Digital Imaging and Communications in Medicine (DICOM)

Sup 172 - Parametric Map Storage

DICOM Standards Committee - Working Group 18 - Research and Clinical Trials

1300 N. 17th Street Suite 1752
Rosslyn
VA
22209
USA

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Scope and Field of Application

This Supplement defines use-cases, image IODs and SOP Classes for storage of information related to quantitative parametric maps.

Parametric maps include quantitative derived images computed from acquired images, whether they be used for clinical, clinical trial or basic research purposes. DICOM objects are needed so that they can be stored in the PACS and wherever possible visualized in conjunction with images for review, and preserve patient (or research subject) identification, management, and acquisition and processing technique information.

Parametric maps are encoded as images just like any other. The distinguishing characteristic of a "parametric map" is that each pixel value has a "meaning" in the real world, and the name "parametric" alludes to the meaning being the parameter of something, such as a pharmacokinetic model. In general, the term "parametric map" is loosely used to refer to any derived image whose pixel values have a quantitative meaning, as opposed to acquired images, whose pixel values may or may not have meaning (e.g., CT HU versus arbitrary MR signal intensity), or derived images whose pixel values are dimensionless.

Examples of parametric maps include:

- parameters of pharmacokinetic models, such as Ktrans of the Tofts model used in DCE-MRI
- regional cerebral blood volume (RCBV) or flow (RCBF) used in perfusion CT
- normalized values based on body size, such as SUVbw used in PET
- diffusion parameters such as Apparent Diffusion Coefficient (ADC) used in MR DWI

Some of these applications, such as SUV and ADC, have been in widespread use already, and use ordinary modality-specific derived image IODs for encoding, with quite satisfactory (interoperable) results in most cases, and it is not the purpose of this Supplement to replace that common usage.

Rather, the goals are to define:

- additional attributes, modules, acquisition context, code sets and scaling functions that may optionally be used to extend existing image IODs
- a new IOD to address the need for encoding some parametric maps with floating point "pixels"
- the basic encoding mechanism changes needed to support floating point "pixels"

Floating point "pixels" are necessary in some cases for subsequent calculations and to prevent the accumulation of rounding and quantization errors, as well as to provide a full fidelity record of the work performed. In many cases, scientific processing applications have been reluctant to sacrifice intermediate precision between processing steps, and have avoided the use of the DICOM Standard as a consequence.

The IOD defined in this supplement uses the enhanced multi-frame encoding.

DICOM PS3.2 Conformance

A DICOM Conformance Statement Template (Normative)

Amend DICOM PS 3.2 - Conformance - Annex A - DICOM Conformance Statement Template (Normative) as follows:

Table A.1-2. UID Values

UID Value	UID Name	Category
...	...	...
1.2.840.10008.5.1.4.1.1.30	**Parametric Map Storage SOP Class**	**Transfer**
...	...	...

DICOM PS3.3 Information Object Definitions

A Composite Information Object Definitions (Normative)

Amend DICOM PS 3.3 - Information Object Definitions - Annex A - Composite Information Object Definitions (Normative), to add Parametric Map IOD Modules to A.1.4 Overview of the Composite IOD Module Content.

Amend DICOM PS 3.3 - Information Object Definitions - Annex A - Composite Information Object Definitions (Normative) as follows, to add a new Parametric Map IOD:

A.75 Parametric Map IOD

A.75.1 Parametric Map IOD Description

The Parametric Map Information Object Definition (IOD) specifies a multi-frame image representing pixels with real world values. Parametric Maps are either integer or floating point.

The Parametric Map IOD does not include the full set of acquisition parameters of any acquired images from which they were derived, e.g., cardiac phase. An application rendering or processing the Parametric Map may need to access the source images for such information.

The Parametric Map IOD requires the presence of VOI LUT (window) information with the intent that at a minimum the image be renderable without special processing. The output space is defined as P-Values to achieve consistency.

Note

- The VOI LUT mechanism specifically supports floating point values, and there is no expectation that it be limited to integer input or output ranges.
- Even though the output of the VOI LUT is not constrained to be integer values, implicit scaling of the output range to the input range of an integer-based Palette Color LUT can be used to apply pseudo-color for display. No pseudo-color mapping information is encoded with the image. This may be applied at the discretion of the receiving application whether it uses a separate DICOM Color Palette IOD or some other mechanism.

The Parametric Map IOD encodes one or more parameters as an image. Other Image IODs may be used to encode related information, and instances of them may be referenced from the Parametric Map, as the source from which a parameter was derived, or some other relationship.

