security Profiles
PS 3.16	-	Content Mapping Resource

These parts are related but independent documents. Their development level and approval status may differ. Additional parts may be added to this multi-part standard.

Introduction - will not appear in final standard

I.1 INTRODUCTION

The current MR Image IOD no longer meets the needs of data storage and transport for a growing number of MR applications.

Acquisition techniques aren't well characterized in an inter-operable manner, and functionality is missing to support modern applications such as:

- Diffusion Imaging
- Functional Imaging
- Spectroscopy

I.2 GLOBAL DESCRIPTION OF THE PROPOSAL

This supplement describes new MR IODs.

A Multi-Frame concept is introduced which allows attributes grouped together to vary on a frame-by frame base. This method is modality independent.

Methods to describe relationships between images and already existing objects are revised for use by MR and other modalities.

I.2.1 New IODs

The supplement describes 3 new IODs:

1. Enhanced MR Image
2. MR Spectroscopy
3. Raw Data

The Enhanced MR Image IOD differs from the previous MR IOD in the following manner:

1. Many new attributes have been defined.
2. The name and/or description of existing attributes have been clarified. When clarification required a new Value Representation, the attribute was replaced.
3. Many attributes that were previously optional (Type 3) are now mandatory (Type 1 or 1C).
4. Multi-frame is supported.

The MR Spectroscopy IOD has been defined for the first time. Since MR spectroscopy shares many of the same principles as MR imaging, modules and attributes are shared between the MR Spectroscopy IOD and Enhanced MR Image IOD whenever possible.

The Raw data IOD has been defined for the first time. The organization used by this IOD s is defined to be modality independent.

I.2.2 New or redefined MR Image attributes and new conditions

Compared to the MR IOD, the Enhanced MR IOD contains many more elements that are used in modern MR implementations. The use of better specified definitions and conditions will improve the interoperability of the object.

The additions can be primarily found in the areas of "pulse sequences", "scan preparation" (like saturation slabs) and "additional timing and synchronization".

The images and frames have been described in terms of their derivation and contrast purpose in a more interoperable and consistent way, which provides means for expanding this in the future. Many elements are now defined to be required for all applicable cases.

Many of the attributes are identically re-used in the MR Spectroscopy IOD.

I.2.3 Color information for functional images

The use of **color** e.g. for functional information in the otherwise solely monochrome images has been added by means of Look Up Tables and is extended by new imaging pipeline attributes.

I.2.4 Multi-frame

Enhanced MR Image and MR Spectroscopy IODs make use of a new multi-frame header approach, a mechanism that in itself is not modality specific.

The multi-frame approach has two advantages:

1. a large number of images can be sent (as frames) in one object (SOP Instance), which reduces network protocol overhead compared to sending many different objects,

2. all attributes that are equal for all individual images/frames are sent only once and thus do not have to be repeated for each image/frame.

All attributes are specified either in modules or in so called functional groups, i.e. a collection of attributes that are likely to vary together.

Functional groups may be:

- modality independent: the **common** functional groups (these can also be re-used by other modalities in future versions of the standard) or

- modality specific: the **MR** functional groups in this supplement.

Other modalities may define their own functional groups as the need arises.

I.2.4.1 Multi-frame Functional Groups Module

The Multi-frame Functional Groups Module consists of **two sequences:**

1. A sequence of functional groups that is shared by all frames in the SOP Instance, the "Shared Functional Groups Sequence".

2. A sequence of functional groups that is repeated for each frame in the SOP Instance, as it contains the attributes whose values may vary on a frame-by-frame basis.
   This is the (Non-Shared) "Per-frame Functional Groups Sequence".

A functional group (documented in this supplement as a macro) is a sequence itself and serves as the container for related attributes.

Depending on the specific application, some functional groups may have attributes varying within the SOP Instance, while other functional groups are completely stable over the total SOP Instance. This means that depending on the application and implementation of a particular vendor, functional groups sometimes will be positioned in either the "Shared Functional Groups Sequence" or in the "Per-frame Functional Groups Sequence".

A receiving application may judge to some extent what kind of object it has received by analyzing the contents of the sequences in the Multi-frame Functional Groups Module.

For example:

> There is a sequence for Image Orientation (Plane Orientation Sequence) and another for Image Position (Plane Position Sequence). When the Plane Orientation Sequence is positioned in the "Shared Functional Groups Sequence" and the Plane Position Sequence is in "Per-frame Functional Groups Sequence", it is guaranteed that all frames will have exactly the same orientation. A receiving application may assume that all images will geometrically change by image position only.
>
> Please note that from this information only, it cannot be judged whether one or more positions are repeatedly imaged or not. Additional information should be inspected from the individual image position attributes.

I.2.5 Referencing

The use of reference image sequences, derived image sequences, and source image sequences has been revised to include a generic referencing method that describes the reference, the purpose of the reference, and allows the coding of the derivation description.

I.2.6 Context Information within and beyond one SOP Instance

The large collection of frames in one or more objects requires a description of the relationship between frames and of the logical structure of the geometry.

This supports interoperability between modalities and:

- workstations that do not have an explicit knowledge of all MR applications, but need to display images in a logical order
- workstations that will rely on the exact description information, such that advanced processing can be based on the contents of specific parameters.

There are 3 levels for presenting context information:

1. Image Type values 1-4 and the associated image type attributes in the "MR Image Description Macro" describe the general origin and purpose of the image. The same Image Type attributes occur both at frame level and at SOP Instance level (describing in aggregate the collection of frames in one image).
   The information at the SOP Instance level could be used in a response to a query by a remote requestor (SCU), thereby reducing the risk of an unintentional reception of a large unwanted object.

   The "image type" values should also serve as the main documentation of the image intention for receiving applications that have no in-depth knowledge, but simply display the available values.

2. The presence or non-presence of certain functional groups in the Shared Functional Groups Sequence (as discussed above): the requirements for the existence of functional groups is specified in the Functional Group Macros Tables (see A.X-2 and A.X-4).

3. The dimensionality of the object or a collection of objects in a concatenation (see below).

The **Multi-frame Dimension Module** is defined to provide explicit dimensionality information.

The rationale is the following:

In the existing (non-enhanced or old) MR IOD only one image was present per SOP Instance. Only the simple fact that there were more images in one series indicated that this could have some meaning and those relationships might exist. Apart from the attributes: Temporal Position Identifier (0020,0100), Cardiac Number of Images (0018,1090), Referenced Image Sequence (0008,1140) no fixed indication

could be given that a relation existed between the images in a series.

With the Multi-frame definition of the Enhanced MR IOD however, many frames (up to many thousands) can be part of one SOP Instance while new MR techniques allow the interactive (simultaneous or sequential) change of parameters during one scan.
Also patient conditions or external stimuli may change during one scan. In essence only the scanning application knows exactly how the data was collected and has the ability to provide dimensionality information to other organizing or post-processing applications.

These observations have lead to a construction that allows the description of such dimensions in fine detail, where the limitation of one SOP Instance has shown to be rather arbitrarily and certainly application dependent.

The sending application provides, by means of the Multi-frame Dimension module, the information about the relationships of the frames within one SOP Instance. It can also describe the relationship with prior defined dimension organizations providing re-use of dimensions and relations between or similarity with other SOP Instances. These relationships can be purely geometrical (like Stacks of frames) or just physical (like different Repetition Time or Flip Angle).

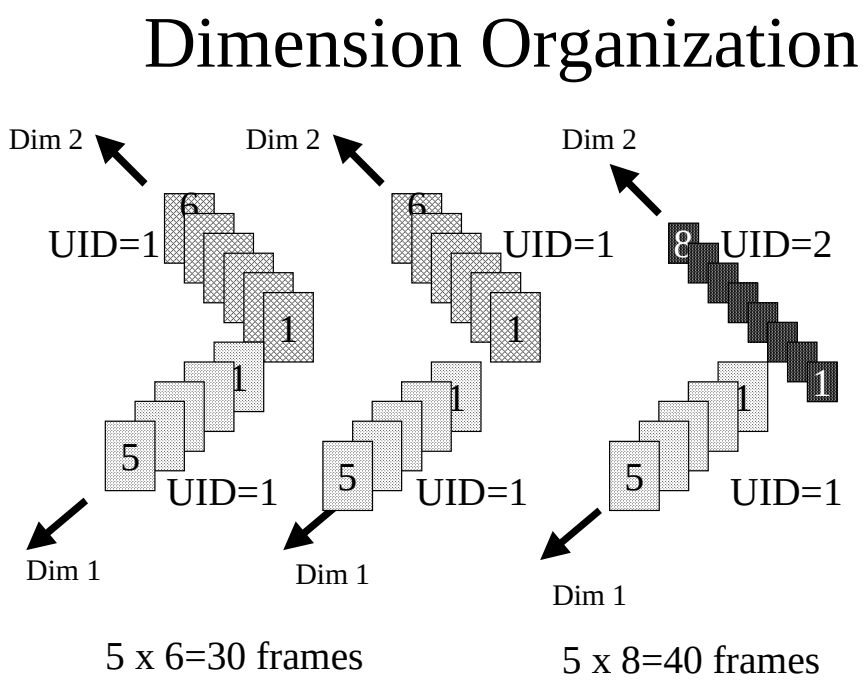
Images may also have a relationship even beyond the contents of one series, as long as there is a common Frame of Reference UID.

I.2.6.1 Dimension Organization

Within one Frame of reference, re-use of defined dimensions is possible.

To define the context of a set of related dimension attributes, a Dimension Organization UID shall be applied to each dimension attribute.

Once a dimension changes (new or modified) the changed attributes will be assigned to a new Dimension Organization UID.

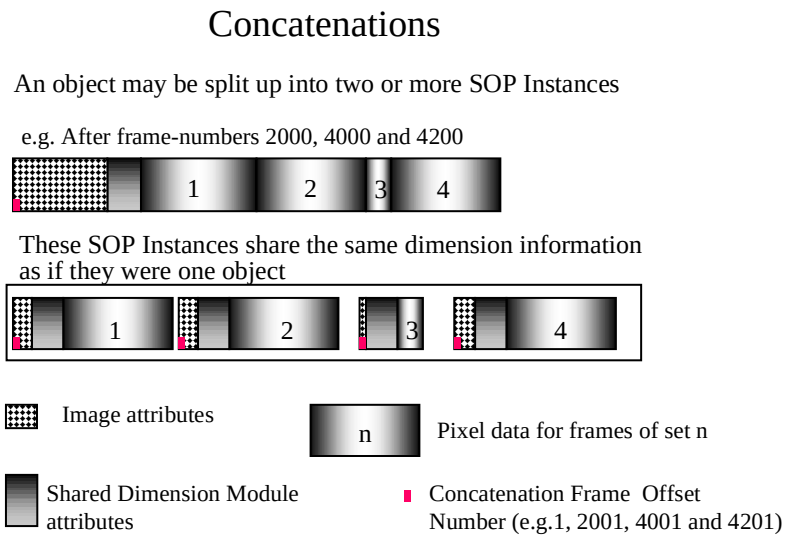


I.2.6.2 Stacks

Next to dimensions, the collection of images in a Frame of Reference may be classified in geometrically related sets of slices that may be re-scanned repeatedly under different conditions. One can think of applications of peripheral angiography runoff studies, where sets of slices are imaged with and without contrast medium. These sets of images are to be subtracted in an orderly and predefined way. It is important to know how these sets are defined.
For that and other purposes images can be combined in packages of slices (called **Stacks**).
Each plane/slice volume has an In-Stack Position Number, which is unique for each value of the Stack ID. The Stack ID in turn must be unique within the Dimension Organization UID.
Stacks are not restricted to one concatenation. In this way re-scanning of the same stack in another series can be done, preserving the Stack ID.

I.2.6.3 Concatenations

An Enhanced MR IOD may be split into several SOP Instances. This can be done for various internal or external reasons without penalty for the sending application. Reasons may be implementation specific like object size. These SOP Instances may then together form a so-called **Concatenation**. From the dimension point of view these SOP Instances are still part of the larger unit. This means that all SOP Instances of a concatenation must contain exactly the same Dimension Module attributes and values. Concatenation UIDs are unique within the Frame of Reference.



I.2.7 Rules for starting a new Enhanced MR IOD

When a scan significantly differs from the previous one, a new SOP Instance should be started.

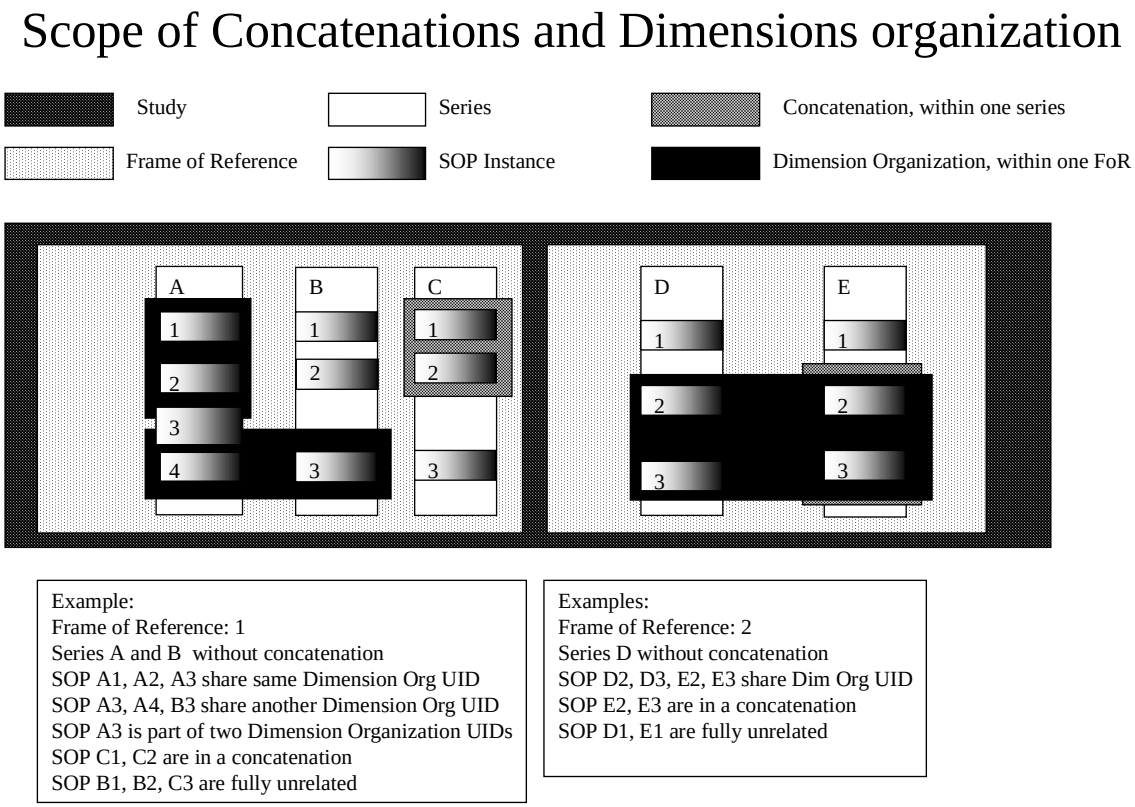
Since **modules** cannot be part of the Multi-frame Functional Groups Module, a change in any attribute in any of the defined modules, automatically gives rise to a new SOP Instance. Also a change in any attribute in the Shared Functional Groups Sequence will require a new SOP instance.

For applications where external stimuli (operator or physiological) might cause changes in an attribute, the application designer has the choice of whether to include the attribute in the shared area or unshared area. If placed in the shared area an unforeseen change in such an attribute requires a new SOP instance. If placed in the unshared header and the attribute eventually does not change, the repetition of the shared attributes in the sequence will lead to a waste of storage and possibly to an incorrect conclusion that something has changed within the sequence.

It is the choice of the creating AE to create a new IOD for other reasons.

I.2.8 Summary of Scope of Concatenations and Dimension Organization

Dimension Organizations are restricted to one Frame of Reference UID



I.2.9 Future work items

The functions related to the new IODs are -by definition- not complete.

The working group has, together with the participants of the public comment phase, identified a number if issues that need a resolution in the future, which are not part of supplement 49.

These include:

1. **Presentation State for Color images**

   Functional images benefit from additional color information. Supplement 49 has taken the initiative to provide a useful although limited method for additional color display through look-up tables in the image. It was identified that future work will be needed in the presentation state. This should also solve issues like transparency / opacity and merging of images.

2. **Presentation state for Spectroscopy data**

   Although Spectroscopy Images (Metabolite Maps) are among the first derived and functional images that could be stored in the MR IODs, it remains so far an exceptional item, because the original image is in another domain (the spectroscopy data domain).

   The display of the mixture of spectroscopy, spectroscopic and patient data on a screen or film is a typical requirement for a future Presentation State solution.

3. **Selection of a single frame (or group of frames) from a multi-frame object**

   Since the images of the MR IOD can now be combined in one SOP Instance of the Enhanced MR IOD, the selection of a single frame is not supported by an existing service. Future work will be needed to support this. It is not a MR specific task.

4. **The selection of media suitable for the Enhanced MR object, including suitable compression algorithms.**

I.3 PARTS OF THE STANDARD THAT ARE AFFECTED

Part 3 defines:

- Enhanced MR Image IOD.
- MR Spectroscopy IOD.
- Raw Data IOD.

Part 4 defines:

- An Enhanced MR Image Storage SOP Class and Media Storage SOP Class.
- A MR Spectroscopy SOP Class and Media Storage SOP Class.
- A Raw Data SOP Class and Media Storage SOP Class.

Part 5 defines a new floating point Value Representation.

Part 6 defines an extended Data Dictionary of new MR attributes.

Part 16 defines MR specific context groups.

There are no new services or messaging defined.

I.4 SCOPE AND FIELD OF APPLICATION

This Supplement describes the new Magnetic Resonance Storage SOP Classes, which allow the MR Image generating systems to store information on systems, which perform as a MR Storage SCP.

The present MR Image IOD is not being retired by this supplement.

Since this document proposes changes to existing Parts of DICOM, the reader should have a working understanding of the Standard.

Changes to NEMA Standards Publication PS 3.3-2001

Digital Imaging and Communications in Medicine (DICOM)

Part 3: Information Object Definitions

Item #1: Add definition of Functional Group in section 3.8

3.8.13 Functional Group: set of logically related Attributes that are likely to vary together. May be used in Multi-frame IODs to describe parameters which change on a per frame basis.

Item #2: Add MR Spectroscopy IOD and Raw Data IOD into Figure 7-1a and 7-2a.

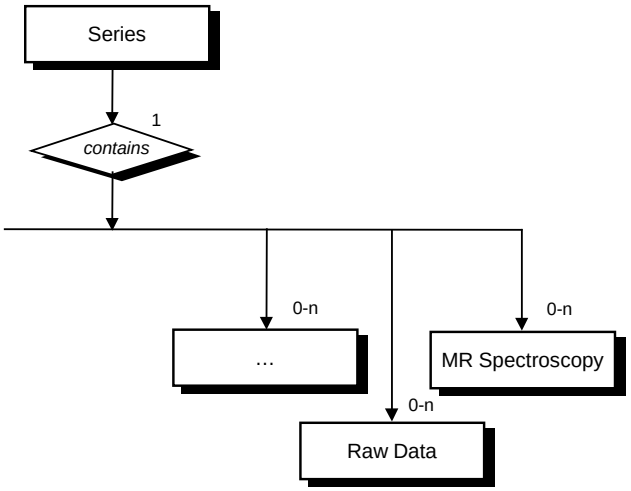


Figure 7-1a

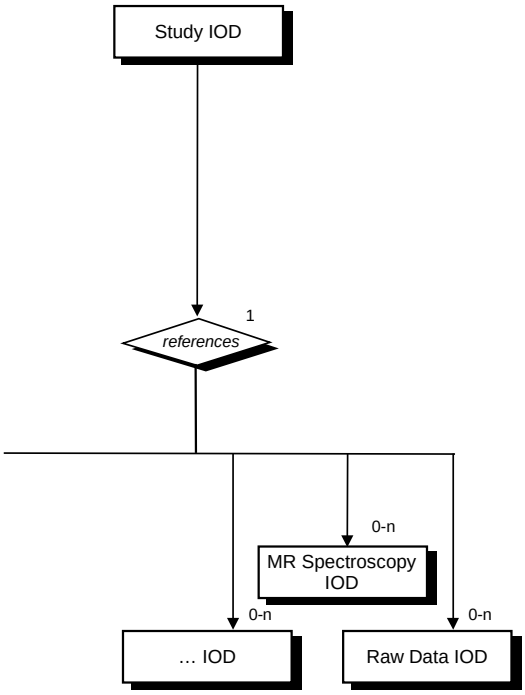


Figure 7-2a

Item #3: Add section after 7.4

7.5 ORGANIZING LARGE SETS OF INFORMATION

For the purpose of accommodating large sets of frames in Multi-frame Image SOP Instances the Real-World Entity Relationship Diagram has been extended to describe the relationships of these instances: Concatenation (see Section 7.5.1) and Dimension Organization (see Section 7.5.2). Figure 7-5.1 depicts the additions to Figure 7-2.

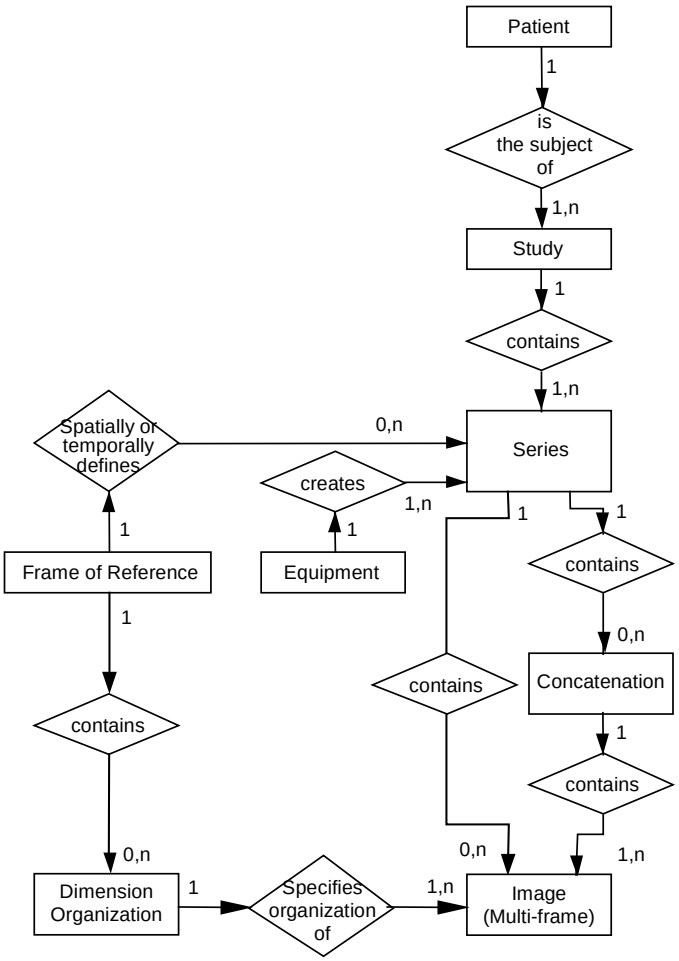


Figure 7-5.1
EXTENSION OF THE REAL-WORLD MODEL WITH CONCATENATIONS AND DIMENSIONS

7.5.1 CONCATENATION

For implementation specific reasons (such as practical limits on the maximum size of an individual SOP Instance) the content of a multi-frame image may need to be split into more than one SOP Instance. These SOP Instances together form a Concatenation, which is a group of SOP Instances within a Series that is uniquely identified by the Concatenation UID (0020,9133).

7.5.2 DIMENSION ORGANIZATION

The Dimension Organization contains a set of dimensions. A dimension is a set of attributes which change on a per-frame basis in a manner which is known before the image is acquired, which are defined by the generating application and which are especially intended for presentation. Other attributes may also change on a per-frame basis but if they are not present in the Dimension Organization, they are not considered significant as a dimension for organizational purposes.

Receiving applications can use the order of dimensions for guidance when presenting images. The first item of the Dimension Index Sequence shall be the slowest varying index.

Note: See Multi-frame Dimension Module section (C.7.6.17) for an example.

Item #4: Modify sections A.1 and A.1.3

A.1 ELEMENTS OF AN INFORMATION OBJECT DEFINITION

Each Composite Information Object Definition is composed of the following Sections

a. IOD Description
b. IOD Entity-Relationship Model
c. IOD Module Table
d. **Optionally, a Functional Group Macros Table used by the Multi-frame Functional Groups Module**

Sections A.1.1 through A.1.3 of this document define the requirements of a) through ~~c~~**d)** above.

.....

A.1.3 IOD Module Table and Functional Group Macro Table

This Section of each IOD defines in a tabular form the Modules comprising the IOD. The following information must be specified for each Module in the table:

- The name of the Module **or Functional Group**
- A reference to the Section in Annex C which defines the Module **or Functional Group**
- The usage of the Module **or Functional Group**; whether it is:
    - Mandatory (see A.1.3.1)
    - Conditional (see A.1.3.2)
    - User Option (see A.1.3.3)

The Modules referenced are defined in Annex C.