Note

- The Blending Presentation State IOD may be used to describe how (selected frames of) a Parametric Map instance may be superimposed on, say, frames of acquired images for anatomical reference encoded as instances of other Image IODs, as well as the relative opacity and pseudo-color applicable to the overlying frames.
- Commonality of the same Frame of Reference UID also allows an application to relate Parametric Map instances and other Image instances, in the absence of explicit references.
- The Parametric Map IOD is not restricted to encoding only a single parameter in one instance. Since it is a multi-frame object, and since the type of parameter is encoded in the Real World Value Mapping functional group macro, which may vary on a per-frame basis, the parameter may also vary from frame-to-frame. In such cases, the Multi-Frame Dimension Module may be used to highlight this, by specifying the Quantity Definition Sequence (0040,9220) as a Dimension Index.

A.75.2 Parametric Map IOD Entity-Relationship Model

The E-R Model in Section A.1.2 depicts those components of the DICOM Information Model that directly reference the Parametric Map IOD. The Parametric Map is a kind of Image.

A.75.3 Parametric Map IOD Module Table

Table A.75-1. Parametric Map IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Parametric Map Series	C.8.32.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Image	General Image	C.7.6.1	M
	Image Pixel	C.7.6.3	C - Required if integer pixels
	Floating Point Image Pixel	C.7.6.24	C - Required if 32 bit floating point pixels
	Double Floating Point Image Pixel	C.7.6.25	C - Required if 64 bit floating point pixels
	Parametric Map Image	C.8.32.2	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Cardiac Synchronization	C.7.6.18.1	U
	Respiratory Synchronization	C.7.6.18.2	U
	Bulk Motion Synchronization	C.7.6.18.3	U
	Acquisition Context	C.7.6.14	M
	Device	C.7.6.12	U
	Specimen	C.7.6.22	U
	Common Instance Reference	C.12.2	C - Required if Referenced Image Functional Group (C.7.6.16.2.5) or Derivation Image Functional Group (C.7.16.2.6) is present.
	SOP Common	C.12.1	M
	Frame Extraction	C.12.3	C - Required if the SOP Instance was created in response to a Frame-Level retrieve request

A.75.4 Parametric Map IOD Content Constraints

Either the Pixel Data Module or the Floating Point Pixel Data Module or the Double Floating Point Image Pixel Module is required, and only one of these shall be present.

Note

I.e., it is not permitted to have more than one of Pixel Data Provider URL (0028,7FE0), Pixel Data (7FE0,0010), Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) in a Standard Extended SOP Class in the top level Data Set. See PS3.5

The VOI LUT Module shall not be present.

The Modality LUT Module shall not be present.

The Overlay Module shall not be present.

The Supplemental Palette Color LUT Module shall not be present.

A.75.5 Parametric Map Functional Groups

Table A.75-2 specifies the use of the Functional Group Macros used in the Multi-frame Functional Group Module for the Parametric Map IOD.

Table A.75-2. Parametric Map Functional Group Macros

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Plane Position (Patient)	C.7.6.16.2.3	M
Plane Orientation (Patient)	C.7.6.16.2.4	M
Referenced Image	C.7.6.16.2.5	U
Derivation Image	C.7.6.16.2.6	C - Required if the image or frame has been derived from another SOP Instance.
Frame Content	C.7.6.16.2.2	M - Shall not be used as a Shared Functional Group
Cardiac Synchronization	C.7.6.16.2.7	U
Frame Anatomy	C.7.6.16.2.8	M
Identity Pixel Value Transformation	C.7.6.16.2.9b	M
Frame VOI LUT With LUT Macro	C.7.6.16.2.10b	M
Real World Value Mapping	C.7.6.16.2.11	M
Contrast/Bolus Usage	C.7.6.16.2.12	U
Respiratory Synchronization	C.7.6.16.2.17	U
Parametric Map Frame Type	C.8.32.3.1	M

A.75.5.1 Parametric Map Functional Groups Description

For the Derivation Image Functional Group Macro, the Baseline CID for:

- Purpose of Reference Sequence (0040,A170) is CID 7222 “Parametric Map Derivation Image Purpose of Reference”.
- Derivation Code Sequence (0008,9215) is CID 7203 "Image Derivation".

For the Real World Value Mapping Functional Group Macro, which defines the type of quantity, the method of generation and the units for the pixel values, the Baseline CID for:

- Concept Name Code Sequence of Quantity Definition Sequence (0040,9220) is CID 9000 "Physical Quantity Descriptors" (CP 1387).

- Concept Code Sequence for Concept Name of (G-C1C6, SRT, "Quantity") of Quantity Definition Sequence (0040,9220) is CID 7180 "Abstract Multi-dimensional Image Model Component Semantics" (CP 1387).
- Measurement Units Code Sequence (0040,08EA) is CID 7181 "Abstract Multi-dimensional Image Model Component Units".