Item #5: Add new IODs in Table A.1-1

A.1.4 Overview of the Composite IOD Module Content

Add the following columns to table A.1-1:

IODs Modules	Enh. MR	MR Spectr.	Raw Data
Patient	M	M	M
Specimen Identification	U	U	U
General Study	M	M	M
Patient Study	U	U	U
General Series	M	M	M
Frame Of Reference	M	M	U
Synchronization	C	C	C
General Equipment	M	M	M
Image Pixel	M		
Contrast/ Bolus	C	C	
Multi-frame Functional Groups	M	M	
Multi-frame Dimension	M	M	
Cardiac Synchronization	C	C	
Respiratory Synchronization	C	C	
Bulk Motion Synchronization	C	C	
Palette Color Lookup Table	C		
Enhanced MR Image	M		
MR Pulse Sequence	C		
MR Spectroscopy		M	
MR Spectroscopy Pulse Sequence		C	
MR Spectroscopy Data		M	
Raw Data			M
Softcopy Presentation LUT	M		
Acquisition Context	M	M	M
SOP Common	M	M	M

Item #6: Add MR Spectroscopy and Raw Data IE to Figure A.1-1

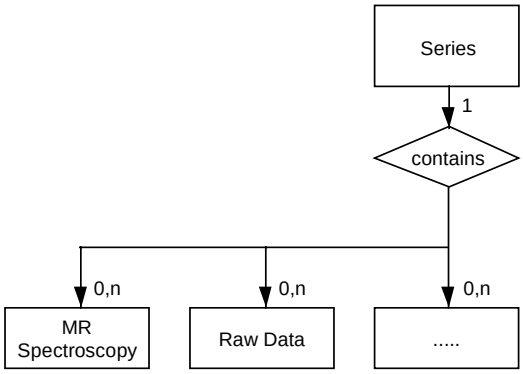


Figure A.1-1

Item #7: Add the following sections to Annex A

A.1.2.14 MR Spectroscopy IE

The MR Spectroscopy IE defines the attributes that describe the data of a MR spectroscopy acquisition created by a magnetic resonance spectroscopy device.

A.1.2.15 Raw Data IE

The Raw Data IE defines the attributes that describe a data set that may be used for further processing to produce image data or other data.

Note: For example, raw data may be used with CT and MR systems to reconstruct sets of images or for MR to reconstruct spectroscopic data. The format of the raw data is vendor specific.

Item #8: Add the following new sections to Annex A

A.36 ENHANCED MR INFORMATION OBJECT DEFINITIONS

A.36.1 Relationship between Enhanced MR IODs

Figure A.36-1 illustrates the relationships between the Enhanced MR IODs described in Section A.36.

Source Image Sequence (0008,2112), Referenced Image Sequence (0008,1140) and Referenced Raw Data Sequence (0008,9121) provide references between SOP Instances.

Note: Many attributes have names and descriptions that include the terms “pixel” and “image”. Although MR spectroscopy is not pixel based, some of these “pixel” and “image” attributes encode concepts that are still relevant for this technique. Where such attributes appear in the MR Spectroscopy IOD, it may be helpful to consider the term “pixel” to be equivalent to a spectroscopy “voxel”, and the term “image” to be equivalent to “MR Spectroscopy SOP Instance”.

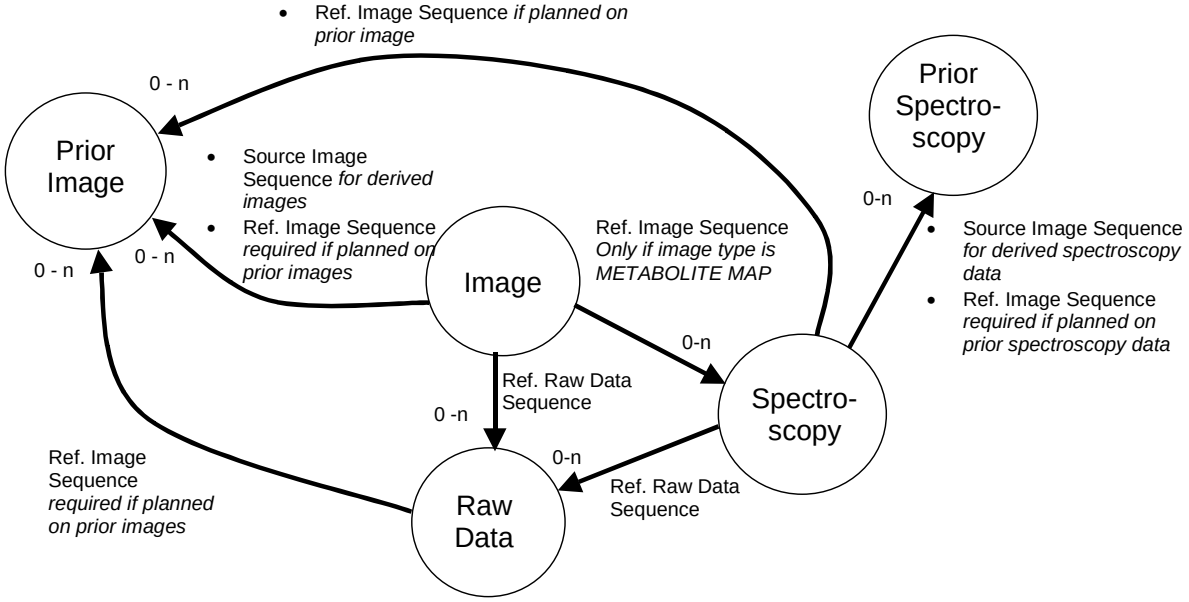


Figure A.36-1
Relationships between Enhanced MR IODs

A.36.2 Enhanced MR Image Information Object Definition

A.36.2.1 Enhanced MR Image IOD Description

The Enhanced Magnetic Resonance (MR) Image Information Object Definition (IOD) specifies an image, which has been created by a magnetic resonance device.

A.36.2.2 Enhanced MR Image Entity-Relationship Model

The E-R Model in section A.1.2 depicts those components of the DICOM Information Model, which directly reference the Enhanced MR Image IOD.

A.36.2.3 Enhanced MR Image IOD Module Table

Table A.36-1
ENHANCED MR IMAGE IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
Frame of Reference	Frame of Reference	C.7.4.1	M
	Synchronization	C.7.4.2	C- Required if time synchronization was applied.
Equipment	General Equipment	C.7.5.1	M
Image	Image Pixel	C.7.6.3	M
	Contrast/Bolus	C.7.6.4	C - Required if contrast media were applied.
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Cardiac Synchronization	C.7.6.18.1	C - Required if cardiac synchronization was applied.
	Respiratory Synchronization	C.7.6.18.2	C - Required if respiratory synchronization was applied.
	Bulk Motion Synchronization	C.7.6.18.3	C - Required if bulk motion synchronization was applied.
	Supplemental Palette Color Lookup Table	C.7.6.19	C – Required if Pixel Presentation (0008,9205) in the Enhanced MR Image Module equals COLOR or MIXED.
	Acquisition Context	C.7.6.14	M
	Enhanced MR Image	C.8.12.1	M
	MR Pulse Sequence	C.8.12.4	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
	Softcopy Presentation LUT	C.11.6	M
	SOP Common	C.12.1	M

A.36.2.3.1 Enhanced MR Image IOD Content Constraints

The General Image Module, Overlay Plane Module, Curve Module and VOI LUT Module shall not be used in a Standard Extended SOP Class of the Enhanced MR Image.

Note: In order to annotate images, whether during acquisition or subsequently, SOP Instances of the Grayscale Softcopy Presentation State Storage or the Structured Report Storage SOP Classes that reference the image SOP Instance, may be used.

No standard mechanism is provided for inclusion of annotations within the image SOP Instance itself, and implementers are discouraged from using private extensions to circumvent this restriction.

Grayscale Softcopy Presentation State Storage Instances that are generated during acquisition may be referenced from the Image SOP Instance by using the Referenced Grayscale Presentation State Sequence in the MR Image and Spectroscopy Instance Macro invoked from the Enhanced MR Image Module. See C.8.12.2.

A.36.2.4 Enhanced MR Image Functional Group Macros

Table A.36-2 specifies the use of the Functional Group macros used in the Multi-frame Functional Groups Module for the Enhanced MR Image IOD.

Table A.36-2
ENHANCED MR IMAGE FUNCTIONAL GROUP MACROS

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Frame Content	C.7.6.16.2.2	M - May not be used as a Shared Functional Group.
Plane Position	C.7.6.16.2.3	M
Plane Orientation	C.7.6.16.2.4	M
Referenced Image	C.7.6.16.2.5	C - Required if the image or frame has been planned on another image or frame. May be present otherwise
Derivation Image	C.7.6.16.2.6	C - Required if the image or frame has been derived from another SOP Instance.
Cardiac Trigger	C.7.6.16.2.7	C - Required if Cardiac Synchronization Technique (0018,9037) equals other than NONE and if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Frame Anatomy	C.7.6.16.2.8	M
Pixel value Transformation	C.7.6.16.2.9	M
Frame VOI LUT	C.7.6.16.2.10	U
Real World Value Mapping	C.7.6.16.2.11	U
MR Image Frame Type	C.8.12.5.1	M
MR Timing and Related Parameters	C.8.12.5.2	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR FOV/Geometry	C.8.12.5.3	C – Required if Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR and if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Echo	C.8.12.5.4	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Modifier	C.8.12.5.5	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Image Modifier	C.8.12.5.6	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Receive Coil	C.8.12.5.7	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

MR Transmit Coil	C.8.12.5.8	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Diffusion	C.8.12.5.9	C - Required if Acquisition Pixel Contrast (0008,9209) in any MR Image Frame Type Functional Group in the SOP Instance equals DIFFUSION and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Averages	C.8.12.5.10	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Spatial Saturation	C.8.12.5.11	C - Required if Spatial Pre-saturation (0018,9027) equals SLAB for any frame in the SOP Instance and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Metabolite Map	C.8.12.5.12	C – Required if Image Type (0008,0008) Value 3 equals METABOLITE_MAP. May be present otherwise.
MR Velocity Encoding	C.8.12.5.13	C – Required if Phase Contrast (0018,9014) equals YES and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

A.36.3 MR Spectroscopy Information Object Definition

A.36.3.1 MR Spectroscopy IOD Description

The Magnetic Resonance (MR) Spectroscopy Information Object Definition (IOD) specifies spectroscopic data, which has been created by a magnetic resonance device.

A.36.3.2 MR Spectroscopy entity-relationship model

The E-R Model in section A.1.2 depicts those components of the DICOM Information Model, which directly reference the MR Spectroscopy IOD.

A.36.3.3 MR Spectroscopy IOD Module Table

Table A.36-3
MR SPECTROSCOPY IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
Frame of Reference	Frame of Reference	C.7.4.1	M
	Synchronization	C.7.4.2	C- Required if time synchronization was applied.
Equipment	General Equipment	C.7.5.1	M
MR Spectroscopy	Contrast/Bolus	C.7.6.4	C – Required if contrast media were applied.
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Cardiac Synchronization	C.7.6.18.1	C - Required if cardiac synchronization was applied.
	Respiratory Synchronization	C.7.6.18.2	C - Required if respiratory synchronization was applied.
	Bulk Motion Synchronization	C.7.6.18.3	C - Required if bulk motion synchronization was applied.
	Acquisition Context	C.7.6.14	M
	MR Spectroscopy	C.8.13.1	M
	MR Spectroscopy Pulse Sequence	C.8.13.2	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL. May be present otherwise.
	MR Spectroscopy Data	C.8.13.3	M
	SOP Common	C.12.1	M

A.36.3.4 MR Spectroscopy Functional Group Macros

Table A.36-4 specifies the use of the Functional Group macros used in the Multi-frame Functional Groups Module for the MR Spectroscopy IOD.

Table A.36-4
MR SPECTROSCOPY FUNCTIONAL GROUP MACROS

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Frame Content	C.7.6.16.2.2	M – May not be used as a Shared Functional Group
Plane Position	C.7.6.16.2.3	M
Plane Orientation	C.7.6.16.2.4	M
Referenced Image	C.7.6.16.2.5	C - Required if the image or frame has been planned on another image or frame. May be present otherwise
Derivation Image	C.7.6.16.2.6	C - Required if the image or frame has been derived from another SOP Instance.
Cardiac Trigger	C.7.6.16.2.7	C - Required if Cardiac Synchronization Technique (0018,9037) equals other than NONE and if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Frame Anatomy	C.7.6.16.2.8	M
MR Spectroscopy Frame Type	C.8.12.5.1	M
MR Timing and Related Parameters	C.8.12.5.2	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Spectroscopy FOV/Geometry	C.8.13.3.1	C – Required if Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR and if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Echo	C.8.12.5.4	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Modifier	C.8.12.5.5	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Receive Coil	C.8.12.5.7	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Transmit Coil	C.8.12.5.8	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Diffusion	C.8.12.5.9	C - Required if Acquisition Pixel Contrast (0008,9209) in any MR Image Frame Type Functional Group in the SOP Instance equals DIFFUSION and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

MR Averages	C.8.12.5.10	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Spatial Saturation	C.8.12.5.11	C - Required if Spatial Pre-saturation (0018,9027) equals SLAB for any frame in the SOP Instance and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Velocity Encoding	C.8.12.5.13	C – Required if Phase Contrast (0018,9014) equals YES and Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

A.37 RAW DATA INFORMATION OBJECT DEFINITION

A.37.1 Raw Data IOD Description

The Raw Data Information Object Definition (IOD) specifies raw data.

A.37.2 Raw Data entity-relationship model

The E-R Model in section A.1.2 depicts those components of the DICOM Information Model, which directly reference the Raw Data IOD.

A.37.3 Raw Data IOD Module Table

Table A.37-1
RAW DATA IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
Frame of Reference	Frame of Reference	C.7.4.1	U
	Synchronization	C.7.4.2	C- Required if time synchronization was applied.
Equipment	General Equipment	C.7.5.1	M
Raw Data	Acquisition Context	C.7.6.14	M
	Raw Data	C.19.1	M
	SOP Common	C.12.1	M

C.7 COMMON COMPOSITE IMAGE IOD MODULES

Item #9: Change in Section C.7.3.1.1.1 the list of Defined Terms for the Modality attribute

Retire the MA and MS Defined Terms for Modality:

C.7.3.1.1.1 Modality

Defined Terms for the Modality (0008,0060) are:

… …	… …
~~**MA = Magnetic resonance angiography**~~	~~**MS = Magnetic resonance spectroscopy**~~
… …	… …

Retired Defined Terms for the Modality (0008,0060) are:

… …	… …
MA = Magnetic resonance angiography	**MS = Magnetic resonance spectroscopy**

Note: 1. The XA modality incorporates the retired modality DS.

2. The RF modality incorporates the retired modalities CF, DF, VF.

3. The modality listed in the Modality Data Element (0008,0060) may not match the name of the IOD in which it appears. For example, a SOP instance from XA IOD may list the RF modality when an RF implementation produces an XA object.

4. The MR modality incorporates the retired modalities MA and MS.

Item #10: Extend PS 3.3 use of Referenced/Source Image Sequence (and repeat elsewhere Referenced Image Sequence used): - ***Editor note: include two corrections of typographic errors in the description of attributes (0008,1140) and (0008,1155).***

C.7.6.1 General Image Module

Table C.7-9 specifies the Attributes which identify and describe an image within a particular series.

Table C.7-9
GENERAL IMAGE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…	…	…	…
Referenced Image Sequence	(0008,1140)	3	A sequence which ~~**provides**~~ reference**s** ~~**to a set of Image SOP Class/Instance identifying**~~ other images significantly related to this image (e.g. post-localizer CT image or Mammographic biopsy or partial view images).
>Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if Referenced Image Sequence (0008,1140) is sent.

>Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if Reference**d** Image Sequence (0008,1140) is sent.
>Referenced Frame Number	(0008,1160)	3	References one or more image frames of a Multi-frame Image SOP Instance, identifying which frames are significantly related to this image**, and the reference is not to all frames**. **Note: If this Attribute is not present, all frames of the SOP Instance are referenced.**
>Purpose of Reference Code Sequence	**(0040,A170)**	**3**	**Describes the purpose for which the reference is made.**
>>Include 'Code Sequence Macro' Table 8.8-1			**Defined Context ID 7201.**
Derivation Description	(0008,2111)	3	A text description of how this image was derived. See C.7.6.1.1.3 for further explanation.
Derivation Code Sequence	**(0008,9215)**	**3**	**A coded description of how this image was derived. See C.7.6.1.1.3 for further explanation.**
>Include 'Code Sequence Macro' Table 8.8-1			**Defined Context ID 7203.**
Source Image Sequence	(0008,2112)	3	A Sequence which identifies the set of Image SOP Class/Instance pairs of the Images which were used to derive this Image. Zero or more Items may be included in this Sequence. See C.7.6.1.1.4 for further explanation.
>Referenced SOP Class UID	(0008,1150)	1C	Uniquely identifies the referenced SOP Class. Required if Source Image Sequence (0008,2112) is sent.
>Referenced SOP Instance UID	(0008,1155)	1C	Uniquely identifies the referenced SOP Instance. Required if Source Image Sequence (0008,2112) is sent.
>Referenced Frame Number	(0008,1160)	3	References one or more image frames of a Multi-frame Image SOP Instance, identifying which frames were used to derive this image**, and the reference is not to all frames**. Note: **If this Attribute is not present, all frames of the SOP Instance are referenced.**
>Purpose of Reference Code Sequence	**(0040,A170)**	**3**	**Describes the purpose for which the reference is made, that is what role the source image or frame(s) played in the derivation of this image.**
>>Include 'Code Sequence Macro' Table 8.8-1			**Defined Context ID 7202.**
...	…	…	…

C.7.6.1.1 General Image Attribute Descriptions

…

C.7.6.1.1.3 Derivation Description

C.7.6.1.1.3 Derivation Description and Derivation Code Sequence

If an Image is identified to be a derived image (see C.7.6.1.1.2 Image Type), Derivation Description (0008,2111) **and Derivation Code Sequence (0008,9215)** ~~**is an optional text description of describe**~~ the way **in which** the image was derived. ~~**It**~~ **They** may be used whether or not the Source Image Sequence (0008,2112) is provided. ~~**It**~~ **They** may also be used in cases when the Derived Image pixel data is not significantly changed from one of the source images and the SOP Instance UID of the Derived Image is the same as the one used for the source image.

Note: Examples of Derived Images which would normally be expected to affect professional interpretation and would thus have a new UID include:

a. images resulting from image processing of another image (e.g. unsharp masking),

b. a multiplanar reformatted CT image,

c. a DSA image derived by subtracting pixel values of one image from another.

d. an image that has been decompressed after having been compressed with a lossy compression algorithm. To ensure that the user has the necessary information about the lossy compression, the approximate compression ratio may be included in Derivation Description (0008,2111).

An example of a Derived Image that would normally not be expected to affect professional interpretation and thus would not require a new UID is an image that has been padded with additional rows and columns for more display purposes.

C.7.6.1.1.4 Source image sequence

If an Image is identified to be a Derived image (see C.7.6.1.1.2 Image Type), Source Image Sequence (0008,2112) is an optional list of Referenced SOP Class UID (0008,1150)/ Referenced SOP Instance UID (0008,1150) pairs which identify the source images used to create the Derived image. It may be used whether or not there is a description of the way the image was derived in Derivation Description (0008,2111) **or Derivation Code Sequence (0008,9215)**.

Item #11: Add the following new sections to C.7.6

C.7.6.16 Multi-frame Functional Groups Module

Table C.7.6.16-1 specifies the attributes of the Multi-frame Functional Groups Module. This module is included in SOP instances even if there is only one frame in the instance.

Table C.7.6.16-1
MULTI-FRAME FUNCTIONAL GROUPS MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Shared Functional Groups Sequence	(5200,9229)	2	Sequence that contains the Functional Group Macros that are shared for all frames in this SOP Instance and Concatenation. Note: The contents of this sequence are the same in all SOP Instances that comprise a Concatenation. Zero or one Item may be included in this sequence. See section C.7.6.16.1.1 for further explanation.
>Include one or more Functional Group Macros that are shared by all frames. The selected Functional Group Macros shall not be present in the Per-frame Functional Groups Sequence (5200,9230).			See section C.7.6.16.1.1 for further explanation. For each IOD that includes this module, a table is defined in which the permitted Functional Group Macros and their usage is specified.
Per-frame Functional Groups Sequence	(5200,9230)	1	Sequence that contains the Functional Group Macros corresponding to each frame of the Multi-frame Image. The first Item corresponds with the first frame, and so on. Each Item shall contain the same set of Functional Group Macros. This Sequence shall contain the same number of Items as the number of frames in the Multi-frame image. See Section C.7.6.16.1.2 for further explanation.
>Include one or more Functional Group Macros.			For each IOD that includes this module, a table is defined in which the permitted Functional Group Macros and their usage is specified.

C.7.6.16.1 Multi-frame Functional Groups Module Attribute Description

C.7.6.16.1.1 Functional Group

A Functional Group is a set of Attributes that are logically related and may vary together. Functional Groups are defined in Macros. Those Functional Group Macros that apply to all frames are included in the Shared Functional Groups Sequence (5200,9229). Functional Group Macros whose attribute values may vary from frame to frame are included in the Per-frame Functional Groups Sequence (5200,9230).

A single Functional Group Macro shall not be included in both the Shared Functional Groups Sequence (5200,9229)and the Per-frame Functional Groups Sequence (5200,9230).

Notes: 1. In the case of a SOP Instance containing a single frame, some Functional Group Macros may be contained in the Shared Functional Groups Sequence (5200,9229) and others in the one Item of the Per-frame Functional Groups Sequence (5200,9230).

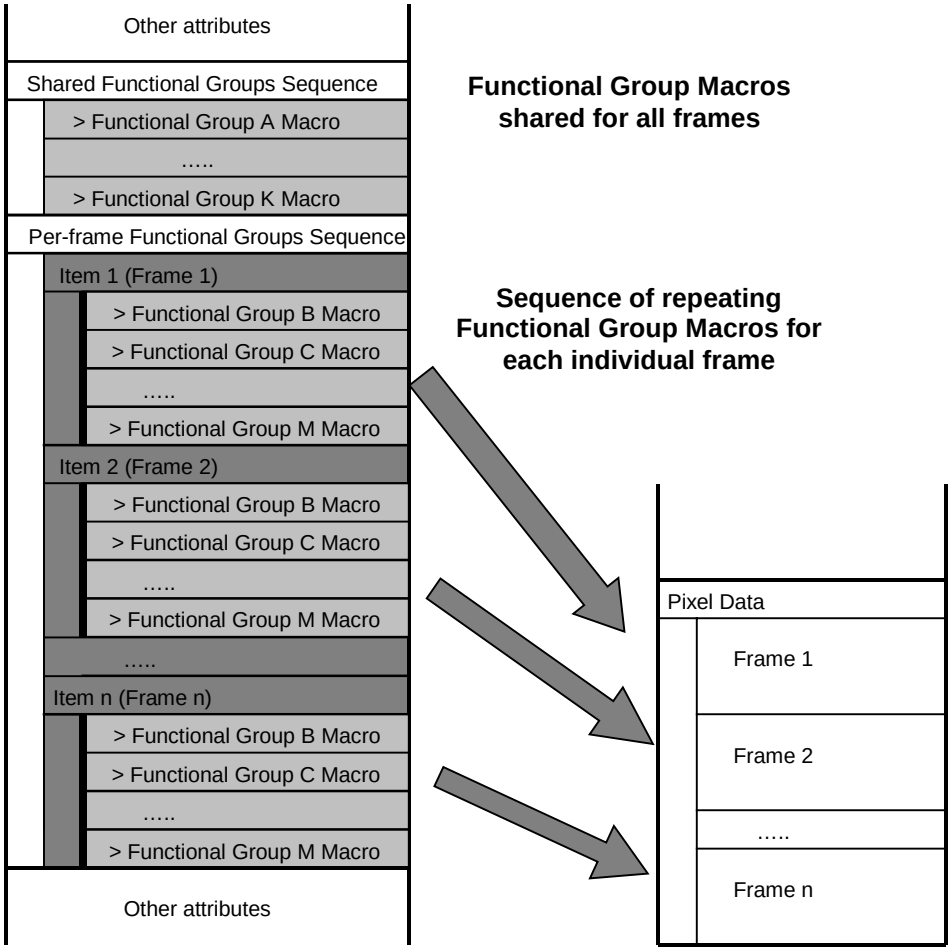
2. Even if there are no Functional Group Macros in the Per-frame Functional Groups Sequence 0008,9230) an empty Item is encoded for every frame.

Private Functional Groups may be defined. The attributes of such a group may be standard or private attributes. A Private Functional Group may not replicate the attributes of a standard Functional Group.

A Private Functional Group can be added to either the Shared Functional Groups Sequence (5200,9229) or the Per-frame Functional Groups Sequence (5200,9230).

C.7.6.16.1.2 Per-frame Functional Groups Sequence

The Per-frame Functional Groups Sequence Attribute (5200,9230) consists of a Sequence of Items. Each Item describes the frame of the same rank in the multi-frame pixel data. The first Item describes frame 1, the second Item describes frame 2, etc. Frames are implicitly numbered starting from 1. See Figure C.7.6.16-1.