C Information Module Definitions (Normative)

Amend DICOM PS 3.3 - Information Object Definitions - to add note to Pixel Padding Value in General Equipment Module:

C.7.5.1 General Equipment Module

...

Table C.7-8. General Equipment Module Attributes

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Pixel Padding Value	(0028,0120)	1C	Single pixel value or one limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed. See Section C.7.5.1.1.2 for further explanation. Required if Pixel Padding Range Limit (0028,0121) is present and either Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present. May be present otherwise if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present. **Note** 1. The Value Representation of this Attribute is determined by the value of Pixel Representation (0028,0103). 2. This Attribute is not used in Presentation State Instances; there is no means in a Presentation State to "override" any Pixel Padding Value specified in the referenced images. 3. This Attribute does apply to RT Dose and Segmentation instances, since they include Pixel Data. 4. **This Attribute does not apply when Float Pixel Data (7FE0,0008) or Double Float Pixel Data ((7FE0,0009) are used instead of Pixel Data (7FE0,0010); Float Pixel Padding Value (0028,0122) or Double Float Pixel Padding Value (0028,0123), respectively, are used instead, and defined at the Image, not the Equipment, level.**

C.7.5.1.1 General Equipment Attribute Descriptions

...

C.7.5.1.1.2 Pixel Padding Value and Pixel Padding Range Limit

Pixel Padding Value (0028,0120) is used to pad grayscale images (those with a Photometric Interpretation of MONOCHROME1 or MONOCHROME2) to rectangular format. The native format of some images is not rectangular. It is common for devices with this format to pad the images to the rectangular format required by the DICOM Standard with a specific pixel value that is not contained in the native image. Further, when resampling, such as after spatial registration, padding may need to be used to fill previously non-existent pixels.

Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) are also used to identify pixels to be excluded from the normal grayscale rendering pipeline for other reasons, such as suppression of background air. Pixel Padding Range Limit (0028,0121) is defined in the Image Pixel Module.

Note

1. The "native image" is that which is being padded to the required rectangular format, e.g., the area within the circular reconstruction perimeter of a CT image, or the subset of the rectangular area that contains useful image information.

2. The pixel padding value is explicitly described in order to prevent display applications from taking it into account when determining the dynamic range of an image, since the Pixel Padding Value will be outside the range between the minimum and maximum values of the pixels in the native image

3. No pixels in the native image will have a value equal to Pixel Padding Value.

Pixel Padding Value (0028,0120) specifies either a single value of this padding value, or when combined with Pixel Padding Range Limit (0028,0121), a range of values (inclusive) that are padding.

The values of Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) shall be valid values within the constraints defined by Bits Allocated (0028,0100), Bits Stored (0028,0101), and High Bit (0028,0102).

Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) shall not be present when padding is performed but the pixel value used for padding does occur in the native image.

If Photometric Interpretation (0028,0004) is MONOCHROME2, Pixel Padding Value (0028,0120) shall be less than (closer to or equal to the minimum possible pixel value) or equal to Pixel Padding Range Limit (0028,0121). If Photometric Interpretation (0028,0004) is MONOCHROME1, Pixel Padding Value (0028,0120) shall be greater than (closer to or equal to the maximum possible pixel value) or equal to Pixel Padding Range Limit (0028,0121).

Note

1. When the relationship between pixel value and X-Ray Intensity is unknown, it is recommended that the following values be used to pad with black when the image is unsigned:

   - 0 if Photometric Interpretation (0028,0004) is MONOCHROME2.
   - $2^{\text{Bits Stored}} - 1$ if Photometric Interpretation (0028,0004) is MONOCHROME1.

   and when the image is signed:

   - $-2^{\text{Bits Stored-1}}$ if Photometric Interpretation (0028,0004) is MONOCHROME2.
   - $2^{\text{Bits Stored-1}} - 1$ if Photometric Interpretation (0028,0004) is MONOCHROME1.

2. For projection radiography, when the relationship between pixel value and X-Ray Intensity is known (for example as defined by Pixel Intensity Relationship (0028,1040) and Pixel Intensity relationship Sign (0028,1041)), it is recommended that a pixel value equivalent to, or rendered similarly to, air (least X-Ray absorbance) be used for padding. However, if such a value may occur in the native image, the Pixel Padding Value (0028,0120) Attribute itself should not be sent.