Note: The Functional Group Macros A, B, C, etc. are examples to illustrate the Multi-frame Functional Groups. The actual Functional Group Sequences are defined elsewhere.

Figure C.7.6.16-1
A Graphical Presentation of the Multi-frame Functional Groups structure

C.7.6.16.2 Common Functional Group Macros

The following sections contain Functional Group macros common to more than one IOD specification.

Note: The attribute descriptions in the Functional Group Macros are written as if they were applicable to a single frame (i.e., the macro is part of the Per-frame Functional Groups Sequence). If an attribute is applicable to all frames (i.e. the macro is part of the Shared Functional Groups Sequence) the phrase "this frame" in the attribute description shall be interpreted to mean " for all frames".

C.7.6.16.2.1 Pixel Measures Macro

Table C.7.6.16-2 specifies the attributes of the Pixel Measures Functional Group macro.

Table C.7.6.16-2
PIXEL MEASURES MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Measures Sequence	(0028,9110)	1	Identifies the physical characteristics of the pixels of this frame. Only a single Item shall be permitted in this sequence.
>Pixel Spacing	(0028,0030)	1C	Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. Required if Volumetric Properties (0008,9206) is other than DISTORTED or SAMPLED. May be present otherwise.
>Slice Thickness	(0018,0050)	1C	Nominal reconstructed slice thickness, in mm. See C.7.6.2.1.1 and C.7.6.16.2.3.1 for further explanation. Required if Volumetric Properties (0008,9206) is VOLUME or SAMPLED. May be present otherwise.

C.7.6.16.2.2 Frame Content Macro

Table C.7.6.16-3 specifies the attributes of the Frame Content Functional Group macro.

This Functional Group Macro may only be part of the Per-frame Functional Groups Sequence (5200,9230) attribute.

Table C.7.6.16-3
FRAME CONTENT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Content Sequence	(0020,9111)	1	Identifies general characteristics of this frame. Only a single Item shall be permitted in this sequence.
>Frame Acquisition Number	(0020,9156)	3	A number identifying the single continuous gathering of data over a period of time which resulted in this frame.
>Frame Reference Datetime	(0018,9151)	1C	The point in time that is most representative of when data was acquired for this frame. See C.7.6.16.2.2.1 and C.7.6.16.2.2.2 for further explanation. Note: The synchronization of this time with an external clock is specified in the synchronization Module in Acquisition Time synchronized (0018,1800). Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Frame Acquisition Datetime	(0018,9074)	1C	The date and time that the acquisition of data that resulted in this frame started. See C.7.6.16.2.2.1 for further explanation. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Frame Acquisition Duration	(0018,9220)	1C	The actual amount of time [in milliseconds] that was used to acquire data for this frame. See C.7.6.16.2.2.1 and C.7.6.16.2.2.3 for further explanation. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Cardiac Cycle Position	(0018,9236)	3	Description of the position in the cardiac cycle that is most representative of this frame. Defined Terms: END_SYSTOLE END_DIASTOLE UNDETERMINED

>Respiratory Cycle Position	(0018,9214)	3	Description of the position in the respiratory cycle that is most representative of this frame. Defined Terms: START_OF_RESPIRATION END_OF_RESPIRATION UNDETERMINED
>Dimension Index Values	(0020,9157)	1C	Contains the values of the indices defined in the Dimension Index Sequence (0020,9222) for this multi-frame header frame. The number of values is equal to the number of Items of the Dimension Index Sequence and shall be applied in the same order. See section C.7.6.17.1 for a description. Required if the value of the Dimension Index Sequence (0020,9222) contains Items.
>Temporal Position Index	(0020,9128)	3	Ordinal number of the frame in the set of frames with different temporal positions.
>Stack ID	(0020,9056)	3	Identification of a group of frames, with different positions and/or orientations that belong together, within a dimension organization. See C.7.6.16.2.2.4 for further explanation
>In-Stack Position Number	(0020,9057)	1C	The ordinal number of a frame in a group of frames, with the same Stack ID Required if Stack ID (0020,9056) is present. See section C.7.6.16.2.2.4 for further explanation.
>Frame Comments	(0020,9158)	3	User-defined comments about the frame.

C.7.6.16.2.2.1 Timing Parameter Relationships

Figure C.7.6.16-2 shows the relationships among the various timing parameters used.

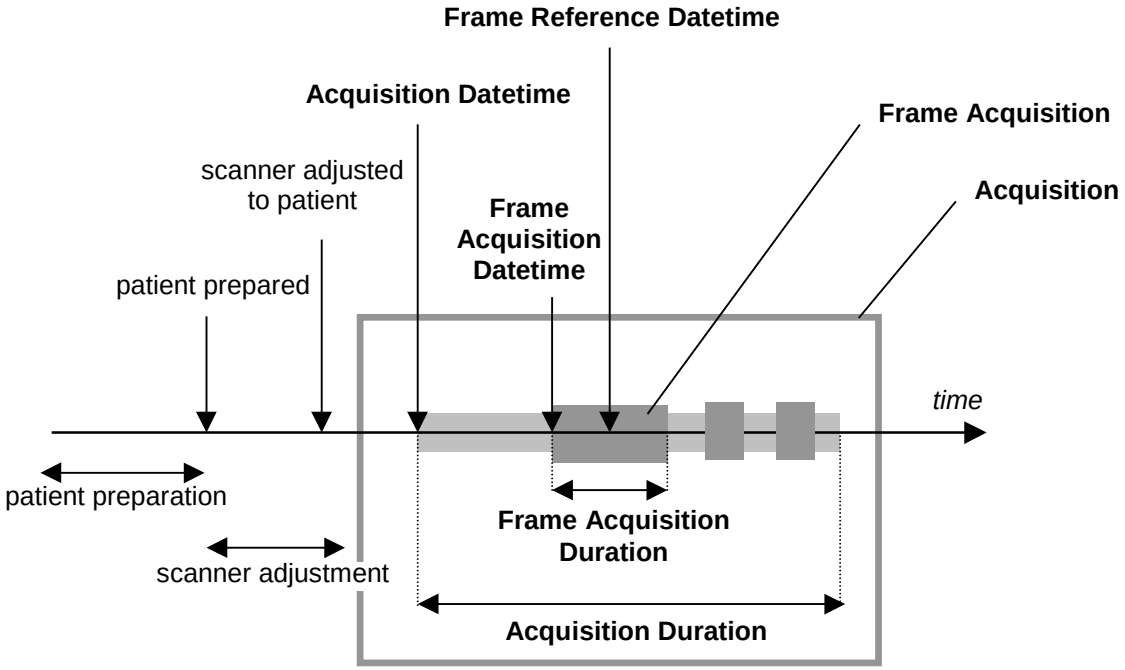


Figure C.7.6.16-2
Relationship of Timing Related Attributes

C.7.6.16.2.2.2 Frame Reference Datetime

The Frame Reference Datetime (0018,9151) is used to indicate the point in time that is most representative for that specific frame.

Note For example, in the case of MR it might be the time of acquisition of the data for the k_y=0 line in k-space (the central Fourier segment).

C.7.6.16.2.2.3 Frame Acquisition Duration

The Frame Acquisition Duration (0018,9220) is used to indicate the duration of the acquisition related to this frame.

C.7.6.16.2.2.4 Concatenations and Stacks

Due to implementation specific reasons (such as maximum object size) the information of a multi-frame image may be split into more than one SOP Instance. These SOP Instances form together a Concatenation. This is a group of SOP Instances within a Series that is uniquely identified by the Concatenation UID (0020,9133).

The Dimension Index Sequence (0020,9222) for each SOP Instance with the same Concatenation UID (0020,9133) shall contain exactly the same tags and values.

In a Concatenation the Dimension Index Sequence (0020,9222) items of the Shared Functional Groups (5200,9229) shall be identical and have the same values for all individual SOP Instances. The items of the Per-frame Functional Groups (5200,9230) shall be identical for all individual SOP Instances but the values may change per frame.

Stacks describe application-specific groups of frames that have a geometric relationship. Stacks have a Stack ID (0020,9056) that contains a descriptive name that identifies the stack. A Stack ID (0020,9056) may be re-used in another SOP Instance even outside a concatenation. The value of Stack ID (0020,9056) is unique within the scope of a particular Dimension Organization UID (0020,9164) if present, otherwise it is unique within in the scope of a particular Concatenation UID (0020,9133). See Figure C7.6.16-3 for an example.

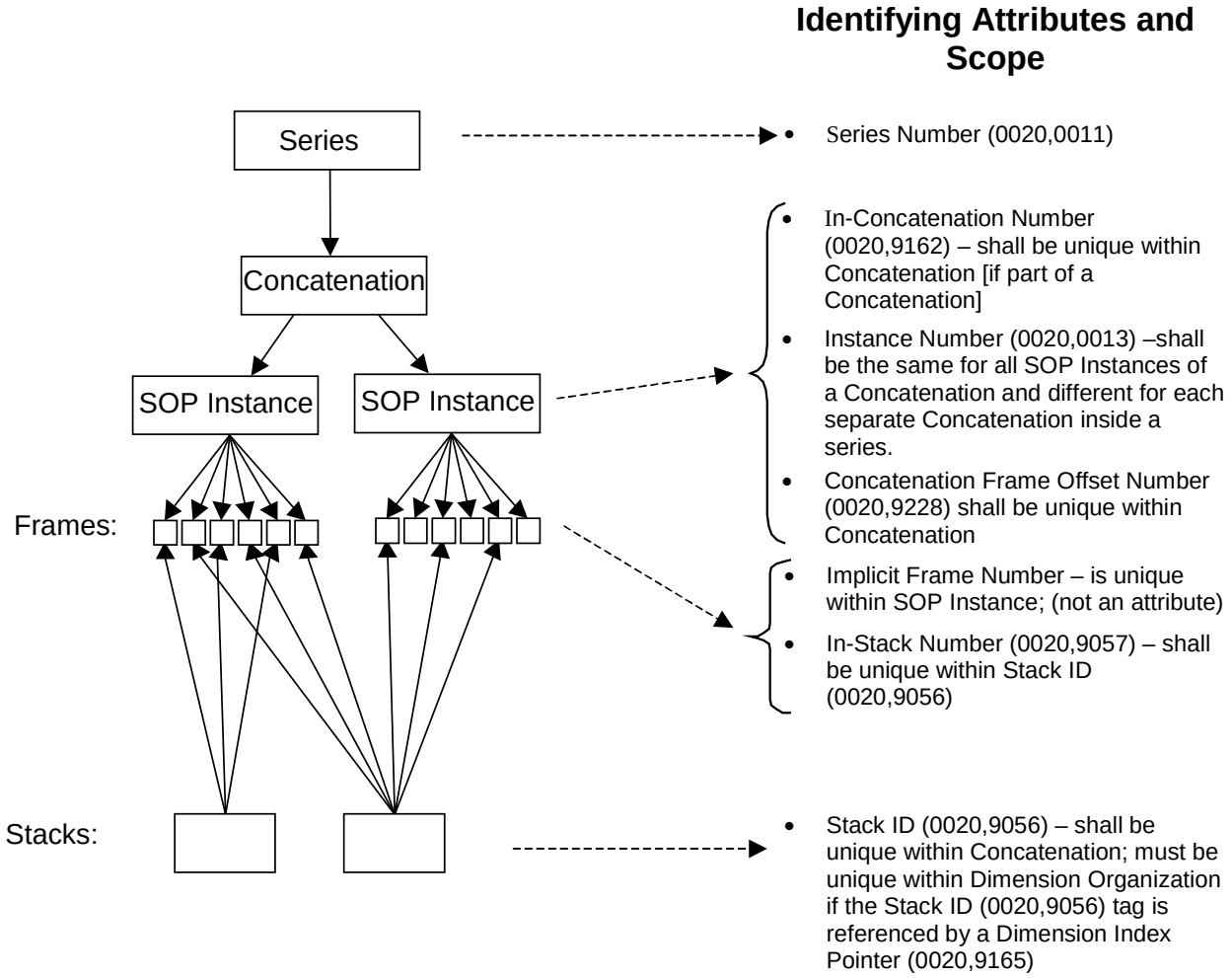


Figure C.7.6.16-3
Identifying attributes for Concatenation, SOP Instances, Frames and Stacks

Each frame in a stack has an In-Stack Position Number (0020,9057) which is the ordinal number (starting from 1) of the frame within the set of frames with the same Stack ID (0020,9056), see Figure C.7.6.16-4 for an example.

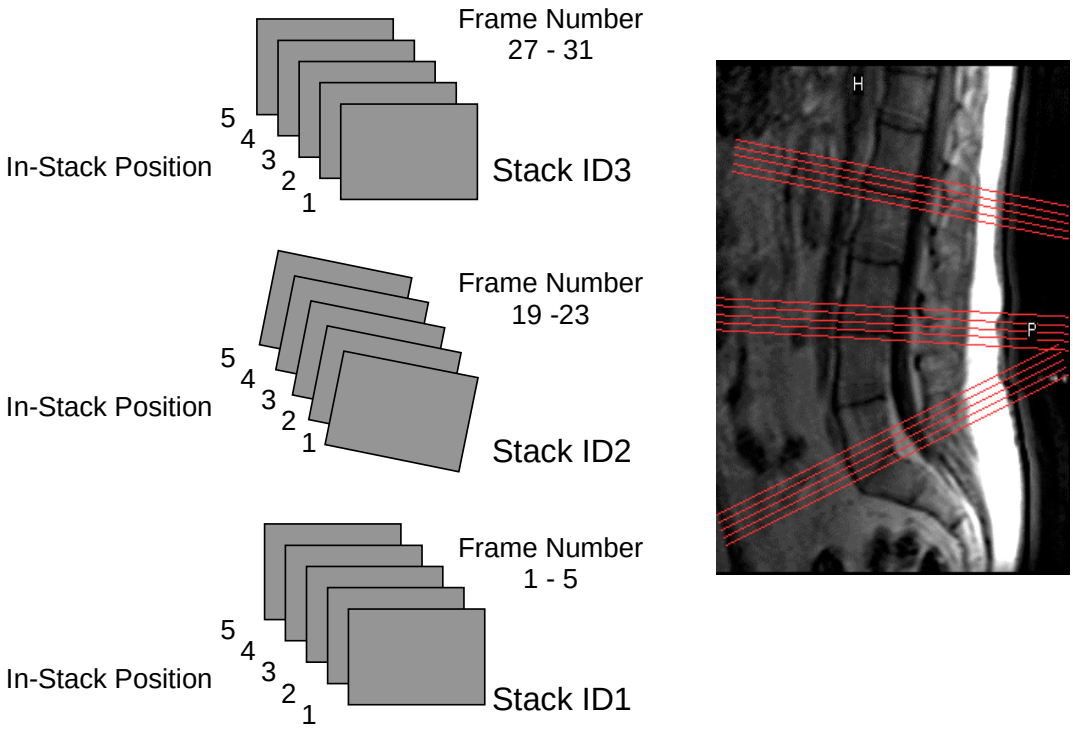


Figure C.7.6.16-4
Example of multiple stacks

In order to allow interoperable operations on stacks, 2 different frames with the same Stack ID (0020,9056) can only have the same In-Stack Position Number (0020,9057) if they have the same values for the following attributes:

1. Dimension Organization UID (0020,9222) or if absent Concatenation UID (0020,9133) to qualify the Stack ID
2. Image Position (Patient) (0020,0032)
3. Image Orientation (Patient) (0020,0037)
4. Rows (0028,0010) ∗ Pixel Spacing (0028,0030) (= field of view in the row direction)
5. Columns (0028,0011) ∗ Pixel Spacing (0028,0030) (= field of view in the column direction)
6. Slice Thickness (0018,0050)

C.7.6.16.2.3 Plane Position Macro

Table C.7.6.16-4 specifies the attributes of the Plane Position Functional Group macro.

Table C.7.6.16-4
PLANE POSITION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Plane Position Sequence	(0020,9113)	1	Identifies the position of the plane of this frame. Only a single Item shall be permitted in this sequence.
>Image Position (Patient)	(0020,0032)	1C	The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the frame, in mm. See C.7.6.2.1.1 and C.7.6.16.2.3.1 for further explanation. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Volumetric Properties (0008,9206) of this frame is other than DISTORTED, may be present otherwise.

C.7.6.16.2.3.1 Position and Orientation for SAMPLED Frames

In the case of Volumetric Properties (0008,9206) having a value of SAMPLED, the Image Position (0020,0032), Image Orientation (0020,0037) and Slice Thickness (0018,0050) shall represent the volume from which the frame was derived based on the orientation of the sampling performed.

Note: For example in the case of MAX_IP:

The Image Orientation shall be the direction of the ray used for projection of the center of the plane.

The image position shall contain the x, y, and z coordinates of the intersection of the mid-plane of the sampled volume with the ray used to project the upper left hand corner of the frame.

The Slice Thickness shall contain the distance that the ray used for projection of the center of the plane traveled through the volume.

C.7.6.16.2.4 Plane Orientation Macro

Table C.7.6.16-5 specifies the attributes of the Plane Orientation Functional Group macro.

Table C.7.6.16-5
PLANE ORIENTATION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Plane Orientation Sequence	(0020,9116)	1	Identifies orientation of the plane of this frame. Only a single Item shall be permitted in this sequence.
>Image Orientation (Patient)	(0020,0037)	1C	The direction cosines of the first row and the first column with respect to the patient. See C.7.6.2.1.1 and C.7.6.16.2.3.1 for further explanation. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Volumetric Properties (0008,9206) of this frame is other than DISTORTED. May be present otherwise.

C.7.6.16.2.5 Referenced Image Macro

Table C.7.6.16-6 specifies the attributes of the Referenced Image Functional Group macro.

Table C.7.6.16-6
REFERENCED IMAGE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Referenced Image Sequence	(0008,1140)	2	A sequence that provides reference to a set of SOP Class/Instance pairs identifying images or other composite SOP Instances used to plan the acquisition or significant related images. See Section C.7.6.16.2.5.1 for further explanation. Zero or more Items may be included in this Sequence.
>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.
>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.
>Referenced Frame Number	(0008,1160)	1C	References one or more image frames of a Multi-frame Image SOP Instance, identifying which frames are significantly related to this image. Required if reference is provided to a Multi-frame SOP Instance and not all frames are referenced.
>Purpose of Reference Code Sequence	(0040,A170)	1	Describes the purpose for which the reference is made. See C.7.6.16.2.5.1 for further explanation.
>>*Include 'Code Sequence Macro' Table 8.8-1*			Defined Context ID 7201.

C.7.6.16.2.5.1 Use of Referenced Image Macro

Referenced Image Sequence (0008,1140) shall be used to provide a reference to a set of SOP Class/Instance pairs identifying other data objects used to plan the acquisition of this image where the images shall share the same Frame of Reference UID (0020,0052). For each Item that contains such a reference, the value of the Purpose of Reference Code Sequence (0040,A170) shall be ("121311", DCM, "Localizer"). Applications can use the Referenced Image Sequence (0008,1140) in combination with data in Plane Position and Plane Orientation Macros to provide projections of the position of an image with respect to the referenced image.

The Referenced Image Sequence (0008,1140) may also be present when references to other images (or frames within other images) are required for other reasons, as specified by Purpose of Reference Code Sequence (0040,A170).

Note: An Image may contain references to itself (e.g. to other frames within itself).

C.7.6.16.2.6 Derivation Image Macro

Table C.7.6.16-7 specifies the attributes of the Derivation Image Functional Group macro.

Table C.7.6.16-7
DERIVATION IMAGE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Derivation Image Sequence	(0008,9124)	2	A sequence that that provides reference to the set of SOP Class/Instance pairs of the Images or other composite SOP Instances which were used to derive this frame. Zero or more Items may be included in this Sequence.
>Derivation Description	(0008,2111)	3	A text description of how this frame data was derived. See C.7.6.1.1.3 for further explanation.
>Derivation Code Sequence	(0008,9215)	1	A coded description of how this frame was derived. See C.7.6.1.1.3 for further explanation.
>>Include 'Code Sequence Macro' Table 8.8-1			Defined Context ID 7203.
>Source Image Sequence	(0008,2112)	2	A Sequence which identifies the set of Image or other SOP Class/Instance pairs of the Instances which were used to derive this frame. Zero or more Items may be included in this Sequence. See C.7.6.1.1.4 for further explanation.
>>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.
>>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.
>>Referenced Frame Number	(0008,1160)	1C	References one or more image frames of a Multi-frame SOP Instance, identifying which frames are significantly related to this image. Required if referenced to another Multi-frame image SOP Instance and not all frames are included.
>>Purpose of Reference Code Sequence	(0040,A170)	1	Describes the purpose for which the reference is made, that is what role the source image or frame played in the derivation of this image or frame.
>>>Include 'Code Sequence Macro' Table 8.8-1			Defined Context ID 7202.

C.7.6.16.2.7 Cardiac Trigger Macro

Table C.7.6.16-8 specifies the attributes of the Cardiac Trigger Functional Group macro.

Table C.7.6.16-8
CARDIAC TRIGGER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Cardiac Trigger Sequence	(0018,9118)	1	Identifies cardiac trigger delay for this frame. Only a single Item shall be permitted in this sequence.
>Trigger Delay Time	(0020,9153)	1	Trigger delay time in ms for the frame relative to the last R-peak. See C.7.6.16.2.7.1 for further explanation.

C.7.6.16.2.7.1 Relationship of Cardiac Timing Attributes

Figure C.7.6.16-4 depicts the usage.

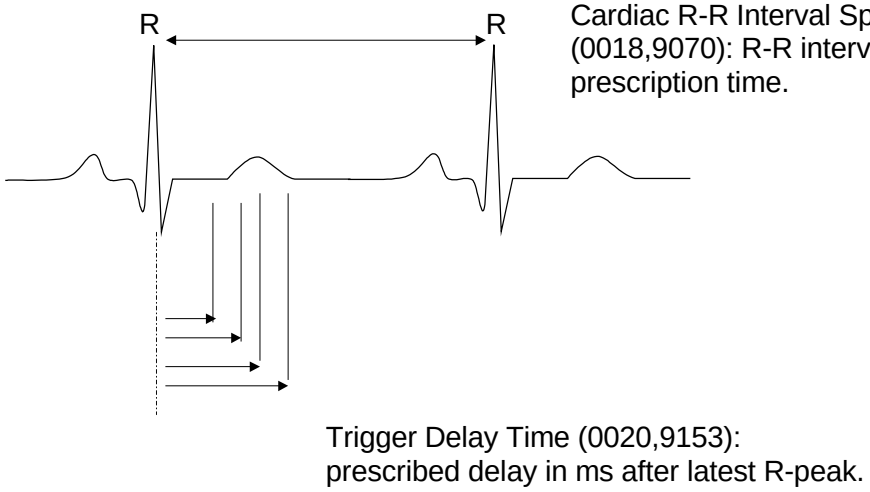


Figure C.7.6.16-4
Cardiac Timing Tags

C.7.6.16.2.8 Frame Anatomy Macro

Table C.7.6.16-9 specifies the attributes of the Frame Anatomy Functional Group macro.

Table C.7.6.16-9
FRAME ANATOMY MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Anatomy Sequence	(0020,9071)	1	Identifies anatomic characteristics of this frame. Only a single Item shall be permitted in this sequence.
>Frame Laterality	(0020,9072)	1	Laterality of (possibly paired) body parts (as described in Anatomic Region Sequence (0008,2218)) examined. Enumerated Values: R = right L = left U = unpaired B = both left and right Note: This Attribute is mandatory, in order to ensure that frames may be positioned correctly relative to one another for display. Shall be consistent with any laterality information contained in Primary Anatomic Structure Modifier Sequence (0008,2230), if present.
>Anatomic Region Sequence	(0008,2218)	2	Sequence that identifies the anatomic region of interest in this frame (i.e. external anatomy, surface anatomy, or general region of the body). Note: It is strongly recommended that this Attribute be sent with a value. See C.8.11.2.1.1 for further explanation. Only a single Item shall be permitted in this Sequence.
>>*Include 'Code Sequence Macro' Table 8.8-1*			Defined Context ID is 4009.
>>Anatomic Region Modifier Sequence	(0008,2220)	3	Sequence that modifies the anatomic region of interest in this frame (i.e. prone, supine, decubitus right). May be present only if Anatomic Region Sequence (0008,2218) is sent. See C.8.11.2.1.1 for further explanation. One or more Items may be included in this Sequence.
>>>*Include 'Code Sequence Macro' Table 8.8-1*			Defined Context ID is 2.
>Primary Anatomic Structure Sequence	(0008,2228)	3	Sequence that identifies the primary anatomic structures of interest in this frame. See C.8.11.2.1.2 for further explanation. One or more Items may be included in this Sequence.
>>*Include 'Code Sequence Macro' Table 8.8-1*			Defined Context ID is 1.

>>Primary Anatomic Structure Modifier Sequence	(0008,2230)	3	Sequence that modifies the primary anatomic structure of interest in this frame. May be present only if Primary Anatomic Structure Sequence (0008,2228) is sent. See C.8.11.2.1.2 for further explanation. One or more Items may be included in this sequence.
>>>Include 'Code Sequence Macro' Table 8.8-1			Defined Context ID is 2.