   E.g., for an XRF image obtained with an image intensifier, if air is black then a padded perimeter, if any, should also appear black. Typically though, if unpadded, this area would be collimated with a circular collimator, in which case the pixels would appear natively as white (greatest X-Ray absorbance) and a circular shutter would be necessary to neutralize them as black. Whether collimated areas are detected and treated as padded, or neutralized with shutters is at the discretion of the application. See also the Display Shutter Module Section C.7.6.11.

3. The conditional requirement for the Pixel Padding Value Range Limit (0028,0121) in the Image Pixel Module means that it shall not be present unless Pixel Padding Value (0028,0120) is also present.

4. The range of values to be suppressed between Pixel Padding Value (0028,0120) and Pixel Padding Value Range Limit (0028,0121) is specified as being inclusive, that is the values themselves as well as all values between are suppressed.

5. When Pixel Padding Value Range Limit (0028,0121) is present, but not supported by a rendering application, the constraint that Pixel Padding Value (0028,0120) is closest to the "blackest" value, which is typically the most frequently occurring background pixel, will most often result in an acceptable display, permitting "backward compatibility" in the majority of cases.

When modifying equipment changes the pixel padding value in the image, it shall change the values of Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121), if present. If modifying equipment changes the pixel padding values in the image to values present in the native image, the attribute Pixel Padding Value (0028,0120) and Pixel Padding Range Limit (0028,0121) shall be removed.

Note

1. For example, if a CT image containing signed values from -1024 to 3191 and a Pixel Padding Value of -2000 and a Rescale Intercept of 0 is converted to an unsigned image with a Rescale Intercept of -1024 by adding 1024 to all pixels and clipping all more negative pixels to 0, then the padding pixels will be indistinguishable from some of the modified native image pixels, and hence Pixel Padding Value (0028,0120) needs to be removed.

2. If the modification involves lossy compression, which may result in changes to the pixel values, then the application of Pixel Padding Value and Pixel Padding Range Limit may result in a different appearance, and hence these attributes may need different values also.

Amend DICOM PS 3.3 - Information Object Definitions - to add new Sections C.7.6.24 and C.7.6.25, with support for Float and Double Float Pixel Data:

C.7.6.24 Floating Point Image Pixel Module

Table C.7.6.24-1 describes the Floating Point Image Pixel Module. This module differs from the Section C.7.6.3 Image Pixel Module in that:

- instead of integer stored pixel values, float stored pixel values are used
- Bits Stored (0028,0101) and High Bit (0029,0102) are not used because the stored pixel values always occupy the entire word
- Pixel Representation (0028,0103) is not used because the stored pixel values are always signed
- Photometric Interpretation is constrained
- color palette tables are not used
- Pixel Data Provider URL (0028,7FE0) is not used

Table C.7.6.24-1. Floating Point Image Pixel Module Attributes

Attribute Name	Tag	Type	Attribute Description
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. See Section C.7.6.3.1.1 for further explanation.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. **Enumerated Values:** **MONOCHROME2**
Rows	(0028,0010)	1	Number of rows in the image.
Columns	(0028,0011)	1	Number of columns in the image.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. See PS3.5 for further explanation. **Enumerated Values:** **32**

Attribute Name	Tag	Type	Attribute Description
Float Pixel Data	(7FE0,0008)	1	A data stream of the pixel samples that comprise the Image. The order of pixels sent for each image plane is left to right, top to bottom, i.e., the upper left pixel (labeled 1,1) is sent first followed by the remainder of row 1, followed by the first pixel of row 2 (labeled 2,1) then the remainder of row 2 and so on.
Pixel Aspect Ratio	(0028,0034)	1C	Ratio of the vertical size and horizontal size of the pixels in the image specified by a pair of integer values where the first value is the vertical pixel size, and the second value is the horizontal pixel size. Required if the aspect ratio values do not have a ratio of 1:1 and the physical pixel spacing is not specified by Pixel Spacing (0028,0030), or Imager Pixel Spacing (0018,1164) or Nominal Scanned Pixel Spacing (0018,2010), either for the entire Image or per-frame in a Functional Group Macro. See Section C.7.6.3.1.7.
Float Pixel Padding Value	(0028,0122)	3	One limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed.
Float Pixel Padding Range Limit	(0028,0124)	1C	Pixel value that represents one limit (inclusive) of a range of padding values used together with Float Pixel Padding Value (0028,0122). Required if Float Pixel Padding Value (0028,0122) is present. **Note** 1. If only a single padding value rather than a range is required, then both Float Pixel Padding Value (0028,0122) and Float Pixel Padding Range Limit (0028,0124) will contain the same value. 2. The general considerations described in Section C.7.5.1.1.2 may be helpful in understanding the corresponding floating point attributes, but are not normative.