C.7.6.16.2.9 Pixel Value Transformation Macro

Table C.7.6.16-10 specifies the attributes of the Pixel Value Transformation Functional Group macro.

Note: This Macro is equivalent with the Modality LUT transformation in non Multi-frame IODs.

Table C.7.6.16-10
PIXEL VALUE TRANSFORMATION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Value Transformation Sequence	(0028,9145)	1	Contains the attributes involved in the transformation of stored pixel values. Only a single Item shall be permitted in this sequence.
>Rescale Intercept	(0028,1052)	1	The value b in relationship between stored values (SV) and the output units. Output units = m*SV + b.
>Rescale Slope	(0028,1053)	1	m in the equation specified by Rescale Intercept (0028,1052).
>Rescale Type	(0028,1054)	1	Specifies the output units of Rescale Slope (0028,1053) and Rescale Intercept (0028,1052). See C.11.1.1.2 for further explanation. Enumerated Value: US = Unspecified if Modality (0008,0060) equals MR.

C.7.6.16.2.10 Frame VOI LUT Macro

Table C.7.6.16-11 specifies the attributes of the Frame VOI LUT Functional Group macro.

Table C.7.6.16-11
FRAME VOI LUT MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame VOI LUT Sequence	(0028,9132)	2	Window Center and Width values applied to the frame. Zero or one item may be included in this sequence.
>Window Center	(0028,1050)	1	Window Center for display. See C.11.2.1.2 for further explanation.
>Window Width	(0028,1051)	1	Window Width for display. See C.11.2.1.2 for further explanation.

C.7.6.16.2.11 Real World Value Mapping Macro

Table C.7.6.16-12 specifies the attributes of the Real World Value Mapping Functional Group macro.

Table C.7.6.16-12
REAL WORLD VALUE MAPPING MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Real World Value Mapping Sequence	(0040,9096)	1	The mapping of stored values to associated real world values. One or more Items may be included in this sequence.
>Real World Value First Value Mapped	(0040,9216)	1	Specifies the first stored value mapped for the Real Word Value Intercept (0040, 9224) and Real World Value Slope (0040,9225) or Real World Value LUT (0040,9212) of this Item. See C.7.6.16.2.11.1 for further explanation.
>Real World Value Last Value Mapped	(0040,9211)	1	Specifies the last stored value mapped for the Real Word Value Intercept (0040, 9224) and Real World Value Slope (0040,9225) or Real World Value LUT (0040,9212) of this Item. See C.7.6.16.2.11.1 for further explanation.
>Real World Value Intercept	(0040,9224)	1C	The Intercept value in relationship between stored values (SV) and the real world values. See section C.7.6.16.2.11.2 for further explanation. Required if Real World Value LUT Data (0040,9212) is not present.

>Real World Value Slope	(0040,9225)	1C	The Slope value in relationship between stored values (SV) and the real world values. See section C.7.6.16.2.11.2 for further explanation. Required if Real World Value LUT Data (0040,9212) is not present.
>Real World Value LUT Data	(0040,9212)	1C	LUT Data in this Sequence. Required if Real World Value Intercept (0040,9224) is not present.
>LUT Explanation	(0028,3003)	1	Free form text explanation of the meaning of the LUT.
>LUT Label	(0040,9210)	1	Label that is used to identify this transformation.
>Measurement Units Code Sequence	(0040,08EA)	1	Units of measurement. Only a single value shall be present. See C.7.6.16.2.11.1 for further explanation.
>>*Include Code Sequence Macro Table 8.8-1*			Defined Context ID is 82

C.7.6.16.2.11.1 Real World Value representation

C.7.6.16.2.11.1.1 Real World Value Mapping Sequence

The items in the Real World Value Mapping Sequence (0040,9096) may be used to translate stored values into real world values when there is such a relationship. The Real World Value Mapping Sequence (0040,9096) is independent of the Modality LUT (or Pixel Value Transformation Macro), as illustrated in Figure C.7.6.16-5.

Each item specifies the range of stored values as well as the associated mapping function. Each item can specify either a linear mapping, using Real World Value Slope (0040, 9225) and Real World Value Intercept (0040, 9224), or a non-linear mapping using Real World Value LUT Data (0040,9212). More than one Real World Value Mapping Item is allowed.

The range of stored pixel values specified by different Real Value World Mapping Sequence (0040,9096) Items can overlap (as illustrated in the example in Figure C.7.6.16-6).

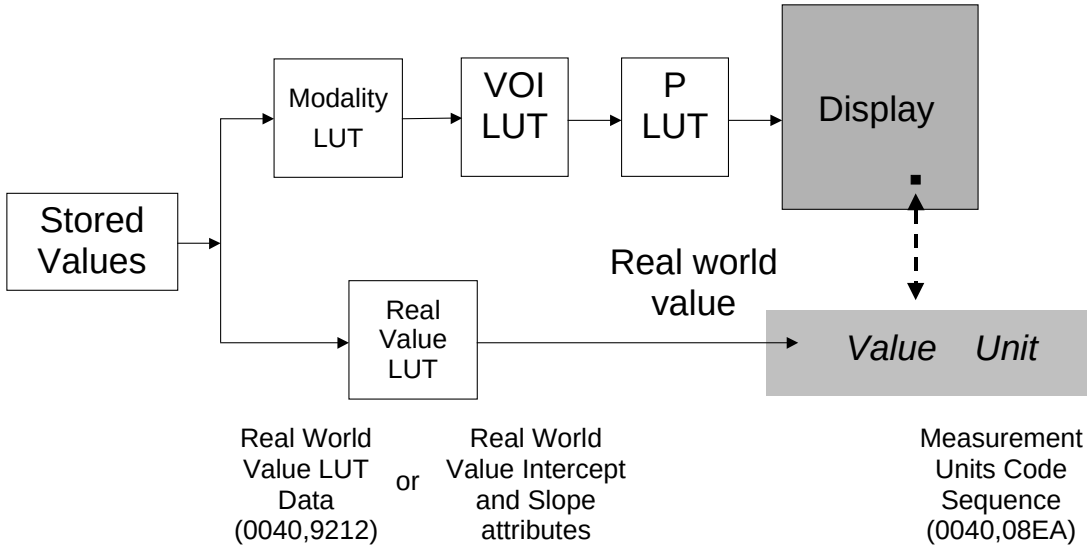


Figure C.7.6.16-5
The Real World Value LUT and the Image Viewing pipeline

Note: For example, MR images may contain data that is not only the result of the physical/chemical properties of the scanned anatomy, but may also contain information that is representing real world values, such as, temperature [in degrees C], flow [in l/min], speed [in m/sec], relative activity [in %], relative contrast enhancement [in %], diffusion [in sec/mm2], etc.

In some cases the conversion from Stored Values to Real World Values can be linear (through "slope" and "intercept") or non-linear (through look-up tables).

Both transformation methods can be applied to one range of stored values. Overlapped ranges might be used for different representations such as log versus linear scales or for different representations in units such as cm/sec versus mm/sec. Alternative methods can be identified by the labels assigned to the transformations.

C.7.6.16.2.11.1.2 Real World Values Mapping Sequence Attributes

The Real World Value First Value Mapped (0040,9216) and Real World Value Last Value Mapped (0040,9211) Attributes describe the range of stored pixel values that are mapped by the Sequence Item. Stored pixel values less than the first value mapped, or greater than the last value mapped have no real value attached.

When the Real World Value Intercept (0040,9224) and Real World Value Slope (0040, 9225) attributes are supplied, the stored value (SV) is converted to a real world value (RV) using the equation:

RV = (Real World Value Slope) * SV + Real World Value Intercept

When the Real World Value LUT Data (0040,9212) attribute is supplied, Real World Values are obtained via a lookup operation. The stored pixel value of the first value mapped is mapped to the first entry in the LUT Data. Subsequent stored pixel values are mapped to the subsequent entries in the LUT Data up to a stored pixel value equal to the last value mapped.

The number of entries in the LUT data is given by:

Number of entries = Real World Value Last Value Mapped – Real World Value First Value Mapped + 1

The physical units for the real world values obtained from the sequence item are given by the Measurement Units Code Sequence (0040,08EA).

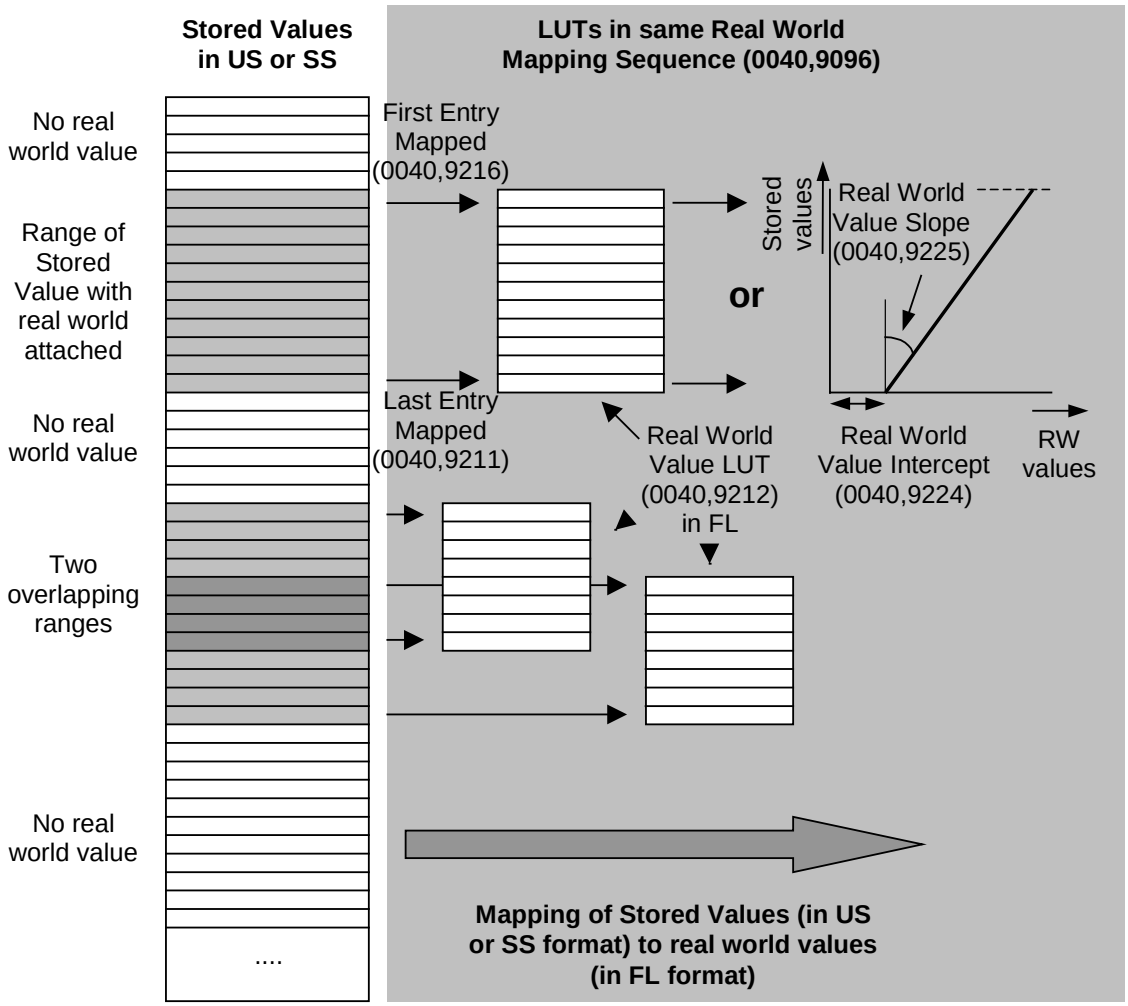


Figure C.7.6.16-6
Example of mapping stored values to real world values

C.7.6.17 Multi-frame Dimension Module

The Multi-frame Dimension Module contains a sequence with items pointing to attributes defining a set of dimensions that are usually known prior to the acquisition commencing. It is up to the generating applications to decide what attributes are important to describe the multi-frame dimensions.

The application that generates the Concatenation or SOP Instances may use the order of Dimension Index Pointers (0020,9165) in the Dimension Index Sequence (0020,9222) to guide the receiving application in determining the order of the presentation of image frames. The first index has the highest ranking, the next index has a lower ranking, etc. Frames with higher values for the dimension with the highest ranking would only be presented after all frames that have values for Dimension Index Pointers (0020,9165) of the lower rankings have been presented.

If the set of Dimension Index Pointers does not provide an attribute set whose values are unique for each frame then the order for the frames with the same value set will be incompletely specified. The receiving application could use the logical frame number to resolve this ambiguity. If the attribute set contains more dimensions than are needed to specify a unique ordering, the lower order ranking attribute(s) will have no effect on the ordering.

Note: For example if there were the following indices in the following order:

- Stack ID (1-3)
- In-stack Position Number (1-2 for Stack ID 1, 1-4 for Stack ID 2, 1-3 for Stack ID 3)
- Effective Echo Time (1-2), i.e. every slice has been scanned with 2 different effective echo's

Then the frames could be presented in the following order:

(Stack ID, In-stack Position, Effective Echo Time)

(1,1,1), (1,1,2), (1,2,1), (1,2,2),

(2,1,1), (2,1,2), (2,2,1), (2,2,2), (2,3,1), (2,3,2), (2,4,1), (2,4,2)

(3,1,1), (3,1,2), (3,2,1), (3,2,2), (3,3,1), (3,3,2)

The actual order of the frames in the object is up to the generating application.

If the effective echo time was not included in the Dimension Index Pointers in the above example then the order of sorting for the frames with the same indices will be undefined – in this case there would be 2 frames with the index set (Stack ID, In-stack Position) = (1,1) and the order of these frames is not specified.

If there were another attribute appended to the Dimension Index Pointers, for example TR, then the TR index would not be used in determining the order of the frames. So the Index Frame Pointers would contain (Stack ID, In-stack Position, Effective Echo Time, TR) but the TR index would be irrelevant for frame ordering purposes.

Table C.7.6.17-1 specifies the attributes of the Multi-frame Dimension Module.

Table C.7.6.17-1
MULTI-FRAME DIMENSION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Dimension Organization Sequence	(0020,9221)	2	Sequence that lists the Dimension Organization UIDs referenced by the containing SOP Instance. See section C.7.6.17.2 for further explanation. Zero or more Items may be included in this Sequence.
>Dimension Organization UID	(0020,9164)	1	Uniquely identifies a set of dimensions referenced within the containing SOP Instance. See section C.7.6.17.2 for further explanation.

Dimension Index Sequence	(0020,9222)	2	Identifies the sequence containing the indices used to specify the dimension of the multi-frame object. Zero or more Items may be included in this sequence.
>Dimension Index Pointer	(0020,9165)	1	Contains the Data Element Tag that is used to identify the Attribute connected with the index. See section C.7.6.17.1 for further explanation.
>Dimension Index Private Creator	(0020,9213)	1C	Identification of the creator of a group of private data elements. Required if the Dimension Index Pointer (0020,9165) value is the Data Element Tag of a Private Attribute.
>Functional Group Pointer	(0020,9167)	1C	Contains the Data Element Tag of the Functional Group Sequence that contains the Attribute that is referenced by the Dimension Index Pointer (0020,9165). See section C.7.6.17.1 for further explanation. Required if the value of the Dimension Index Pointer (0020,9165) is the Data Element Tag of an Attribute that is contained within a Functional Group Sequence.
>Functional Group Private Creator	(0020,9238)	1C	Identification of the creator of a group of private data elements. Required if the Functional Group Pointer 0020,9167) value is the Data Element Tag of a Private Attribute.
>Dimension Organization UID	(0020,9164)	1C	Uniquely identifies a set of dimensions referenced within the containing SOP Instance. In particular the dimension described by this sequence item is associated with this Dimension Organization UID. See section C.7.6.17.2 for further explanation. Required if the value of the Dimension Index Sequence (0020,9222) contains Items

C.7.6.17.1 Dimension Indices

With the Dimension Index Sequence (0020,9222) , Data Element Tags are specified that identify the indices used for a particular SOP Instance.

The actual index values for each frame in a multi-frame header are stored in a single Dimension Index Values Attribute (0020,9157) defined in the Frame Content Functional Group. For each SOP Instance this Attribute has a Value Multiplicity equal to the number of Items in the Sequence. The ordering of the Items in the Sequence defines the ordering in the Dimension Index Values Attribute: Item 1 of the Sequence relates to Value 1, Item 2 to Value 2, etc.

The Dimension Index Pointer (0020,9165) stores ordinal numbers that comprise logical indices for a referenced Attribute. Each Attribute referenced in the Dimension Index Sequence (0020,9222) will have an index stored in the Dimension Index Values (0020,9157) for each frame. Frames assigned the same index shall contain nominally the same value for the underlying Attribute. It is at the discretion of the SOP Instance creator whether the Attribute values are equivalent, and therefore appropriate for assignment to the same index value.

The Dimension Index Pointer (0020,9165) shall contain the Data Element Tag (gggg,eeee) of the Attribute being indexed.

Note: Dimension Index Pointer (0020,9165) may point to a Sequence containing a Functional Group. In that case all the Attributes of the Sequence are associated with the index value.

The Functional Group Pointer (0020,9167) value is the Data Element Tag (gggg,eeee) of the Functional Group Sequence that contains the Attribute being indexed. If the Dimension Index Pointer 0020,9165) contains a Data Element Tag that identifies a Functional Group Sequence then the Functional Group Pointer (0020,9167) shall not be present.

If the Dimension Index Pointer (0020,9165) attribute contains a Private Data Element, then the Dimension Index Private Creator (0020,9213) shall contain the Private Creator of the block of Private Data Elements.

If the Functional Group Pointer (0020,9167) attribute contains a Private Data Element, then the Functional Group Private Creator (0020,9238) shall contain the Private Creator of the block of Private Data Elements.

Note: An example of the usage of the Dimension Index Sequence (0020,9222) and Dimension Index Values (0020,9157) attributes:

Dimension Index Sequence (0020,9222) specifies two indices:

Trigger Delay Time (0020,9153)
Image Position (Patient) (0020,0032)

The Dimension Index Sequence (0020,9222) is filled with the following contents:

Item	Attribute	Value
1	Dimension Index Pointer	(0020,9153)
	Functional Group Pointer	(0018,9118)
	.....	
2	Dimension Index Pointer	(0020,0032)
	Functional Group Pointer	(0020,9113)
	.....	

The Dimension Index Values (0020,9157) (in the Frame Content Functional Group) for each frame consists of two values:

Index of Trigger Delay Time \ Index of Image Position

The SOP Instance creator is responsible for maintaining consistency between the actual value of the attribute listed as the Dimension Index Pointer (0020,9165) and the corresponding value in the Dimension Index Values (0020,9157) attribute.

See Figure C.7.6.17-1 for an illustration of this example.

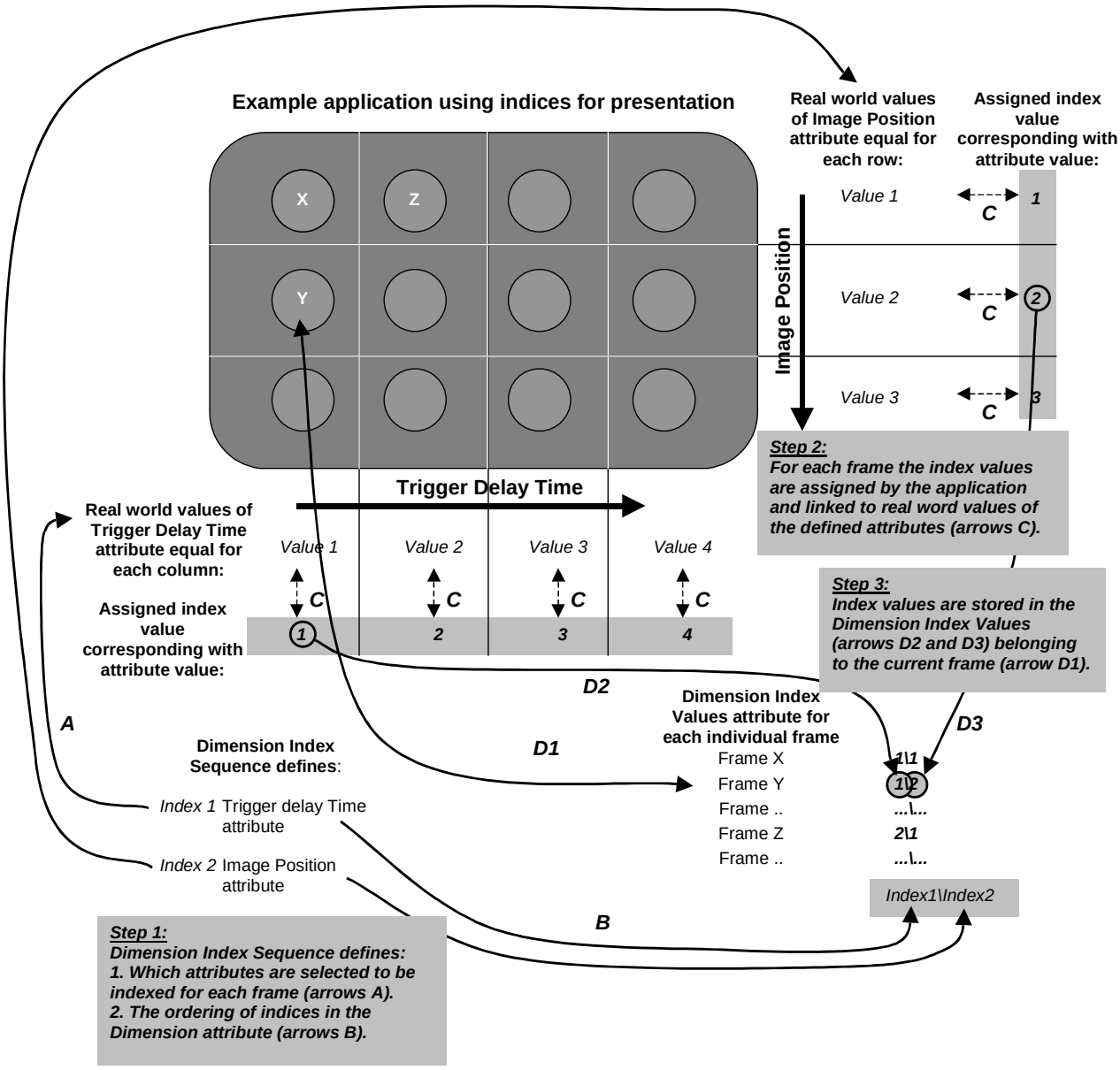


Figure C.7.6.17-1
Example of Dimension Index Sequence and Dimension Index Values attributes

C.7.6.17.2 Dimension Organization UID

The Dimension Organization UID (0020,9164) value identifies a set of dimensions to which an Item of the Dimension Index Sequence (0020,9222) belongs.

When different SOP Instances share the same Dimension Organization UID (0020,9164) for a particular Item of the Dimension Index Sequence (0020,9222), equivalent indices from the corresponding Dimension Index Values (0020,9157) shall have the same meaning across the SOP Instances.

This mechanism allows an image creator to explicitly specify that indices are intended to convey identical information across SOP Instances.

The Dimension Organization Sequence attribute (0020,9221) contains a summary of all the Dimension Organization UID (0020,9164) values used in a SOP Instance.

Note: Figure C.7.6.17-2 illustrates how this is used for a SOP Instance created by a multi-planar reformat application from a SOP Instance containing three Items in the Dimension Index Sequence. The meaning of the indices for Temporal Position Index (0020,9128), and MR Echo Sequence (0018,9114) were preserved in the derived SOP Instance, so it shares the Dimension Organization UID for these attributes with the original. Since the reformat was performed with a different orientation, the meaning of the In-Stack Position Number (0020,9057) was not preserved. Therefore a new Dimension Organization UID (0020,9164) was created.

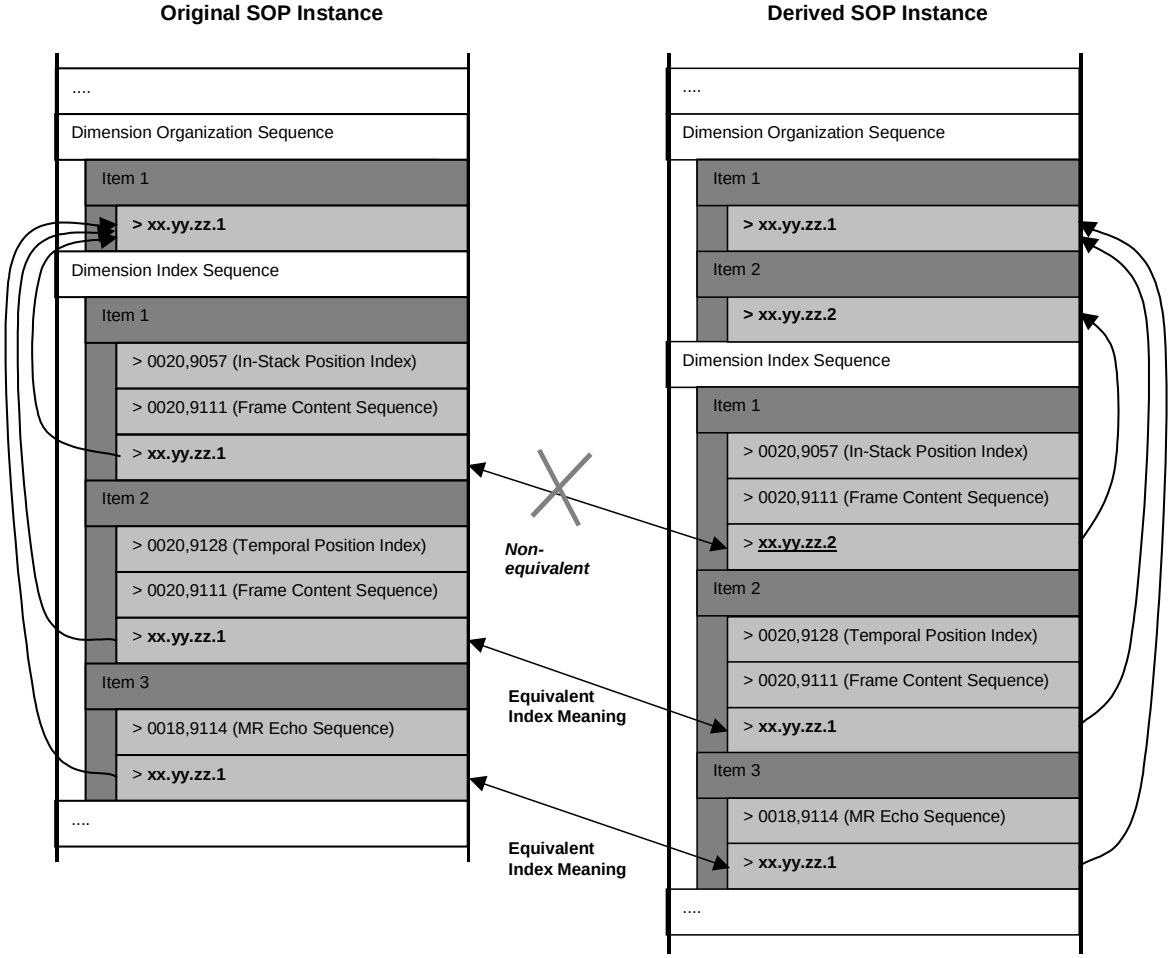


Figure C.7.6.17-2
Example of use of Dimension Organization Module

C.7.6.18 Physiological Synchronization

C.7.6.18.1 Cardiac Synchronization Module

Table C.7.6.18-1 specifies the attributes of the Cardiac Synchronization Module.

Table C.7.6.18-1
CARDIAC SYNCHRONIZATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Cardiac Synchronization Technique	(0018,9037)	1C	Defines if a cardiac synchronization technique was applied during or after the acquisition. Enumerated Values: NONE REALTIME = total time for the acquisition is shorter than cardiac cycle, no gating is applied PROSPECTIVE = certain thresholds have been set for a gating window that defines the acceptance of measurement data during the acquisition RETROSPECTIVE = certain thresholds have been set for a gating window that defines the acceptance of measurement data after the acquisition PACED = there is a constant RR interval (e.g., Pacemaker), which makes thresholding not required Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Cardiac Signal Source	(0018,9085)	1C	Cardiac Signal Source. Defined Terms: ECG = electrocardiogram VCG = vector cardiogram PP = peripheral pulse MR = magnetic resonance, i.e. M-mode or cardiac navigator Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals other than NONE.
Cardiac RR Interval Specified	(0018,9070)	1C	R-R interval in ms measured prior to or during the scan. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals other than NONE.
Cardiac Beat Rejection Technique	(0018,9169)	1C	Cardiac arrhythmia rejection technique. Defined Terms: NONE RR_INTERVAL = rejection based on deviation from average RR interval QRS_LOOP = rejection based on deviation from regular QRS loop PVC = rejection based on PVC criteria Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE.

Low R-R Value	(0018,1081)	2C	R-R interval low limit for beat rejection, in ms. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE.
High R-R Value	(0018,1082)	2C	R-R interval high limit for beat rejection, in ms. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals PROSPECTIVE or RETROSPECTIVE.
Intervals Acquired	(0018,1083)	2C	Number of R-R intervals acquired. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals other than NONE.
Intervals Rejected	(0018,1084)	2C	Number of R-R intervals rejected. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Cardiac Synchronization Technique (0018,9037) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Cardiac Synchronization Technique (0018,9037) equals other than NONE.

C.7.6.18.2 Respiratory Synchronization Module

Table C7.6.18-2 specifies the attributes of the Respiratory Synchronization Module.

Table C.7.6.18-2
RESPIRATORY SYNCHRONIZATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Respiratory Motion Compensation Technique	(0018,9170)	1C	Applied technique to reduce respiratory motion artifacts. Defined Terms: NONE BREATH_HOLD REALTIME = image acquisition shorter than respiratory cycle GATING = Prospective gating TRACKING = prospective through-plane or in-plane motion tracking PHASE_ORDERING = prospective phase ordering PHASE_RESCANNING = prospective techniques, such as real-time averaging, diminishing variance and motion adaptive gating RETROSPECTIVE = retrospective gating CORRECTION = retrospective image correction Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Respiratory Signal Source	(0018,9171)	1C	Signal source from which respiratory motion is derived. Defined Terms: NONE BELT NASAL_PROBE CO2_SENSOR NAVIGATOR = MR navigator and organ edge detection MR_PHASE = phase (of center k-space line) ECG = baseline demodulation of the ECG Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Respiratory Motion Compensation Technique (0018,9170) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Respiratory Motion Compensation Technique (0018,9170 equals other than NONE.

C.7.6.18.3 Bulk Motion Synchronization Module

Table C7.6.18-3 specifies the attributes of the Bulk Motion Synchronization Module.

Table C.7.6.18-3
BULK MOTION SYNCHRONIZATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Bulk Motion Compensation Technique	(0018,9172)	1C	Applied technique to reduce bulk or other physiology motion artifacts. Defined Terms: NONE REALTIME = image acquisition shorter than motion cycle GATING = prospective gating TRACKING = prospective through and/or in-plane motion tracking RETROSPECTIVE = retrospective gating CORRECTION = retrospective image correction Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Bulk Motion Signal Source	(0018,9173)	1C	Signal source to measure motion. Defined Terms: JOINT = joint motion detection NAVIGATOR = MR navigator and organ edge detection MR_PHASE = phase (of center k-space line) Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Bulk Motion Compensation Technique (0018,9172) equals other than NONE. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Bulk Motion Compensation Technique (0018,9172) equals other than NONE.

C.7.6.19 Supplemental Palette Color Lookup Table Module

This module is used in conjunction with Multi-frame IODs that use RGB color in a number of frames. The value of the Pixel Presentation (0008,9205) for such frames equals COLOR.

Table C.7.6.19-1 specifies the Attributes that describe the Lookup table data.

Table C.7.6.19-1
SUPPLEMENTAL PALETTE COLOR TABLE LOOKUP MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Red Palette Color Lookup Table Descriptor	(0028,1101)	1	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201). See C.7.6.3.1.5 for further explanation.
Green Palette Color Lookup Table Descriptor	(0028,1102)	1	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202). See C.7.6.3.1.5 for further explanation.
Blue Palette Color Lookup Table Descriptor	(0028,1103)	1	Specifies the format of the Blue Palette Color Lookup table Data (0028,1203). See C.7.6.3.1.5 for further explanation.
Red Palette Color Lookup Table Data	(0028,1201)	1	Red Palette Color Lookup Table Data. See C.7.6.3.1.6 for further explanation.
Green Palette Color Lookup Table Data	(0028,1202)	1	Green Palette Color Lookup Table Data. See C.7.6.3.1.6 for further explanation.
Blue Palette Color Lookup Table Data	(0028,1203)	1	Blue Palette Color Lookup Table Data. See C.7.6.3.1.6 for further explanation.

C.8 MODALITY SPECIFIC MODULES

Item #12: Modify Table C.8-4

C.8.3.1 MR Image Module

Table C.8-4
MR IMAGE MODULE ATTRIBUTES

.....			
~~**Receiving**~~ **Receive** Coil **Name**	(0018,1250)	3	Receive~~**d**~~ coil used.
~~**Transmitting**~~ **Transmit** Coil **Name**	(0018,1251)	3	Transmit~~**ted**~~ coil used.
.....			

Item #13: Add the following new sections to C.8

C.8.12 Enhanced MR Image

This section describes the specific modules for the Enhanced MR Image IOD.

C.8.12.1 Enhanced MR Image Module

This section describes the Enhanced MR Image Module.

Table C.8.12-1 specifies the attributes of the Enhanced MR Image module.

Table C.8.12-1
ENHANCED MR IMAGE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include ' MR Image and MR Spectroscopy Instance Macro' Table C.8.12-2			
Include 'MR Image Description Macro' Table C.8.12-4			The Frame Type (0008,9007) attribute shall not be used.
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. This value shall be 1.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. Enumerated Value: MONOCHROME2. See C.7.6.3.1.2 for definition of this term.
Largest Monochrome Pixel Value	(0028,9099)	3	Largest value in the monochrome portion of any frame whose Pixel Presentation (0008,9205) in the Frame Content Macro has a value COLOR. Color values must be greater than the Largest Monochrome Pixel Value. See section C.8.12.2.1.2.1 for further explanation.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. Enumerated Values: 8 and 16.

Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. Enumerated Values: 8, 12 and 16. See C.8.12.1.1.1 for specialization.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. Shall be one less than the value in Bits Stored (0028,0101).
Spacing between Slices	(0018,0088)	3	Value of the prescribed spacing to be applied between the slices in a volume that is to be acquired. The spacing in mm is defined as the center-to-center distance of adjacent slices.
Lossy Image Compression	(0028,2110)	1C	Specifies whether an Image has undergone lossy compression. Enumerated Values: 00 = Image has NOT been subjected to lossy compression. 01 = Image has been subjected to lossy compression. See C.7.6.1.1.5 for further explanation. Required if Lossy Compression has been performed on the Image.
Lossy Image Compression Ratio	(0028,2112)	1C	Describes the approximate lossy compression ratio(s) that have been applied to this image. See C.7.6.1.1.5 for further explanation. May be multivalued if successive lossy compression steps have been applied. Note: For example, a compression ratio of 30:1 would be described in this Attribute with a single value of 30. Required if Lossy Compression has been performed on the Image.
Icon Image Sequence	(0088,0200)	3	This icon image is representative of the Image.
> Image Pixel Module			See C.7.6.1.1.6 for further explanation.

C.8.12.2 MR Image and Spectroscopy Instance Macro

Table C.8.12-2 specifies the common attributes Enhanced MR Image Module and MR Spectroscopy Module.

Table C.8.12-2
MR IMAGE AND SPECTROSCOPY INSTANCE MACRO

Attribute Name	Tag	Type	Attribute Description
Instance Number	(0020,0013)	1	A number that identifies this instance. The value shall be the same for all SOP Instances of a Concatenation, and different for each separate Concatenation and for each SOP Instance not within a Concatenation in a series.
Content Date	(0008,0023)	1	The date the data creation was started.
Content Time	(0008,0033)	1	The time the data creation was started.
Acquisition Number	(0020,0012)	3	A number identifying the single continuous gathering of data over a period of time which resulted in this image.
Acquisition Datetime	(0008,002A)	1C	The date and time that the acquisition of data started. Note: The synchronization of this time with an external clock is specified in the synchronization Module in Acquisition Time synchronized (0018,1800). Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Acquisition Duration	(0018,9073)	1C	The time in seconds needed to run the prescribed pulse sequence. See C.7.6.16.2.2.1 for further explanation. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Number of Frames	(0028,0008)	1	Number of frames in a multi-frame image. See C.7.6.6.1.1 for further explanation.
Concatenation Frame Offset Number	(0020,9228)	1C	Offset of the first frame in a multi-frame image of a concatenation. Logical frame numbers in a concatenation can be used across all its SOP instances. This offset can be applied to the implicit frame number to find the logical frame number in a concatenation. Required if Concatenation UID (0020,9161) is present.
Representative Frame Number	(0028,6010)	3	The frame number selected for use as a pictorial representation (e.g. icon) of the multi-frame Image.

Concatenation UID	(0020,9161)	1C	Identifier of all SOP Instances that belong to the same concatenation. Required if a group of multi-frame image SOP Instances within a Series are part of a Concatenation.
In-concatenation Number	(0020,9162)	1C	Identifier for one SOP Instance belonging to a concatenation. See C.7.6.16.2.2.4 for further specification. Required if Concatenation UID (0020,9161) is present.
In-concatenation Total Number	(0020,9163)	3	The number of SOP Instances sharing the same Concatenation UID.
Referenced Raw Data Sequence	(0008,9121)	3	A sequence which identifies the set of Raw Data SOP Class/Instance pairs of the Raw data which were used to derive this Image. One or more Items may be included in this Sequence.
>Include 'SOP Instance Reference Macro' Table C.17-3			
Referenced Waveform Sequence	(0008,113A)	3	References to waveforms acquired in conjunction with this image. These Waveforms may or may not be temporally synchronized with this image. One or more Items may be included in this Sequence.
>Include 'SOP Instance Reference Macro' Table C.17-3			
Referenced Image Evidence Sequence	(0008,9092)	1C	Full set of Composite SOP Instances referred to inside the Referenced Image Sequences of this Enhanced MR Image SOP Instance. See C.8.12.2.1.3 for further explanation. One or more Items may be included in this sequence. Required if the Referenced Image Sequence (0008,1140) is present.
>Include 'SOP Instance Reference Macro' Table C.17-3			
Source Image Evidence Sequence	(0008,9154)	1C	Full set of Composite SOP Instances referred to inside the Source Image Sequences of this Enhanced MR Image SOP Instance. See C.8.12.2.1.3 for further explanation. One or more Items may be included in this sequence. Required if the Source Image Sequence (0008,2112) is present.
>Include 'SOP Instance Reference Macro' Table C.17-3			

Referenced Grayscale Presentation State Sequence	(0008,9237)	1C	References to Grayscale Presentation State instances acquired in conjunction with this instance. Note: May only be used to reference Presentation States belonging to the acquired data and not to reference Presentation States generated subsequently such as during interpretation. One or more Items may be included in this sequence. Required if Presentation State is generated during acquisition, shall not be present otherwise.
>Include 'SOP Instance Reference Macro' Table C.17-3			
Content Qualification	(0018,9004)	1	Content Qualification Indicator Enumerated Values: PRODUCT RESEARCH SERVICE See C.8.12.2.1.2 for further explanation.
Resonant Nucleus	(0018,9100)	1C	Nucleus that is resonant at the transmitter frequency. Defined Terms: 1H 3HE 7LI 13C 19F 23NA 31P 129XE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Magnetic Field Strength	(0018,0087)	1C	Nominal field strength of the MR Magnet, in Tesla. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Applicable Safety Standard Agency	(0018,9174)	1	Agency that established MR safety standard applicable to the acquisition of this Instance. Defined Terms: IEC FDA MHW
Applicable Safety Standard Description	(0018,9175)	3	Name and Version of the applicable standard.
Image Comments	(0020,4000)	3	User-defined comments about the image.

C.8.12.2.1 MR Image and Spectroscopy Instance Macro Attribute Description

C.8.12.2.1.1 Bits Allocated and Bits Stored

Table C.8.12-3 specifies the allowed combinations of Bits Allocated (0028,0100) and Bits Stored (0028,0101).

Table C.8.12-3
ALLOWED COMBINATIONS OF ATTRIBUTE VALUES
FOR BITS ALLOCATED AND BITS STORED

Bits Allocated	Bits Stored
8	8
16	12, 16

C.8.12.2.1.2 Content Qualification

Content Qualification (0018,9004) shall have the value PRODUCT if the content (image or Spectroscopy data) was produced with approved hardware and software. It shall have the value RESEARCH or SERVICE if there is any doubt as to whether the content was produced with approved hardware and software.

If data with Content Qualification (0018,9004) of RESEARCH or SERVICE is used to derive other content then it is expected that this derived content will also have Content Qualification (0018,9004) set to RESEARCH or SERVICE.

The intent of this element is to allow annotation of an advisory message that indicates that this content may not be suitable for clinical interpretation.

C.8.12.2.1.3 Evidence Sequence Attributes

The intent of the Referenced Image Evidence Sequence (0008,9092) and Source Image Evidence Sequence (0008,9154) is to provide a list of all unique SOP Instances listed in the Referenced Image Sequence (0008,1140) and Source Image Sequence (0008,2112) attributes respectively.

C.8.12.3 MR Image Description Macro

This section describes the MR Image Description Macro.

Table C.8.12-4 specifies the attributes of the MR Image Description Macro.

Table C.8.12-4
MR IMAGE DESCRIPTION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See C.8.12.3.1.1 for specialization.
Frame Type	(0008,9007)	1	Type of Frame. A multi-valued attribute analogous to the Image Type (0008,0008). Enumerated Values and Defined Terms are the same as those for the four values of the Image Type (0008,0008) attribute, except that the value MIXED is not allowed. See section C.8.12.3.1.1 for further description.
Pixel Presentation	(0008,9205)	1	Indication of the presence or absence of color information that may be used during rendering. See C.8.12.3.1.2 for a description and Enumerated Values.
Volumetric Properties	(0008,9206)	1	Indication if geometric manipulations are possible with frames in the SOP Instance. See C.8.12.3.1.3 for a description and Enumerated Values.
Volume Based Calculation Technique	(0008,9207)	1	Method used for volume calculations with frames in the SOP Instance. See C.8.12.3.1.4 for a description and Defined Terms.
Complex Image Component	(0008,9208)	1	Representation of complex data of frames in the SOP Instance. See C.8.12.3.1.5 for a description and Defined Terms.
Acquisition Contrast	(0008,9209)	1	Indication of acquisition contrast used with frames in the SOP Instance. See C.8.12.3.1.6 for a description and Defined Terms.

C.8.12.3.1 MR Image Description Attribute Description

C.8.12.3.1.1 Image Type and Frame Type

This module contains the description of the Enhanced MR Image.

The Image Type (0008,0008) and associated Image Type related attributes provide a high level description of a multi-frame SOP Instance. These attributes describe properties that provide key summary information to users of the SOP Instance. Image Type (0008,0008) contains the highest level summary of what is in the SOP Instance.

The attributes in the MR Image Frame Type Macro and the MR Spectroscopy Frame Type Macro: the Frame Type (0008,9007) and associated Frame Type related attributes mirror the corresponding Image Type attributes and apply to the frame level rather than to the image level.

If more than one value is used by the set of frames for a given Frame Type (0008,9007) attribute value or associated attribute value then the corresponding value of the Image Type (0008,0008) or associated attribute shall contain a value of MIXED. This indicates that a mixed set of values exists within the multi-frame SOP Instance.

The value MIXED shall only be used in the attributes of this Module when the corresponding values for the individual frames are not equal. When a value of an attribute is equal for all frames, the same value shall be used for the corresponding value of the attribute in this module. Values 2 and 3 of Image Type (0008,0008) is an exception to the rule for MIXED: Values 2 and 3 may never have the value of MIXED as described in sections C.8.12.3.1.1.2 and C.8.12.3.1.1.3.

Image Type (0008,0008) shall consist of four non-zero length values.

C.8.12.3.1.1.1 Pixel Data Characteristics

Value 1 of Image Type (0008,0008) and Frame Type (0008,9007) shall use one of the following Enumerated Values from Table C.8.12-5.

Value 1 of Image Type (0008,0008) and Value 1 of Frame Type (0008,9007) shall not be zero length.

Table C.8.12-5
IMAGE TYPE AND FRAME TYPE VALUE 1

Enumerated Value Name	Enumerated Value Description
ORIGINAL	An image or frame is original if its pixel data was directly reconstructed from the original data that is obtained from the sensors of the imaging equipment, Image Type (0008,0008) Value 4 is NONE, and Volume Pixel Calculation Technique (0008,9207) is NONE. Original data is data directly reconstructed from k-space data.
DERIVED	An image or frame is derived if its pixel data was calculated from original or other derived pixel data (i.e. it is not original).
MIXED	Used only as a value in Image Type (0008,0008) if frames within the SOP Instance contain different values for Value 1 in their Frame Type (0008,9007).

C.8.12.3.1.1.2 Patient Examination Characteristics

Value 2 for Image Type (0008,0008) and Frame Type (0008,9007) follows the standard definition and shall have the following Enumerated Value from Table C.8.12-6.

Value 2 of Image Type (0008,0008) and Value 2 of Frame Type (0008,9007) shall not be zero length.

Table C.8.12-6
IMAGE TYPE AND FRAME TYPE VALUE 2

Enumerated Value Name	Enumerated Value Description
PRIMARY	See C.7.1.1.2

C.8.12.3.1.1.3 Image Flavor

Value 3 is an overall representation of the image type. This value may be a summary of several other attributes or a duplication of one of the other attributes to indicate the most important aspect of this image. Value 3 Image Flavor is to be used with Value 4 Derived Pixel Contrast to indicate the nature of the image set.

Note: For example Value 3 = DIFFUSION together with Value 4 = NONE indicates that the image set was originally collected for DIFFUSION.

If Value 3 = DIFFUSION together with Value 4 = DIFFUSION this indicates that the object contains DIFFUSION weighted post processed images.

Value 3 of Image Type (0008,0008) shall not be zero length.

Value 3 of Frame Type (0008,9007) may have the same value as found in Value 3 of Image Type (0008,0008), or may have a different value or may be of zero length.

The attribute value may not be MIXED as this value needs to be a summary of the primary purpose of the images, whether the frames have the same value or not.

Table C.8.12-7 specifies the Defined Terms for Value 3 for Image Type (0008,0008) and Frame Type (0008,9007).

Table C.8.12-7
IMAGE TYPE AND FRAME TYPE VALUE 3

Defined Term Name	Defined Term Description
ANGIO_TIME	Angio time acquisition (peripheral vascular/carotid)
METABOLITE_MAP	Metabolite Maps from spectroscopy data
CINE	Cardiac CINE
DIFFUSION	Collected to show diffusion effects.
FLOW_ENCODED	Flow Encoded
FLUID_ATTENUATED	Fluid Attenuated T2 weighted
FMRI	Collected for functional imaging calculations.
LOCALIZER	Collected for the purpose of planning other images.
MAX_IP	Maximum Intensity Projection
MIN_IP	Minimum Intensity Projection
M_MODE	Image line over time
MOTION	Collected for looking at body motion
PERFUSION	Collected for the purposes of perfusion calculations.
PROTON_DENSITY	Proton density weighted
REALTIME	Real-time collection of single slices
STIR	Short Tau Inversion Recovery
STRESS	Cardiac stress image set
TAGGING	Images with superposition of thin saturation bands
TEMPERATURE	Images record temperature
T1	T1 weighted
T2	T2 weighted
T2_STAR	T2* weighted
TOF	Time Of Flight weighted
VELOCITY	Velocity encoded

C.8.12.3.1.1.4 Derived Pixel Contrast

Value 4 shall be used to indicate derived pixel contrast – generally, contrast created by combining or processing images with the same geometry. Value 4 shall have a value of NONE when Value 1 is ORIGINAL.

Note: If more than one of the following derived types is applicable, then it is up to the generating application to specify the value that best characterizes the derived image.

Value 4 of Image Type (0008,0008) and Value 4 of Frame Type (0008,9007) shall not be zero length.

Table C.8.12-8 specifies the Defined Terms for Value 4 for Image Type (0008,0008) and Frame Type (0008,9007).

Table C.8.12-8
IMAGE TYPE AND FRAME TYPE VALUE 4

Defined Term Name	Defined Term Description
ADC	Apparent Diffusion Coefficient
ADDITION	Created through Pixel by pixel addition operation
DIFFUSION	Diffusion weighted
DIFFUSION_ANISO	Diffusion Anisotropy
DIFFUSION_ATTNTD	Diffusion Attenuated. Derived by removing the T2 contributions from a Diffusion Weighted image.
DIVISION	Created through Pixel by pixel division operation
MASKED	Created through Pixel by pixel masking operation
MAXIMUM	Created through Pixel by Pixel Maximum operation
MEAN	Created through Pixel by pixel mean operation
METABOLITE_MAP	Metabolite Maps from spectroscopy data
MINIMUM	Created through Pixel by Pixel Minimum operation
MTT	Mean Transit Time
MULTIPLICATION	Created through Pixel by pixel multiplication operation
NEI	Created through Negative Enhancement Integral operation
RCBF	Regional Cerebral Blood Flow (rCBF)
RCBV	Regional Cerebral Blood Volume (rCBV)
R_COEFFICIENT	R-Coefficient Map (fMRI)
RHO	Proton Density map
SCM	Signal Change Map
SNR_MAP	Signal to Noise Map
STD_DEVIATION	Standard Deviation
SUBTRACTION	Created through Pixel by pixel subtraction operation
T1_MAP	T1 Map
T2_STAR_MAP	T2* Map
T2_MAP	T2 Map
TCS	Time Course of Signal
TEMPERATURE	Temperature encoded
T_TEST	Student's T-Test

TTP	Time To Peak map
VELOCITY	Velocity encoded
Z_SCORE	Z-Score Map
NONE	Not a calculated image
MIXED	Used only as value in Image Type (0008,0008) if frames within the image SOP Instance contain different values for value 4 in their Frame Type (0008,9007)attribute.

C.8.12.3.1.2 Pixel Presentation

Table C.8.12-9 specifies the Enumerated Values for the Pixel Presentation Attribute (0008,9205).

Table C.8.12-9
PIXEL PRESENTATION ATTRIBUTE VALUES

Enumerated Value Name	Enumerated Value Description
COLOR	Image is best displayed in color using Supplemental Palette Color LUTs, but can be displayed in grayscale if current display does not support color. See section C.8.12.3.1.2.1.
MONOCHROME	Image is intended to be displayed in grayscale only. No Supplemental Palette Color LUTs are supplied.
MIXED	Used only as a value in Pixel Presentation (0008,9205) in the Enhanced MR Image Module if frames within the image SOP Instance contain different values for the Pixel Presentation attribute in the MR Image Frame Type Functional Group.

C.8.12.3.1.2.1 Supplemental Palette Color LUTs

Figure C.8.12-1 presents two separate image visualization pipelines that can be used for interpreting the stored pixel values.

If Pixel Presentation (0008,9205) equals COLOR, the stored values are split into two ranges. The stored values up to the values specified in the attribute Largest Monochrome Pixel Value (0020,9099) are passed through the gray scale visualization pipeline. The values greater then the Largest Monochrome Pixel Value (0008,9007) are mapped by the Palette Color LUTs.

The complete range of stored pixel values can also be displayed via the grayscale visualization pipeline only, but the information content may be less useful because the color information is not available.

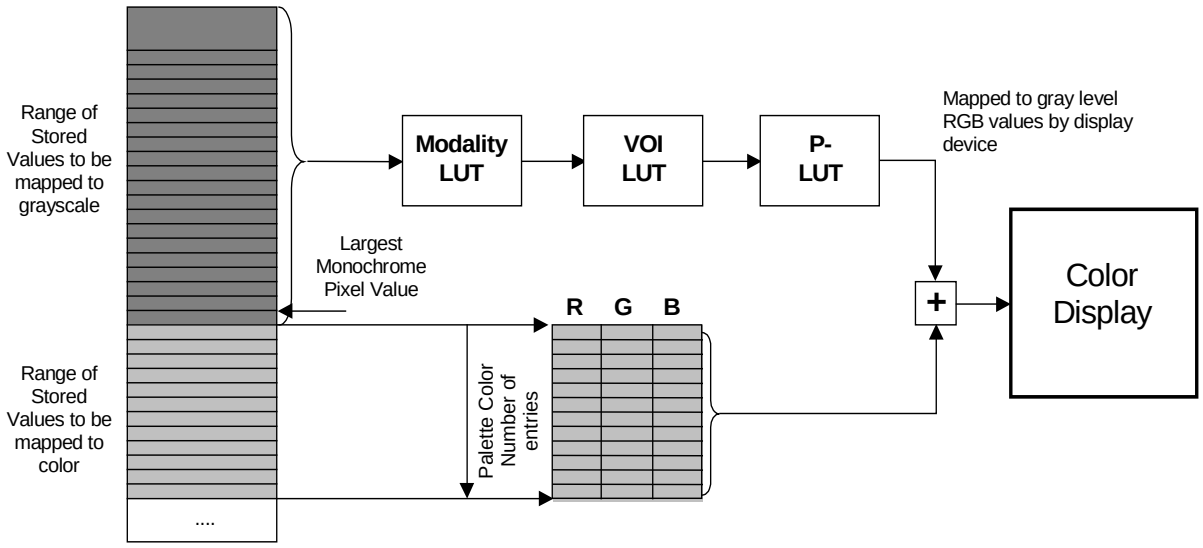


Figure C.8.12-1
MONOCHROME2 Photometric Interpretation with Supplemental Palette Color mapping

C.8.12.3.1.3 Volumetric Properties

The value of the Volumetric Properties attribute (0008,9206) allows applications doing geometric manipulations (e.g., MAX_IP or MPR or planning) to determine if the image is an appropriate candidate for an operation without having to know all the details of the generating application.

Table C.8.12-10 specifies the Enumerated Values for the Volumetric Properties (0008,9206) attribute.

Table C.8.12-10
VOLUMETRIC PROPERTIES ATTRIBUTE VALUES

Enumerated Value Name	Enumerated Value Description
VOLUME	Image contains pixels that represent the volume specified for the image (Examples: Volume Based Pixel Calculation Technique is NONE or MPR).
SAMPLED	The specified frame or each frame within the image will not contain a representation of the average information in the slice direction because the frame was calculated by the non-linear re-sampling of a volume where each pixels of the resulting frame does not contain an average representation of the voxel represented by the frame's pixel. For example a projection (MAX_IP) frame uses the maximum value along a ray for each pixel rather than the average value of the represented voxel.
DISTORTED	Image contains significantly distorted information from what is specified by the image volume attributes. For example this image should not be used in planning or for 3D volume. An example of this image type is a curved reformatted image (CURVED_MPR).
MIXED	Used only as a value in the Volumetric Properties (0008,9206) attribute in the Enhanced MR Image Type Module or MR Spectroscopy Module if frames within the image SOP Instance contain different values for the Volumetric Properties (0008,9206)attributes in the MR Image Frame Type Functional Group or MR Spectroscopy Frame Type Functional Group.

C.8.12.3.1.4 Volume Based Calculation Technique Attribute

The value of the Volume Based Calculation Technique attribute (0008,9207) shall be used to indicate the method used for calculating pixels based on geometry.

Shall have a value of NONE when Value 1 of Image Type (0008,0008) or Value 1 of Frame Type (0008,9007) is ORIGINAL.

Table C.8.12-11 specifies the Defined Terms for the Volume Based Calculation Technique (0008,9207) attribute.

Table C.8.12-11
VOLUME BASED CALCULATION TECHNIQUE ATTRIBUTE VALUES

Defined Term Name	Defined Term Description
MAX_IP	Maximum Intensity Projection
MIN_IP	Minimum Intensity Projection
VOLUME_RENDER	Volume Rendering Projection Volume Rendering Image represents 3D voluminar information constructed from measured voxel intensities covering a 3D volume.
SURFACE_RENDER	Surface Rendering Projection Surface Rendering Image represents 3D surface information constructed from measured voxel intensities covering a 3D volume.
MPR	Multi-Planar Reformat
CURVED_MPR	Curved Multi-Planar Reformat
NONE	Pixels not derived geometrically
MIXED	Used only as a value in Volume Based Calculation Technique (0008,9207) attribute in the Enhanced MR Image Module or MR Spectroscopy Module if frames within the image SOP Instance contain different terms for the Volume Based Calculation Technique attribute in MR Frame Type Functional Group or MR Spectroscopy Frame Type Functional Group.

C.8.12.3.1.5 Complex Image Component

The value of the Complex Image Component attribute (0008,9208) shall be used to indicate which component of the complex representation of the signal is represented in the pixel data.

Table C.8.12-12 specifies the Defined Terms for Complex Image Component attribute (0008,9208).

Table C.8.12-12
COMPLEX IMAGE COMPONENT ATTRIBUTE VALUES

Defined Term Name	Defined Term Description
MAGNITUDE	The magnitude component of the complex image data.
PHASE	The phase component of the complex image data.
REAL	The real component of the complex image data.
IMAGINARY	The imaginary component of the complex image data.
MIXED	Used only as a value in Complex Image Component (0008,9208) in the Enhanced MR Image Module or MR Spectroscopy Module if frames within the image SOP Instance contain different values for the Complex Image Component attribute in the MR Frame Type Functional Group or MR Spectroscopy Frame Type Functional Group.

C.8.12.3.1.6 Acquisition Contrast

Table C.8.12-13 specifies the Defined Terms for Acquisition Contrast attribute (0008,9209).

Table C.8.12-13
ACQUISITION CONTRAST VALUES

Defined Term Name	Defined Term Description
DIFFUSION	Diffusion weighted contrast
FLOW_ENCODED	Flow Encoded contrast
FLUID_ATTENUATED	Fluid Attenuated T2 weighted contrast
PERFUSION	Perfusion weighted contrast
PROTON_DENSITY	Proton Density weighted contrast
STIR	Short Tau Inversion Recovery
TAGGING	Superposition of thin saturation bands onto image
T1	T1 weighted contrast
T2	T2 weighted contrast
T2_STAR	T2* weighted contrast
TOF	Time Of Flight weighted contrast
UNKNOWN	Value should be UNKNOWN if acquisition contrasts were combined resulting in an unknown contrast. Also this value should be used when the contrast is not known.
MIXED	Used only as a value in Acquisition Contrast (0008,9209) attribute in the Enhanced MR Image Type Module or MR Spectroscopy Module if frames within the image SOP Instance contain different values for the Acquisition Contrast attribute in the MR Frame Type Functional Group or MR Spectroscopy Frame Type Functional Group.

C.8.12.4 MR Pulse Sequence Module

The primary purpose of this module is to identify the pulse sequence and variations on that, which was used in creation of the image. Terminology is intended to be neutral, and allow equivalent sequences provided by different vendors to be classified the same.

Table C.8.12-14 specifies the attributes of the MR Pulse Sequence Module.

Table C.8.12-14
MR PULSE SEQUENCE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pulse Sequence Name	(0018,9005)	1C	Name of the pulse sequence for annotation purposes. Potentially vendor-specific name. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Acquisition Type	(0018,0023)	1C	Identification of spatial data encoding scheme. Defined Terms: 1D 2D 3D Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Echo Pulse Sequence	(0018,9008)	1C	Echo category of pulse sequences. Enumerated Values: SPIN GRADIENT BOTH Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Multiple Spin Echo	(0018,9011)	1C	Multiple Spin Echo category of pulse sequence used to collect different lines in k-space for a single frame. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Echo Pulse sequence (0018,9008) equals SPIN or BOTH. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Echo Pulse sequence (0018,9008) equals SPIN or BOTH.

Multi-planar Excitation	(0018,9012)	1C	Technique that simultaneously excites several volumes. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Phase Contrast	(0018,9014)	1C	Phase Contrast Pulse sequence is a pulse sequence in which the flowing spins are velocity encoded in phase. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Time of Flight Contrast	(0018,9015)	1C	Time of Flight contrast is created by the inflow of blood in the saturated plane. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Steady State Pulse Sequence	(0018,9017)	1C	Steady State Sequence. Defined Terms: FREE_PRECESSION TRANSVERSE TIME_REVERSED LONGITUDINAL NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Echo Planar Pulse Sequence	(0018,9018)	1C	Echo Planar category of Pulse Sequences. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Saturation Recovery	(0018,9024)	1C	Saturation recovery pulse sequence. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Spectrally Selected Suppression	(0018,9025)	1C	Spectrally Selected Suppression. Defined Terms: FAT WATER SILICON_GEL NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Oversampling Phase	(0018,9029)	1C	Oversampling Phase. Enumerated Values: 2D = phase direction 3D = out of plane direction 2D_3D = both NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Geometry of k-Space Traversal	(0018,9032)	1C	Geometry category of k-Space traversal. Defined Terms: RECTILINEAR RADIAL SPIRAL Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Rectilinear Phase Encode Reordering	(0018,9034)	1C	Rectilinear phase encode reordering. Defined Terms: LINEAR CENTRIC SEGMENTED REVERSE_LINEAR REVERSE_CENTRIC Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR.

Segmented k-Space Traversal	(0018,9033)	1C	Segmented k-Space traversal. If Geometry of k-Space Traversal is rectilinear, multiple lines can be acquired at one time. If Geometry of k-Space Traversal is spiral or radial, paths can be interleaved and acquired at one time. Enumerated Values: SINGLE = successive single echo coverage PARTIAL = segmented coverage FULL = single shot full coverage Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Coverage of k-Space	(0018,9094)	1C	Coverage of k-Space in the ky-kz plane. Defined Terms: FULL ELLIPTICAL WEIGHTED Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and MR Acquisition Type (0018,0023) equals 3D. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and MR Acquisition Type (0018,0023) equals 3D.
Number of k-Space Trajectories	(0018,9093)	1C	Number of interleaves or shots. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

C.8.12.5 Enhanced MR Image Functional Group Macros

The following sections contain Functional Group macros specific to the Enhanced MR Image IOD.

Note: The attribute descriptions in the Functional Group Macros are written as if they were applicable to a single frame (i.e., the macro is part of the Per-frame Functional Groups Sequence). If an attribute is applicable to all frames (i.e. the macro is part of the Shared Functional Groups Sequence) the phrase "this frame" in the attribute description shall be interpreted to mean " for all frames".".

C.8.12.5.1 MR Image Frame Type Macro

Table C.8.12-15 specifies the attributes of the MR Image Frame Type Functional Group macro.

Table C.8.12-15
MR IMAGE FRAME TYPE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Image Frame Type Sequence	(0018,9226)	1	Identifies the characteristics of this frame. Only a single Item shall be permitted in this sequence.
>Include 'MR Image Description Macro' Table C.8.12-4			The Image Type (0008,0008) attribute shall not be used.

C.8.12.5.2 MR Timing and Related Parameters Macro

Table C.8.12-16 specifies the attributes of the MR Timing and Related Parameters Functional Group macro.

Table C.8.12-16
MR TIMING AND RELATED PARAMETERS MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Timing and Related Parameters Sequence	(0018,9112)	1	Identifies the timing and safety information of this frame. Only a single Item shall be permitted in this sequence.
>Repetition Time	(0018,0080)	1C	The time in ms between two successive excitations of the same volume. Shall be 0 (zero) if there is a single excitation per volume. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Flip Angle	(0018,1314)	1C	Steady state angle in degrees to which the magnetic vector is flipped from the magnetic vector of the primary field. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Echo Train Length	(0018,0091)	1C	Number of lines in k-space acquired per excitation of the same volume. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Specific Absorption Rate Sequence	(0018,9239)	1C	Sequence containing the methods of SAR calculation and the corresponding values. One or more items may be present. Required if the system is capable of calculating Specific Absorption Rate (0018,9181).
>>Specific Absorption Rate Definition	(0018,9179)	1	Specification of the method of SAR calculation as defined in Applicable Safety Standard Description (0018,9174). Defined Terms: IEC_WHOLE_BODY IEC_PARTIAL_BODY IEC_HEAD IEC_LOCAL
>>Specific Absorption Rate Value	(0018,9181)	1	Specific Absorption Rate in W/kg.

>Gradient Output Type	(0018,9180)	1C	Definition of gradient output unit, for which the value is stored in Gradient Output (0018,9182). Defined Terms: DB_DT = in T/s ELECTRIC_FIELD = in V/m PER_NERVE_STIM = percentage of peripheral nerve stimulation Required if the system is capable of calculating Gradient Output (0018,9182).
>Gradient Output	(0018,9182)	1C	Unit is defined by Gradient Output Type (0018,9180). Required if the system is capable of calculating Gradient Output (0018,9182).
>Operating Mode Sequence	(0018,9176)	1C	Sequence of operating mode information relating to the frame/SOP instance as required to adhere to the Applicable Safety Standard Agency (0018,9174) regulations. One or more Items may be included in this sequence. Required if required by law or regulations. May be present otherwise.
>>Operating Mode Type	(0018,9177)	1	Defined Terms: STATIC FIELD RF GRADIENT
>>Operating Mode	(0018,9178)	1	Operating mode applicable for the defined by the applicable standard. Defined Terms: IEC_NORMAL IEC_FIRST_LEVEL IEC_SECOND_LEVEL

C.8.12.5.3 MR FOV/Geometry Macro

Table C.8.12-17 specifies the attributes of the MR FOV/Geometry Functional Group macro.

Table C.8.12-17
MR FOV/GEOMETRY MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR FOV/Geometry Sequence	(0018,9125)	1	Identifies the geometry parameters of this frame. Only a single Item shall be permitted in this sequence.
>In-plane Phase Encoding Direction	(0018,1312)	1C	The axes of the in-plane phase encoding with respect to the frame. Enumerated Values: COLUMN ROW OTHER Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>MR Acquisition Frequency Encoding Steps	(0018,9058)	1	Number of Frequency Encoding steps (kx) acquired Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>MR Acquisition Phase Encoding Steps in-plane	(0018,9231)	1	Number of In-Plane Phase Encoding steps (ky) acquired Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>MR Acquisition Phase Encoding Steps out-of-plane	(0018,9232)	1C	Number of Out-of-Plane Phase Encoding steps (kz) acquired Required if MR Acquisition Type (0018,0023) equals 3D and Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Percent Sampling	(0018,0093)	1C	Fraction of acquisition matrix lines acquired, expressed as a percent. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Percent Phase Field of View	(0018,0094)	1C	Ratio of field of view dimension in phase direction to field of view dimension in frequency direction, expressed as a percent. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

C.8.12.5.4 MR Echo Macro

Table C.8.12-18 specifies the attributes of the MR Echo Functional Group macro.

Table C.8.12-18
MR ECHO MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Echo Sequence	(0018,9114)	1	Identifies echo timing of this frame. Only a single Item shall be permitted in this sequence.
>Effective Echo Time	(0018,9082)	1	The time in ms between the middle of the excitation pulse and the peak of the echo produced for kx=0.

C.8.12.5.5 MR Modifier Macro

Table C.8.12-19 specifies the attributes of the MR Modifier Functional Group macro.

Table C.8.12-19
MR MODIFIER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Modifier Sequence	(0018,9115)	1	Identifies general acquisition parameters of this frame. Only a single Item shall be permitted in this sequence.
>Inversion Recovery	(0018,9009)	1C	Inversion Recovery preparatory sequence. Enumerated Values: YES NO Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Inversion Times	(0018,9079)	1C	Times in ms after the middle of inverting RF pulse to middle of excitation pulse to detect the amount of longitudinal magnetization. Required if Frame Type (0008,9007) Value 1 and Inversion Recovery (0018,9009) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Inversion Recovery (0018,9009) equals YES.
>Flow Compensation	(0018,9010)	1C	Flow Compensation. Defined Terms: ACCELERATION VELOCITY OTHER NONE Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

>Flow Compensation Direction	(0018,9183)	1C	Flow Compensation Direction. Enumerated Values: PHASE FREQUENCY SLICE_SELECT SLICE_AND_FREQ SLICE_FREQ_PHASE PHASE_AND_FREQ SLICE_AND_PHASE OTHER Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Flow Compensation (0018,9010) equals other than NONE. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Flow Compensation (0018,9010) equals other than NONE.
>Spoiling	(0018,9016)	1C	Spoiling. Enumerated Values: RF = RF spoiled GRADIENT = gradient spoiled RF_AND_GRADIENT NONE Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Echo Pulse Sequence (0018,9008) equals GRADIENT or BOTH. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Echo Pulse Sequence (0018,9008) equals GRADIENT or BOTH.
>T2 Preparation	(0018,9021)	1C	T2 prepared Pulse Sequence. Enumerated Values: YES NO Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Spectrally Selected Excitation	(0018,9026)	1C	Spectrally Selected Excitation. Enumerated Values: WATER = water excitation FAT = fat excitation NONE Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Spatial Pre-saturation	(0018,9027)	1C	Spatial Pre-saturation. Defined Terms: SLAB NONE Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

>Partial Fourier	(0018,9081)	1C	Partial Fourier. Enumerated Values: YES NO Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Partial Fourier Direction	(0018,9036)	1C	Direction of Partial Fourier. Enumerated Values: PHASE FREQUENCY SLICE_SELECT COMBINATION Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Partial Fourier (0018,9081) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Partial Fourier (0018,9081) equals YES.
>Parallel Acquisition	(0018,9077)	1C	Parallel acquisition has been used to reduce measurement time. Enumerated Values: YES NO Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Parallel Acquisition Technique	(0018,9078)	1C	Parallel acquisition characteristics. Defined Terms: PILS SENSE SMASH OTHER Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Parallel Acquisition (0018,9077) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Parallel Acquisition (0018,9077) equals YES.
>Parallel Reduction Factor In-plane	(0018,9069)	1C	Measurement time reduction factor expressed as ratio of original and reduced measurement time for the in-plane direction. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Parallel Acquisition (0018,9077) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Parallel Acquisition (0018,9077) equals YES.

>Parallel Reduction Factor out-of-plane	(0018,9155)	1C	Measurement time reduction factor expressed as ratio of original and reduced measurement time for the out-of-plane direction Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Parallel Acquisition (0018,9077) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Parallel Acquisition (0018,9077) equals YES.
>Parallel Reduction Factor Second In-plane	(0018,9168)	1C	Measurement time reduction factor expressed as ratio of original and reduced measurement time for the second in-plane direction. Only required for MR Spectroscopy SOP Instances. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Parallel Acquisition (0018,9077) equals YES. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Parallel Acquisition (0018,9077) equals YES.

C.8.12.5.6 MR Imaging Modifier Macro

Table C.8.12-20 specifies the attributes of the MR Imaging Modifier Functional Group macro.

Table C.8.12-20
MR IMAGING MODIFIER MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Imaging Modifier Sequence	(0018,9006)	1	Identifies sequence containing MR modifier Sequence Attributes. Only one item may be included in this sequence.
>Magnetization Transfer	(0018,9020)	1C	Magnetization Transfer pulse sequence. Enumerated Values: ON_RESONANCE OFF_RESONANCE NONE Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Blood Signal Nulling	(0018,9022)	1C	Blood Signal Nulling (“Black Blood”) preparatory pulse sequence. Enumerated Values: YES NO Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Tagging	(0018,9028)	1C	Tagging. Defined Terms: GRID LINE NONE Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Tag Spacing First Dimension	(0018,9030)	1C	Space between lines in mm. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Tagging (0018,9028) is GRID or LINE. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Tagging (0018,9028) is GRID or LINE.
>Tag Spacing Second Dimension	(0018,9218)	1C	Space between the lines in mm in the other direction. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Tagging (0018,9028) is GRID. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Tagging (0018,9028) is GRID.

>Tag Angle First Axis	(0018,9019)	1C	Angle of the tag lines relative to the rows axis (left to right) of the image, with a range of 0-180 degrees. The angle is increasing in clockwise direction. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Tagging (0018,9028) is GRID or LINE. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Tagging (0018,9028) is GRID or LINE.
>Tag Angle Second Axis	(0018,9219)	1C	Angle of the tag lines relative to the rows axis (left to right) of the image, with a range of 0-180 degrees. The angle is increasing in clockwise direction. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Tagging (0018,9028) is GRID. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Tagging (0018,9028) is GRID.
>Tag Thickness	(0018,9035)	1C	Thickness of the line in mm. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Tagging (0018,9028) is GRID or LINE. Otherwise may be present if Frame Type (0008,9007) Value 1 is DERIVED and Tagging (0018,9028) is GRID or LINE.
>Tagging Delay	(0018,9184)	3	Delay time in ms of the beginning of the application of the tagging pattern relative to the last R-peak.
>Transmitter Frequency	(0018,9098)	1C	Center transmitter frequency in MHz. Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
> Pixel Bandwidth	(0018,0095)	1C	Reciprocal of the effective sampling period, in hertz per pixel. Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.

C.8.12.5.7 MR Receive Coil Macro

Table C.8.12-21 specifies the attributes of the MR Receive Coil Functional Group macro.

Table C.8.12-21
MR RECEIVE COIL MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Receive Coil Sequence	(0018,9042)	1	A sequence that provides information about each receive coil used. Only a single Item shall be permitted in this sequence.
>Receive Coil Name	(0018,1250)	1	Name of receive coil used.
>Receive Coil Manufacturer Name	(0018,9041)	2	Name of manufacturer of receive coil.
>Receive Coil Type	(0018,9043)	1	Type of receive coil used. Defined Terms: BODY VOLUME = head, extremity, etc. SURFACE MULTICOIL
>Quadrature Receive Coil	(0018,9044)	1	Indicates whether the receive coil is quadrature. Enumerated Values: YES = quadrature or circularly polarized NO = linear
>Multi-Coil Definition Sequence	(0018,9045)	1C	A sequence which provides information regarding each element of a multi-coil. It should include attributes for all elements, whether used in the current acquisition or not. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Receive Coil Type (0018,9043) equals MULTICOIL. May be present otherwise.
>>Multi-Coil Element Name	(0018,9047)	1C	Name of element of multi-coil.
>>Multi-Coil Element Used	(0018,9048)	1C	Indicates whether the multi-coil element was used in the current acquisition. Enumerated Values: YES NO
>Multi-Coil Configuration	(0018,9046)	3	A textual description of the configuration of multi-coil elements which was used in the current acquisition.

C.8.12.5.8 MR Transmit Coil Macro

Table C.8.12-22 specifies the attributes of the MR Transmit Coil Functional Group macro.

Table C.8.12-22
MR TRANSMIT COIL MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Transmit Coil Sequence	(0018,9049)	1	A sequence that provides information about the transmit coil used. Only a single Item shall be permitted in this sequence.
>Transmit Coil Name	(0018,1251)	1	Name of transmit coil used.
>Transmit Coil Manufacturer Name	(0018,9050)	2	Name of manufacturer of transmit coil.
>Transmit Coil Type	(0018,9051)	1	Type of transmit coil used. Defined Terms: BODY VOLUME = head, extremity, etc. SURFACE

C.8.12.5.9 MR Diffusion Macro

Table C.8.12-23 specifies the attributes of the MR Diffusion Functional Group macro.

Table C.8.12-23
MR DIFFUSION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Diffusion Sequence	(0018,9117)	2	Identifies the diffusion parameters of this frame. Zero or one Item may be included in this sequence. One item is required if Acquisition Contrast (0008,9209) equals DIFFUSION.
>Diffusion b-value	(0018,9087)	1C	Diffusion sensitization factor in sec/mm^2. This is the actual b-value for original frames and those derived from frames with the same b-value, or the most representative b-value when derived from images with different b-values. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Diffusion Directionality	(0018,9075)	1C	Specifies whether diffusion conditions for the frame are directional, or isotropic with respect to direction. Defined Terms: DIRECTIONAL ISOTROPIC NONE = to be used when Frame Type (0008,9007) value 4 equals DIFFUSION_ANISO or Diffusion b-value (0018,9087) is 0 (zero). Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Diffusion Gradient Direction Sequence	(0018,9076)	1C	Sequence containing orientations of all diffusion sensitization gradients that were applied during the preparation phase for this frame. Required if Diffusion Directionality (0018,9075) equals DIRECTIONAL
>>Diffusion Gradient Orientation	(0018,9089)	1C	The direction cosines of the diffusion gradient vector with respect to the patient Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

>Diffusion Anisotropy Type	(0018,9147)	1C	Class of diffusion anisotropy calculation. Defined Terms: FRACTIONAL RELATIVE VOLUME_RATIO Required if Frame Type (0008,9007) value 4 equals DIFFUSION_ANISO.

C.8.12.5.10 MR Averages Macro

Table C.8.12-24 specifies the attributes of the MR Averages Functional Group macro.

Table C.8.12-24
MR AVERAGES MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Averages Sequence	(0018,9119)	1	Identifies the averaging parameters of this frame. Only a single Item shall be permitted in this sequence.
>Number of Averages	(0018,0083)	1	Maximum number of times any point in k-space is acquired.

C.8.12.5.11 MR Spatial Saturation Macro

Table C.8.12-25 specifies the attributes of the MR Spatial Saturation Functional Group macro.

Table C.8.12-25
MR SPATIAL SATURATION MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Spatial Saturation Sequence	(0018,9107)	2	A sequence that provides the position of spatial saturation bands deposited as part of the pulse sequence. Zero or one Item may be included in this sequence.
>Slab Thickness	(0018,9104)	1	Thickness of slab in mm.
>Slab Orientation	(0018,9105)	1	The direction cosines of a normal vector perpendicular to the saturation plane with respect to the patient. See C.7.6.2.1.1 for further explanation.
>Mid Slab Position	(0018,9106)	1	The x, y, and z coordinates of the midpoint of the slab plane in mm with respect to the patient. See C.7.6.2.1.1 for further explanation.

C.8.12.5.12 MR Metabolite Map Macro

Table C.8.12-26 specifies the attributes of the MR Metabolite Map Functional Group macro.

TABLE C.8.12-26
MR METABOLITE MAP MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Metabolite Map Sequence	(0018,9152)	1	Identifies chemical shift parameters of this frame. Only a single Item shall be permitted in this sequence.
>Metabolite Map Description	(0018,9080)	1	Text describing the Metabolite Map.
>Chemical Shift Sequence	(0018,9084)	3	The list of frequencies that were used to create the Metabolite Map. One or more Items may be included in this sequence.
>>Chemical Shift Minimum Integration Limit	(0018,9195)	1	Minimal value of Chemical Shift Frequency in Hz.
>>Chemical Shift Maximum Integration Limit	(0018,9196)	1	Maximum value of Chemical Shift Frequency in Hz.

C.8.12.5.13 MR Velocity Encoding Macro

Table C.8.12-27 specifies the attributes of the MR Velocity Encoding Functional Group macro.

Table C.8.12-27
MR VELOCITY ENCODING MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Velocity Encoding Sequence	(0018,9197)	1	Identifies the velocity encoding of this frame. Only a single Item shall be permitted in this sequence.
>Velocity Encoding Direction	(0018,9090)	1	The direction cosines of the velocity encoding vector with respect to the patient. See C.7.6.2.1.1 for further explanation.
>Velocity Encoding Minimum Value	(0018,9091)	1	Minimum velocity in cm/s.
>Velocity Encoding Maximum Value	(0018,9217)	1	Maximum velocity in cm/s.

C.8.13 MR Spectroscopy Modules

This section describes the MR Spectroscopy Modules.

Note: Many attributes have names and descriptions that include the terms “pixel” and “image”. Although MR spectroscopy is not pixel based, some of these “pixel” and “image” attributes encode concepts that are still relevant for this technique. Where such attributes appear in the MR Spectroscopy IOD, it may be helpful to consider the term “pixel” to be equivalent to a spectroscopy “voxel”, and the term “image” to be equivalent to “MR Spectroscopy SOP Instance”.

C.8.13.1 MR Spectroscopy Module

Table C.8.13-1 specifies the attributes of the MR Spectroscopy Module.

Table C.8.13-1
MR SPECTROSCOPY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include ' MR Image and MR Spectroscopy Instance Macro' Table C.8.X-2			
Include 'MR Image Description Macro' Table C.8.12-4			The Frame Type (0008,9007) attribute and Pixel Presentation (0008,9205) shall not be used.
Transmitter Frequency	(0018,9098)	1C	Precession frequency in MHz of the nucleus being addressed for each spectral axis. See section C.8.13.1.1 for further explanation of the ordering. Required if Image Type (0008,0008) Value 1 is ORIGINAL. May be present otherwise.
Spectral Width	(0018,9052)	1C	Spectral width in Hz. See section C.8.13.1.1 for further explanation of the ordering. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Chemical Shift Reference	(0018,9053)	1C	The chemical shift at the transmitter frequency in ppm. See section C.8.13.1.1 for further explanation of the ordering. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Volume Localization Technique	(0018,9054)	1C	Name of volume localization technique used. Shall be “NONE” if no spatial localization was performed. Defined Terms: ILOPS ISIS PRIME PRESS SLIM SLOOP STEAM NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Volume Localization Sequence	(0018,9126)	1C	A sequence of one or more Items that provide the position of RF excitations used to select a volume of tissue. The selected volume is described by the intersection of the sequence Items. Required if Volume Localization Technique (0018,9054) is other than NONE, otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED on the same condition.
>Slab Thickness	(0018,9104)	1	Thickness of slab in mm.
>Slab Orientation	(0018,9105)	1	The direction cosines of a normal vector perpendicular to the selection plane with respect to the patient. See C.7.6.2.1.1 for further explanation.
>Mid Slab Position	(0018,9106)	1	The x, y, and z coordinates of the mid-point of the slab in mm. See C.7.6.2.1.1 for further explanation.
De-coupling	(0018,9059)	1	Indicates whether de-coupling was active. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
De-coupled Nucleus	(0018,9060)	1C	Nucleus being de-coupled. Defined Terms: 1H 3HE 7LI 13C 19F 23NA 31P 129XE See section C.8.13.1.1 for further explanation of the ordering. Required if De-coupling (0018,9059) equals YES.

De-coupling Frequency	(0018,9061)	1C	The center frequency (Hz) for the de-coupling. See section C.8.13.1.1 for further explanation of the ordering. Required if De-coupling (0018,9059) equals YES.
De-coupling Method	(0018,9062)	1C	The de-coupling modulation scheme used. Defined Terms: MLEV WALTZ NARROWBAND Required if De-coupling (0018,9059) equals YES.
De-coupling Chemical Shift Reference	(0018,9063)	1C	The chemical shift in ppm at the de-coupling frequency. See section C.8.13.1.1 for further explanation of the ordering. Required if De-coupling (0018,9059) equals YES.
k-space Filtering	(0018,9064)	1C	Describes k-space filtering applied. Shall be NONE if no k-space filter. Defined Terms: COSINE COSINE_SQUARED FERMI GAUSSIAN HAMMING HANNING LORENTZIAN LRNTZ_GSS_TRNSFM RIESZ TUKEY NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Time Domain Filtering	(0018,9065)	1C	Describes time domain filtering or apodization applied. Shall be NONE if no filtering operations were applied to the time domain data. Defined Terms: COSINE COSINE_SQUARED EXPONENTIAL GAUSSIAN HAMMING HANNING LORENTZIAN LRNTZ_GSS_TRNSFM NONE See section C.8.13.1.1 for further explanation of the ordering. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Number of Zero Fills	(0018,9066)	1C	Number of zero fills added to the time domain data before FT. Shall be 0 (zero) if no zero filling performed. See section C.8.13.1.1 for further explanation of the ordering. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Baseline Correction	(0018,9067)	1C	Describes baseline correction techniques. Shall be NONE if no baseline correction was performed. Defined Terms: LINEAR_TILT LOCAL_LINEAR_FIT POLYNOMIAL_FIT SINC_DECONVOLUTN TIME_DOMAIN_FIT SPLINE NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Frequency Correction	(0018,9101)	1C	Specifies whether operations were performed to correct resonant frequency of metabolite peaks due to B0 field inhomogeneities. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

First Order Phase Correction	(0018,9198)	1C	Describes whether a first order (frequency dependent) phase correction was applied to the spectral data. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Water Referenced Phase Correction	(0018,9199)	1C	Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

C.8.13.1.1 MR Spectroscopy Attribute Multiplicity Ordering

The following attributes may have a Value Multiplicity of one or two depending whether one or two frequency axes are used as specified by the value of Data Point Columns (0028,9002):

Transmitter Frequency (0018,9098)
Resonant Nucleus (0018,9100)
Spectral Width (0018,9052)
Chemical Shift Reference (0018,9053)
De-coupled Nucleus (0018,9060)
De-coupling Frequency (0018,9061)
De-coupling Chemical Shift Reference (0018,9063)
Time Domain Filtering (0018,9065)
Number of Zero Fills (0018,9066)

Value 1 shall contain the value corresponding to the sampling time axis (the axis along a data point row).

Value 2, if present, shall contain the value corresponding to the evolution time axis (the axis along a data point column).

C.8.13.2 MR Spectroscopy Pulse Sequence Module

The primary purpose of this module is to identify the pulse sequence and variations which were used in creation of the spectroscopic data. Terminology is intended to be neutral, and allow equivalent sequences provided by different vendors to be classified together.

Table C.8.13-2 specifies the attributes of the MR Spectroscopy Pulse Sequence Module.

Table C.8.13-2
MR SPECTROSCOPY PULSE SEQUENCE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pulse Sequence Name	(0018,9005)	1C	Name of the pulse sequence for annotation purposes. Potentially vendor-specific name. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
MR Spectroscopy Acquisition Type	(0018,9200)	1C	Identification of data encoding scheme. Defined Terms: SINGLE_VOXEL ROW PLANE VOLUME Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Echo Pulse Sequence	(0018,9008)	1C	Echo category of pulse sequences. Enumerated Values: SPIN GRADIENT BOTH Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Multiple Spin Echo	(0018,9011)	1C	Multiple Spin Echo category of pulse sequence used to collect different lines in k-space for a single frame. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Echo Pulse Sequence (0018,9008) equals SPIN or BOTH. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Echo Pulse Sequence (0018,9008) equals SPIN or BOTH.

Multi-planar Excitation	(0018,9012)	1C	Technique that simultaneously excites several volumes. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Steady State Pulse Sequence	(0018,9017)	1C	Steady State Sequence. Defined Terms: FREE_PRECESSION TRANSVERSE TIME_REVERSED LONGITUDINAL NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Echo Planar Pulse Sequence	(0018,9018)	1C	Echo Planar category of pulse-sequences. Enumerated Values: YES NO Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Spectrally Selected Suppression	(0018,9025)	1C	Spectrally Selected Suppression. Defined Terms: WATER FAT FAT_AND_WATER SILICON_GEL NONE Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Geometry of k-Space Traversal	(0018,9032)	1C	Geometry category of k-Space traversal. Defined Terms: RECTILINEAR RADIAL SPIRAL Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

Rectilinear Phase Encode Reordering	(0018,9034)	1C	Rectilinear phase encode reordering. Defined Terms: LINEAR CENTRIC SEGMENTED REVERSE_LINEAR REVERSE_CENTRIC Required if Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and Geometry of k-Space Traversal (0018,9032) equals RECTILINEAR.
Segmented k-Space Traversal	(0018,9033)	1C	Segmented k-Space traversal. If Geometry of k-Space Traversal is rectilinear, multiple lines can be acquired at one time. If Geometry of k-Space Traversal is spiral or radial, paths can be interleaved and acquired at one time. Enumerated Values: SINGLE = successive single echo coverage PARTIAL = segmented coverage FULL = single shot full coverage Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
Coverage of k-Space	(0018,9094)	1C	Coverage of k-Space. Defined Terms: FULL CYLINDRICAL ELLIPSOIDAL WEIGHTED Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED and MR Acquisition Type (0018,0023) equals 3D. Otherwise may be present if Image Type (0008,0008) Value 1 is DERIVED and MR Acquisition Type (0018,0023) equals 3D.
Number of k-Space Trajectories	(0018,9093)	1C	Number of interleaves or shots. Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.

C.8.13.3 MR Spectroscopy Functional Group Macros

The following sections contain Functional Group Macro's specific to the MR Spectroscopy IOD.

Note: The attribute descriptions in the Functional Group Macros are written as if they were applicable to a single frame (i.e., the macro is part of the Per-frame Functional Groups Sequence). If an attribute is applicable to all frames (i.e. the macro is part of the Shared Functional Groups Sequence) the phrase "this frame" in the attribute description shall be interpreted to mean " for all frames".".

C.8.13.3.1 MR Spectroscopy Frame Type Macro

Table C.8.13-3 specifies the attributes of the MR Spectroscopy Frame Type Functional Group macro.

This Functional Group Macro may only be part of the Per-frame Functional Groups Sequence (0008,9124) attribute.

Table C.8.13-3
MR SPECTROSCOPY FRAME TYPE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Spectroscopy Frame Type Sequence	(0018,9227)	1	Identifies sequence containing Frame Type Attributes. Only a single Item shall be permitted in this sequence.
>Include 'MR Image Description Macro' Table C.8.12-4			The Image Type (0008,0008) attribute and Pixel Presentation (0008,9205) attribute shall not be used.

C.8.13.3.2 MR Spectroscopy FOV/Geometry Macro

Table C.8.13-4 specifies the attributes of the MR Spectroscopy FOV/Geometry Functional Group Macro.

Table C.8.13-4
MR SPECTROSCOPY FOV/GEOMETRY MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
MR Spectroscopy FOV/Geometry Sequence	(0018,9103)	1	Identifies the geometry parameters of this frame. Only a single Item shall be permitted in this sequence.
>Spectroscopy Acquisition Data Columns	(0018,9127)	1C	Number of data points in the columns direction Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Spectroscopy Acquisition Phase Rows	(0018,9095)	1C	Number of Phase Encoding Rows Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
> Spectroscopy Acquisition Phase Columns	(0018,9234)	1C	Number of Phase Encoding Columns Required if Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Spectroscopy Acquisition Out-of-plane Phase Steps	(0018,9159)	1C	Number of out-of-plane Phase Encoding steps Required if MR Spectroscopy Acquisition Type (0018,9200) equals PLANE and Frame Type (0008,9007) Value 1 is ORIGINAL. May be present otherwise.
>Percent Sampling	(0018,0093)	1C	Fraction of acquisition matrix lines acquired, expressed as a percent. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
>Percent Phase Field of View	(0018,0094)	1C	Ratio of field of view dimension in phase direction to field of view dimension in frequency direction, expressed as a percent. Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.

C.8.13.4 MR Spectroscopy Data Module

Table C.8.13-5 specifies the attributes that describe the Spectroscopy Data.

Table C. 8.13-5
MR SPECTROSCOPY DATA MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Rows	(0028,0010)	1	Number of voxels in the vertical direction in the frame.
Columns	(0028,0011)	1	Number of voxels in the horizontal direction in the frame.
Data Point Rows	(0028,9001)	1	Number of rows of data points in spectroscopic data.
Data Point Columns	(0028,9002)	1	Number of columns of data points in spectroscopic data.
Data Representation	(0028,9108)	1	Data representation of the data points. Each data point shall have the same representation. Enumerated Values: COMPLEX = Data is complex pair REAL = Data contains only real component IMAGINARY = Data contains only imaginary component MAGNITUDE = Magnitude data
Signal Domain Columns	(0028,9003)	1	Domain of represented signal in column direction. Enumerated Values: FREQUENCY TIME
Signal Domain Rows	(0028,9235)	1C	Domain of represented signal in row direction. Enumerated Values: FREQUENCY TIME Required if Data Point Rows (0028,9001) has a value of more than 1.
First Order Phase Correction Angle	(5600,0010)	1C	First Order Phase Correction Angle. Number of values is determined by Row ∗ Column ∗ Number of Frames. Required if First Order Phase Correction (0018,9198) equals YES
Spectroscopy Data	(5600,0020)	1	A data stream of the signal intensities that comprise the spectroscopic data. See C.8.13.4.1 for further explanation.

C.8.13.4.1 Spectroscopy Data

The Spectroscopy Data attribute (5600,0020) contains the Signal intensities for the spectra. The order of voxels sent for each spectral plane is left to right, top to bottom, i.e., the upper left voxel (labeled 1,1)

is sent first followed by the remainder of row 1, followed by the first voxel of row 2 (labeled 2,1) then the remainder of row 2 and so on. Each "voxel" represents an entire spectrum. The complete spectral data from each voxel is sent, followed by the spectral data from the next voxel position.

The number of voxels on each frame are described by Rows (0028,0010) and Columns (0028,0011). The number of frames is described by Number of Frames (0028,0008). The frames may represent different locations in a 3D acquisition, or the same position at a different point of time, or a difference of some other combination of attributes.

The spectral data points are ordered from lower effective magnetic field strength (down-field) to higher effective magnetic field strength (up-field) when the Signal Domain Columns (0028,9003) or Signal Domain Rows (0028,9235) attributes contain the value FREQUENCY and from first sample acquired to last sample acquired when the Signal Domain Columns (0028,9003) or Signal Domain Rows (0028,9235) attributes contain the value TIME.

For two-dimensional spectral acquisitions, the ordering is such that all data points from a row (corresponding to all data points acquired in an individual sampling period), are followed by all data points from the successive sampling period. Following all data of the rows from a given voxel position, the data from the subsequent voxel position are sent. The axis parallel to the row direction corresponds to the sampling time axis. The axis parallel to the column direction corresponds to the evolution time axis.

The dimensions of each spectrum that make up a voxel are described by Data Point Rows (0028,9001) and Data Point Columns (0028,9002). In the case of 1D spectra, the number of Data Point Rows shall be 1.

For a Data Representation (0028,9108) value of COMPLEX, the order of data points is real channel followed by imaginary channel for each spectral data point. For the other Data Representation values (REAL, IMAGINARY and MAGNITUDE), each spectral data point contains only a single value.

The Figure C.8.13-1 depicts 6 frames each made up of 4 rows and 4 columns of voxels. Specific values for Data Point Rows (0028,9001) and Data Point Columns (0028,9002) of these voxels are not depicted.

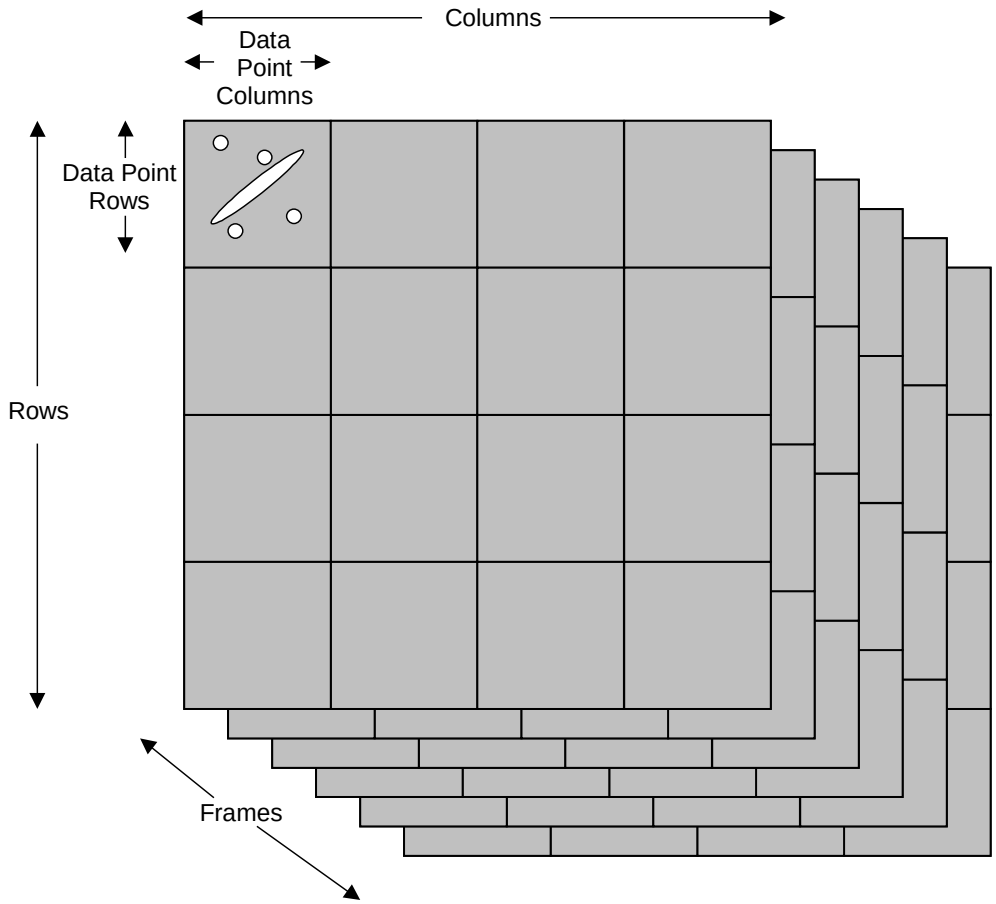


Figure C.8.13-1
Dimensions of spectroscopy data.

Item #14: Add the following sections to Annex C

C.19 RAW DATA SPECIFIC MODULES

The following Modules are used by the Raw Data IOD.

C.19.1 Raw Data Module

Table C.19-1 specifies the attributes that describe a raw data stream.

Table C.19-1
RAW DATA MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Instance Number	(0020,0013)	2	A number that identifies this image. The value shall be unique within a series.
Content Date	(0008,0023)	1	The date the raw data creation was started.
Content Time	(0008,0033)	1	The time the raw data creation was started.
Acquisition Datetime	(0008,002A)	3	The date and time that the acquisition of data started. Note: The synchronization of this time with an external clock is specified in the synchronization Module in Acquisition Time synchronized (0018,1800).
Creator-Version UID	(0008,9123)	1	Unique identification of the equipment and version of the software that has created the Raw Data information. The UID allows one to avoid attempting to interpret raw data with an unknown format.
Referenced Instance Sequence	(0008,114A)	3	A sequence that provides reference to a set of SOP Class/Instance pairs identifying other Instances significantly related to this Instance. One or more Items may be included in this Sequence.
>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.
>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.
>Referenced Frame Number	(0008,1160)	1C	References one or more image frames of a Multi-frame Image SOP Instance, identifying which frames are significantly related to this Instance. Required if reference is provided to a Multi-frame SOP Instance and not all frames are referenced.

>Purpose of Reference Code Sequence	(0040,A170)	1	Describes the purpose for which the reference is made. See C.7.6.16.2.5.1.
>>Include 'Code Sequence Macro' Table 8.8-1			No Baseline Context ID is defined.
Include any private attributes that contain Raw Data information. See section C.19.1.1 for further explanation.			

C.19.1.1 Raw Data

The Raw Data stored with the Raw Data Module consists of one or more private attributes that are vendor specific. No rules are specified about the content and format of the raw data.

Item #15: Add new annex

Annex M Explanation of Grouping Criteria for Multi-frame Functional Group IODs (Informative)

When considering how to group an attribute, one needs to consider first of all whether or not the values of an attribute are different per frame. The reasons to consider whether to allow an attribute to change include:

1. The more attributes that change, the more parsing a receiving application has to do in order to determine if the multi-frame object has frames the application should deal with. The more choices, the more complex the application becomes, potentially resulting in interoperability problems.

2. The frequency of change of an attribute must also be considered. If an attribute could be changed every frame then obviously it is not a very good candidate for making it fixed, since this would result in a multi-frame size of 1.

3. The number of applications that depend on frame level attribute grouping is another consideration. For example, one **might** imagine a pulse sequence being changed in a real–time acquisition, but the vast majority of acquisitions would leave this constant. Therefore, it was judged not too large a burden to force an acquisition device to start a new object when this happens. Obviously, this is a somewhat subjective decision, and one should take a close look at the attributes that are required to be fixed in this document.

4. The attributes from the image pixel module must not change in a multi-frame object due to legacy toolkits and implementations.

5. The potential frequency of change is dependent on the applications both now and likely during the life of this standard. The penalty for failure to allow an attribute to change is rather high since it will be hard/impossible to change later. Making an attribute variable that is static is more complex and could result in more header space usage depending on how it is grouped. Thus there is a trade-off of complexity and potentially header size with not being able to take advantage of the multi-frame organization for an application that requires changes per frame.

Once it is decided which attributes should be changed within a multi-frame object then one needs to consider the criteria for grouping attributes together:

1. Groupings should be designed so those attributes that are likely to vary together should be in the same sequence. The goal is to avoid the case where attributes that are mostly static have to be included in a sequence that is repeated for every frame.

2. Care should be taken so that we define a manageable number of grouping sequences. Too few sequences could result in many static attributes being repeated for each frame, when some other element in their sequence was varying, and too many sequences becomes unwieldy.

3. The groupings should be designed such that modality independent attributes are kept separate from those that are MR specific. This will presumably allow future working groups to reuse the more general groupings. It also should allow software that operates on multi-frame objects from multiple objects maximize code reuse.

4. Grouping related attributes together could convey some semantics of the overall contents of the multi-frame object to receiving applications. For instance, if a volumetric application finds the Plane Orientation Macro present in the Per-frame Functional Groups Sequence , it may decide to reject the object as inappropriate for volumetric calculations.

Specific notes on attribute grouping:

- Attributes not allowed to change: Image Pixel Module (due to legacy toolkit concerns); and Pulse Sequence Module attributes (normally do not change except in real-time – it is expected real time applications can handle the complexity and speed of starting new IODs when pulse sequence changes).
- Sequences not starting with the word “MR” could be applied to more modalities than just MR.
- All attributes that must be in a frame header were placed in the Frame Content Macro.
- Position and orientation are in separate sequences since they are changed independently.
- For real-time sequences there are contrast mechanisms that can be applied to base pulse sequences and are turned on and off by the operator depending on the anatomy being imaged and the time/contrast trade-off associated with these. Such modifiers include: IR, flow compensation, spoiled, MT, and T2 preparation… These probably are not changed in non-real-time scans. These are all kept in the MR Modifier Macro.

“Number of Averages” attributes is in its own sequence because real-time applications may start a new averaging process every time a slice position/orientation changes. Each subsequent frame will average with the preceding N frames where N is chosen based on motion and time. Each frame collected at a particular position/orientation will have a different number of averages, but all other attributes are likely to remain the same. This particular application drives this attribute being in its own group.

Changes to NEMA Standards Publication PS 3.4-2001

Digital Imaging and Communications in Medicine (DICOM)

Part 4: Service Class Specifications

Item #16: Add definition of Functional Group

3.6 DICOM INFORMATION OBJECT DEFINITIONS

This Part of the Standard makes use of the following terms defined in PS 3.3:

a. Attribute Tag
b. Composite IOD
c. DICOM Application Model
d. DICOM Information Model
e. Information Object Definition
f. Module
g. Normalized IOD
h. Functional Group

Item #17: Add Conformance Statement Requirements to Section B.4.3.1

B.4.3.1 Conformance Statement for An SCU

The following issues shall be documented in the Conformance Statement of any implementation claiming conformance to the Storage SOP Class as an SCU:

— The behavior of the SCU in the case of a successful C-STORE response status shall be described.
— The behavior of the SCU in each case of an unsuccessful C-STORE response status shall be described.
— The behavior of the SCU in the case of a Warning status received in response to a C-STORE operation.
— Whether extended negotiation is supported.
— The optional elements which may be included in Storage SOP Instances for each IOD supported shall be listed.
— The standard and privately defined Functional Groups which may be included in Storage SOP Instances for each Multi-frame IOD that support Functional Groups.

Item #18: Add to Table B.5-1

B.5 STANDARD SOP CLASSES

Table B.5-1
Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification (defined in PS 3.3)
Enhanced MR Image Storage	1.2.840.10008.5.1.4.1.1.4.1	Enhanced MR Image
MR Spectroscopy Storage	1.2.840.10008.5.1.4.1.1.4.2	MR Spectroscopy

Raw Data Storage	1.2.840.10008.5.1.4.1.1.66	Raw Data

Item #19: Add section to B.5.1

B.5.1.6 Enhanced MR Image Storage SOP Class

An SCP of the Enhanced MR Image Storage SOP Class shall also support the Grayscale Softcopy Presentation State Storage SOP Class.

Note: This requirement is present in order to allow the exchange of graphical annotations created by an acquisition device.

I.4 MEDIA STORAGE SOP CLASS

Item #20: Add to Table I.4-1

Table I.4-1
Media Storage Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification
Enhanced MR Image Storage	1.2.840.10008.5.1.4.1.1.4.1	defined in PS 3.3
MR Spectroscopy Storage	1.2.840.10008.5.1.4.1.1.4.2	defined in PS 3.3
Raw Data Storage	1.2.840.10008.5.1.4.1.1.66	defined in PS 3.3

Changes to NEMA Standards Publication PS 3.5-2001

Digital Imaging and Communications in Medicine (DICOM)

Part 5: Data Structures and Encoding

Item #21: Add to Table 6.2-1

Table 6.2-1
DICOM VALUE REPRESENTATIONS

VR Name	Definition	Character Repertoire	Length of Value
…	…	…	…
OF Other Float String	**A string of 32-bit IEEE 754:1985 floating point words. OF is a VR which requires byte swapping within each 32-bit word when changing between Little Endian and Big Endian byte ordering (see Section 7.3).**	**not applicable**	**2^{32}-4 maximum**
…	…	…	…

Item #22: Modify section 6.4

VALUE MULTIPLICITY (VM) AND DELIMITATION

…

Data Elements with a VR of SQ, **OF,** OW, OB or UN shall always have a Value Multiplicity of one.

Item #23: Modify section 7.1.2

7.1.2 Data Element Structure With Explicit VR

When using the Explicit VR structures, the Data Element shall be constructed of four consecutive fields: Data Element Tag, VR, Value Length, and Value. Depending on the VR of the Data Element, the Data Element will be structured in one of two ways:

- for VRs of OB, OW, **OF,** SQ and UN the 16 bits following the two character VR Field are reserved for use by later versions of the DICOM Standard. These reserved bytes shall be set to 0000H and shall not be used or decoded (Table 7.1-1). The Value Length Field is a 32-bit unsigned integer. If the Value Field has an Explicit Length, then the Value Length Field shall contain a value equal to the length (in bytes) of the Value Field. Otherwise, the Value Field has an Undefined Length and a Sequence Delimitation Item marks the end of the Value Field.

- for VRs of UT the 16 bits following the two character VR Field are reserved for use by later versions of the DICOM Standard. These reserved bytes shall be set to 0000H and shall not be used or decoded. The Value Length Field is a 32-bit unsigned integer. The Value Field is required to have an Explicit Length, that is the Value Length Field shall contain a value equal to the length (in bytes) of the Value Field.

  Note: VRs of UT may not have an Undefined Length, i.e. A Value Length of FFFFFFFFH.

- for all other VRs the Value Length Field is the 16-bit unsigned integer following the two character VR Field (Table 7.1-2). The value of the Value Length Field shall equal the length of the Value Field.

Table 7.1-1
DATA ELEMENT WITH EXPLICIT VR OF OB, OW, OF, SQ, UT OR UN

Tag		VR		Value Length	Value
Group Number (16-bit unsigned integer)	Element Number (16-bit unsigned integer)	VR (2 byte character string) of "OB", "OW", **"OF",** "SQ", **"UT"** or "UN"	Reserved (2 bytes) set to a value of 0000H	32-bit unsigned integer	Even number of bytes containing the Data Element Value(s) encoded according to the VR and negotiated Transfer Syntax. Delimited with Sequence Delimitation Item if of Undefined Length.
2 bytes	2 bytes	2 bytes	2 bytes	4 bytes	'Value Length' bytes if of Explicit Length

Table 7.1-2
DATA ELEMENT WITH EXPLICIT VR OTHER THAN OB, OW, OF, SQ, UT OR UN

Tag		VR	Value Length	Value
Group Number (16-bit unsigned integer)	Element Number (16-bit unsigned integer)	VR (2 byte character string)	(16-bit unsigned integer)	Even number of bytes containing the Data Element Value(s) encoded according to the VR and negotiated Transfer Syntax.
2 bytes	2 bytes	2 bytes	2 bytes	'Value Length' bytes

Item #24: Modify section 7.3

BIG ENDIAN VERSUS LITTLE ENDIAN BYTE ORDERING

…

In the default case of Little Endian encoding, Big Endian Machines interpreting Data Sets shall do 'byte swapping' before interpreting or operating on certain Data Elements. The Data Elements affected are all those having VRs that are multiple byte Values and that are not a character string of 8-bit single byte codes. VRs constructed of a string of characters of 8-bit single byte codes are really constructed of a string of individual bytes, and are therefore not affected by byte ordering. The VRs that are not a string of characters and consist of multiple bytes are:

— 2-byte US, SS, OW and each component of AT

— 4-byte **OF,** UL, SL, and FL

— 8 byte FD

of ensuring its uniqueness.

Changes to NEMA Standards Publication PS 3.6-2001

Digital Imaging and Communications in Medicine (DICOM)

Part 6: Data Dictionary

Item #25: Replace the following rows in Section 6

Tag	Name	VR	VM
(0018,1250)	~~Receiving~~**Receive** Coil **Name**	SH	1
(0018,1251)	~~Transmitting~~**Transmit** Coil **Name**	SH	1

Item #26: Add the following rows to Section 6

Tag	Name	VR	VM
(0008,9007)	Frame Type	CS	4
(0008,9121)	Referenced Raw Data Sequence	SQ	1
(0008,9123)	Creator-Version UID	UI	1
(0008,9124)	Derivation Image Sequence	SQ	1
(0008,9092)	Referring Image Evidence Sequence	SQ	1
(0008,9154)	Source Image Evidence Sequence	SQ	1
(0008,9205)	Pixel Presentation	CS	1
(0008,9206)	Volumetric Properties	CS	1
(0008,9207)	Volume Based Calculation Technique	CS	1
(0008,9208)	Complex Image Component	CS	1
(0008,9209)	Acquisition Contrast	CS	1
(0008,9215)	Derivation Code Sequence	SQ	1
(0008,9237)	Referenced Grayscale Presentation State Sequence	SQ	1

Tag	Name	VR	VM
(0018,9004)	Content Qualification	CS	1
(0018,9005)	Pulse Sequence Name	SH	1
(0018,9006)	MR Imaging Modifier Sequence	SQ	1
(0018,9008)	Echo Pulse Sequence	CS	1
(0018,9009)	Inversion Recovery	CS	1
(0018,9010)	Flow Compensation	CS	1
(0018,9011)	Multiple Spin Echo	CS	1
(0018,9012)	Multi-planar Excitation	CS	1
(0018,9014)	Phase Contrast	CS	1
(0018,9015)	Time of Flight Contrast	CS	1
(0018,9016)	Spoiling	CS	1
(0018,9017)	Steady State Pulse Sequence	CS	1
(0018,9018)	Echo Planar Pulse Sequence	CS	1
(0018,9019)	Tag Angle First Axis	FD	1

Tag	Name	VR	VM
(0018,9020)	Magnetization Transfer	CS	1
(0018,9021)	T2 Preparation	CS	1
(0018,9022)	Blood Signal Nulling	CS	1
(0018,9024)	Saturation Recovery	CS	1
(0018,9025)	Spectrally Selected Suppression	CS	1
(0018,9026)	Spectrally Selected Excitation	CS	1
(0018,9027)	Spatial Pre-saturation	CS	1
(0018,9028)	Tagging	CS	1
(0018,9029)	Oversampling Phase	CS	1
(0018,9030)	Tag Spacing First Dimension	FD	1
(0018,9032)	Geometry of k-Space Traversal	CS	1
(0018,9033)	Segmented k-Space Traversal	CS	1
(0018,9034)	Rectilinear Phase Encode Reordering	CS	1
(0018,9035)	Tag Thickness	FD	1
(0018,9036)	Partial Fourier Direction	CS	1
(0018,9037)	Gating Synchronization Technique	CS	1
(0018,9041)	Receive Coil Manufacturer Name	LO	1
(0018,9042)	MR Receive Coil Sequence	SQ	1
(0018,9043)	Receive Coil Type	CS	1
(0018,9044)	Quadrature Receive Coil	CS	1
(0018,9045)	Multi-Coil Definition Sequence	SQ	1
(0018,9046)	Multi-Coil Configuration	LO	1
(0018,9047)	Multi-Coil Element Name	SH	1
(0018,9048)	Multi-Coil Element Used	CS	1
(0018,9049)	MR Transmit Coil Sequence	SQ	1
(0018,9050)	Transmit Coil Manufacturer Name	LO	1
(0018,9051)	Transmit Coil Type	CS	1
(0018,9052)	Spectral Width	FD	1-2
(0018,9053)	Chemical Shift Reference	FD	1-2
(0018,9054)	Volume Localization Technique	CS	1
(0018,9058)	MR Acquisition Frequency Encoding Steps	US	1
(0018,9059)	De-coupling	CS	1
(0018,9060)	De-coupled Nucleus	CS	1-2
(0018,9061)	De-coupling Frequency	FD	1-2
(0018,9062)	De-coupling Method	CS	1
(0018,9063)	De-coupling Chemical Shift Reference	FD	1-2
(0018,9064)	k-space Filtering	CS	1
(0018,9065)	Time Domain Filtering	CS	1-2
(0018,9066)	Number of Zero fills	US	1-2
(0018,9067)	Baseline Correction	CS	1
(0018,9070)	Cardiac R-R Interval Specified	FD	1

Tag	Name	VR	VM
(0018,9073)	Acquisition Duration	FD	1
(0018,9074)	Frame Acquisition Datetime	DT	1
(0018,9075)	Diffusion Directionality	CS	1
(0018,9076)	Diffusion Gradient Direction Sequence	SQ	1
(0018,9077)	Parallel Acquisition	CS	1
(0018,9078)	Parallel Acquisition Technique	CS	1
(0018,9079)	Inversion Times	FD	1-n
(0018,9080)	Metabolite Map Description	ST	1
(0018,9081)	Partial Fourier	CS	1
(0018,9082)	Effective Echo Time	FD	1
(0018,9084)	Chemical Shift Sequence	SQ	1
(0018,9085)	Cardiac Signal Source	CS	1
(0018,9087)	Diffusion b-value	FD	1
(0018,9089)	Diffusion Gradient Orientation	FD	3
(0018,9090)	Velocity Encoding Direction	FD	3
(0018,9091)	Velocity Encoding Minimum Value	FD	1
(0018,9093)	Number of k-Space Trajectories	US	1
(0018,9094)	Coverage of k-Space	CS	1
(0018,9095)	Spectroscopy Acquisition Phase Rows	UL	1
(0018,9096)	Parallel Reduction Factor In-plane	FD	1
(0018,9098)	Transmitter Frequency	FD	1-2
(0018,9100)	Resonant Nucleus	CS	1-2
(0018,9101)	Frequency Correction	CS	1
(0018,9103)	MR Spectroscopy FOV/Geometry Sequence	SQ	1
(0018,9104)	Slab Thickness	FD	1
(0018,9105)	Slab Orientation	FD	3
(0018,9106)	Mid Slab Position	FD	3
(0018,9107)	MR Spatial Saturation Sequence	SQ	1
(0018,9112)	MR Timing and Related Parameters Sequence	SQ	1
(0018,9114)	MR Echo Sequence	SQ	1
(0018,9115)	MR Modifier Sequence	SQ	1
(0018,9117)	MR Diffusion Sequence	SQ	1
(0018,9118)	Cardiac Trigger Sequence	SQ	1
(0018,9119)	MR Averages Sequence	SQ	1
(0018,9125)	MR FOV/Geometry Sequence	SQ	1
(0018,9127)	Spectroscopy Acquisition Data Columns	UL	1
(0018,9126)	Volume Localization Sequence	SQ	1
(0018,9147)	Diffusion Anisotropy Type	CS	1
(0018,9151)	Frame Reference Datetime	DT	1
(0018,9152)	Metabolite Map Sequence	SQ	1
(0018,9155)	Parallel Reduction Factor out-of-plane	FD	1

Tag	Name	VR	VM
(0018,9159)	Spectroscopy Acquisition Out-of-plane Phase Steps	UL	1
(0018,9166)	Bulk Motion Status	CS	1
(0018,9168)	Parallel Reduction Factor Second In-plane	FD	1
(0018,9169)	Cardiac Beat Rejection Technique	CS	1
(0018,9170)	Respiratory Motion Compensation	CS	1
(0018,9171)	Respiratory Signal Source	CS	1
(0018,9172)	Bulk Motion Compensation Technique	CS	1
(0018,9173)	Bulk Motion Signal	CS	1
(0018,9174)	Applicable Safety Standard Agency	CS	1
(0018,9175)	Applicable Safety Standard Version	LO	1
(0018,9176)	Operation Mode Sequence	SQ	1
(0018,9177)	Operating Mode Type	CS	1
(0018,9178)	Operation Mode	CS	1
(0018,9179)	Specific Absorption Rate Definition	CS	1
(0018,9180)	Gradient Output Type	CS	1
(0018,9181)	Specific Absorption Rate Value	FD	1
(0018,9182)	Gradient Output	FD	1
(0018,9183)	Flow Compensation Direction	CS	1
(0018,9184)	Tagging Delay	FD	1
(0018,9195)	Chemical Shifts Minimum Integration Limit	FD	1
(0018,9196)	Chemical Shifts Maximum Integration Limit	FD	1
(0018,9197)	MR Velocity Encoding Sequence	SQ	1
(0018,9198)	First Order Phase Correction	CS	1
(0018,9199)	Water Referenced Phase Correction	CS	1
(0018,9200)	MR Spectroscopy Acquisition Type	CS	1
(0018,9214)	Respiratory Motion Status	CS	1
(0018,9217)	Velocity Encoding Maximum Value	FD	1
(0018,9218)	Tag Spacing Second Dimension	SS	1
(0018,9219)	Tag Angle Second Axis	SS	1
(0018,9220)	Frame Acquisition Duration	FD	1
(0018,9226)	MR Image Frame Type Sequence	SQ	1
(0018,9227)	MR Spectroscopy Frame Type Sequence	SQ	1
(0018,9231)	MR Acquisition Phase Encoding Steps in-plane	US	1
(0018,9232)	MR Acquisition Phase Encoding Steps out-of-plane	US	1
(0018,9234)	Spectroscopy Acquisition Phase Columns	UL	1
(0018,9236)	Cardiac Motion Status	CS	1
(0018,9239)	Specific Absorption Rate Sequence	SQ	1

Tag	Name	VR	VM
(0020,9056)	Stack ID	SH	1

Tag	Name	VR	VM
(0020,9057)	In-Stack Position Number	UL	1
(0020,9071)	Frame Anatomy Sequence	SQ	1
(0020,9072)	Frame Laterality	CS	1
(0020,9111)	Frame Content Sequence	SQ	1
(0020,9113)	Plane Position Sequence	SQ	1
(0020,9116)	Plane Orientation Sequence	SQ	1
(0018,9127)	Spectroscopy Acquisition Data Columns	UL	1
(0020,9128)	Temporal Position Index	UL	1
(0020,9153)	Trigger Delay Time	FD	1
(0020,9156)	Frame Acquisition Number	US	1
(0020,9157)	Dimension Index Values	UL	1-n
(0020,9158)	Frame Comments	LT	1
(0020,9161)	Concatenation UID	UI	1
(0020,9162)	In-concatenation Number	US	1
(0020,9163)	In-concatenation Total Number	US	1
(0020,9164)	Dimension Organization UID	UI	1
(0020,9165)	Dimension Index Pointer	AT	1
(0020,9167)	Functional Group Sequence Pointer	AT	1
(0020,9213)	Dimension Index Private Creator	LO	1
(0020,9221)	Dimension Organization Sequence	SQ	1
(0020,9222)	Dimension Sequence	SQ	1
(0020,9228)	Concatenation Frame Offset Number	UL	1
(0020,9238)	Functional Group Private Creator	LO	1

Tag	Name	VR	VM
(0028,9001)	Data Point Rows	UL	1
(0028,9002)	Data Point Columns	UL	1
(0028,9003)	Signal Domain	CS	1-2
(0028,9099)	Largest Monochrome Pixel Value	US	1
(0028,9108)	Data Representation	CS	1
(0028,9110)	Pixel Matrix Sequence	SQ	1
(0028,9132)	Frame VOI LUT Sequence	SQ	1
(0028,9145)	Pixel Value Transformation Sequence	SQ	1
(0028,9235)	Signal Domain Rows	CS	1

Tag	Name	VR	VM
(0040,9096)	Real World Value Mapping Sequence	SQ	1
(0040,9210)	LUT Label	SS	1

Tag	Name	VR	VM
(0040,9211)	Real World Value LUT Last Value Mapped	US/SS	1
(0040,9212)	Real World Value LUT Data	FD	1-n
(0040,9216)	Real World Value LUT First Value Mapped	US/SS	1
(0040,9224)	Real World Value Intercept	FD	1
(0040,9225)	Real World Value Slope	FD	1

Tag	Name	VR	VM
(5200,9229)	Shared Functional Groups Sequence	SQ	1
(5200,9230)	Per-frame Functional Groups Sequence	SQ	1

Tag	Name	VR	VM
(5600,0010)	First Order Phase Correction Angle	OF	1
(5600,0020)	Spectroscopy Data	OF	1

Item #27: Add the following rows to Table A-1

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.4.1	Enhanced MR Image Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.4.2	MR Spectroscopy Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.66	Raw Data Storage	SOP Class	PS 3.4

Changes to NEMA Standards Publication PS 3.16-2001

Digital Imaging and Communications in Medicine (DICOM)

Part 16: Content Mapping Resource

Item #28: Add new context groups to Annex B

CID 7201

REFERENCED IMAGE PURPOSES OF REFERENCE

(Most Restrictive Use: Defined)

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	121311	Localizer
DCM	121312	Biopsy localizer
DCM	121313	Other partial views
DCM	121314	Other image of biplane pair
DCM	121315	Other image of stereoscopic pair
DCM	121316	Images related to standalone object
DCM	121317	Spectroscopy

CID 7202

SOURCE IMAGE PURPOSES OF REFERENCE

(Most Restrictive Use: Defined)

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	121320	Uncompressed predecessor
DCM	121321	Mask image for image processing operation
DCM	121322	Source image for image processing operation

CID 7203

IMAGE DERIVATION

(Most Restrictive Use: Defined)

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	113040	Lossy Compression
DCM	113041	Apparent Diffusion Coefficient
DCM	113042	Pixel by pixel addition
DCM	113043	Diffusion weighted
DCM	113044	Diffusion Anisotropy
DCM	113045	Diffusion Attenuated
DCM	113046	Pixel by pixel division
DCM	113047	Pixel by pixel mask
DCM	113048	Pixel by pixel Maximum
DCM	113049	Pixel by pixel mean
DCM	113050	Metabolite Maps from spectroscopy data
DCM	113051	Pixel by pixel Minimum
DCM	113052	Mean Transit Time
DCM	113053	Pixel by pixel multiplication
DCM	113054	Negative Enhancement Integral
DCM	113055	Regional Cerebral Blood Flow
DCM	113056	Regional Cerebral Blood Volume
DCM	113057	R-Coefficient Map
DCM	113058	Proton Density map
DCM	113059	Signal Change Map
DCM	113060	Signal to Noise Map
DCM	113061	Standard Deviation
DCM	113062	Pixel by pixel subtraction
DCM	113063	T1 Map
DCM	113064	T2* Map
DCM	113065	T2 Map
DCM	113066	Time Course of Signal
DCM	113067	Temperature encoded
DCM	113068	Student’s T-Test
DCM	113069	Time To Peak map
DCM	113070	Velocity encoded
DCM	113071	Z-Score Map

Item #29: Add new codes to Annex D

DICOM Code Definitions (Coding Scheme Designator "DCM" Coding Scheme Version "01")

Code Value	Code Meaning	Definition
.....		
113040	Lossy Compression	
113041	Apparent Diffusion Coefficient	
113042	Pixel by pixel addition	
113043	Diffusion weighted	
113044	Diffusion Anisotropy	
113045	Diffusion Attenuated	
113046	Pixel by pixel division	
113047	Pixel by pixel mask	
113048	Pixel by pixel Maximum	
113049	Pixel by pixel mean	
113050	Metabolite Maps from spectroscopy data	
113051	Pixel by pixel Minimum	
113052	Mean Transit Time	
113053	Pixel by pixel multiplication	
113054	Negative Enhancement Integral	
113055	Regional Cerebral Blood Flow	
113056	Regional Cerebral Blood Volume	
113057	R-Coefficient Map	
113058	Proton Density map	
113059	Signal Change Map	
113060	Signal to Noise Map	
113061	Standard Deviation	
113062	Pixel by pixel subtraction	
113063	T1 Map	
113064	T2* Map	
113065	T2 Map	
113066	Time Course of Signal	
113067	Temperature encoded	
113068	Student's T-Test	
113069	Time To Peak map	
113070	Velocity encoded	
113071	Z-Score Map	
.....		

121311	Localizer	
121312	Biopsy localizer	
121313	Other partial views	
121314	Other image of biplane pair	
121315	Other image of stereoscopic pair	
121316	Images related to standalone object	
121317	Spectroscopy	
.....		
121320	Uncompressed predecessor	
121321	Mask image for image processing operation	
121322	Source image for image processing operation	
.....		

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