C.7.6.25 Double Floating Point Image Pixel Module

Table C.7.6.25-1 describes the Floating Point Image Pixel Module. This module differs from the Section C.7.6.3 Image Pixel Module in that:

- instead of integer stored pixel values, double float stored pixel values are used
- Bits Stored (0028,0101) and High Bit (0029,0102) are not used because the stored pixel values always occupy the entire word
- Pixel Representation (0028,0103) is not used because the stored pixel values are always signed
- Photometric Interpretation is constrained
- color palette tables are not used
- Pixel Data Provider URL (0028,7FE0) is not used

Table C.7.6.25-1. Double Floating Point Image Pixel Module Attributes

Attribute Name	Tag	Type	Attribute Description
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. See Section C.7.6.3.1.1 for further explanation.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. **Enumerated Values:** **MONOCHROME2**

Attribute Name	Tag	Type	Attribute Description
Rows	(0028,0010)	1	Number of rows in the image.
Columns	(0028,0011)	1	Number of columns in the image.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. See PS3.5 for further explanation. **Enumerated Values:** **64**
Double Float Pixel Data	(7FE0,0009)	1	A data stream of the pixel samples that comprise the Image. The order of pixels sent for each image plane is left to right, top to bottom, i.e., the upper left pixel (labeled 1,1) is sent first followed by the remainder of row 1, followed by the first pixel of row 2 (labeled 2,1) then the remainder of row 2 and so on.
Pixel Aspect Ratio	(0028,0034)	1C	Ratio of the vertical size and horizontal size of the pixels in the image specified by a pair of integer values where the first value is the vertical pixel size, and the second value is the horizontal pixel size. Required if the aspect ratio values do not have a ratio of 1:1 and the physical pixel spacing is not specified by Pixel Spacing (0028,0030), or Imager Pixel Spacing (0018,1164) or Nominal Scanned Pixel Spacing (0018,2010), either for the entire Image or per-frame in a Functional Group Macro. See Section C.7.6.3.1.7.
Double Float Pixel Padding Value	(0028,0123)	3	One limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed.
Double Float Pixel Padding Range Limit	(0028,0125)	1C	Pixel value that represents one limit (inclusive) of a range of padding values used together with Float Pixel Padding Value (0028,0122). Required if Double Float Pixel Padding Value (0028,0123) is present. **Note** 1. If only a single padding value rather than a range is required, then both Double Float Pixel Padding Value (0028,0123) and Double Float Pixel Padding Range Limit (0028,0125) will contain the same value. 2. The general considerations described in Section C.7.5.1.1.2 may be helpful in understanding the corresponding floating point attributes, but are not normative.

Amend DICOM PS 3.3 - Information Object Definitions as follows, to add new Modules and Macros for Parametric Maps:

C.8.32 Parametric Map

This section describes the specific modules for the Parametric Map IOD.

C.8.32.1 Parametric Map Series Module

Table C.8.32-1 defines the general Attributes of the Parametric Map Series Module.

Table C.8.32-1. Parametric Map Series Module Attributes

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Modality Type **Note** 1. It is expected that the majority of Parametric Maps will use the appropriate value for the acquisition modality, e.g. "MR", and so no specific Defined Terms or Enumerated Values are specified here. 2. If the image is derived from multiple modalities, then a value of "OT" is appropriate.
Series Number	(0020,0011)	1	A number that identifies this Series
Referenced Performed Procedure Step Sequence	(0008,1111)	1C	Uniquely identifies the Performed Procedure Step SOP Instance to which the Series is related Only a single Item shall be included in this sequence. Required if a Performed Procedure Step SOP Class was involved in the creation of this Series.
>Include Table 10-11 "SOP Instance Reference Macro"			

C.8.32.2 Parametric Map Image Module

Table C.8.32-2 defines the general Attributes of the Parametric Map Image Module.

Table C.8.32-2. Parametric Map Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. **Enumerated Values for Value 1:** **DERIVED** **Enumerated Values for Value 2:** **PRIMARY** Value 3 shall be Image Flavor, Defined Terms for which are specified in Section C.8.16.1.3. Value 4 shall be Derived Pixel Contrast, common Defined Terms for which are specified in Section C.8.16.1.4 and MR-specific Defined Terms for which are specified in Section C.8.13.1.1.1.4.
Include Table 10-12 "Content Identification Macro"			
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. **Enumerated Values:** **1**

Attribute Name	Tag	Type	Attribute Description
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. **Enumerated Values:** **MONOCHROME2**
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. **Enumerated Values if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present:** **16** **Enumerated Values if Float Pixel Data (7FE0,0008) is present:** **32** **Enumerated Values if Double Float Pixel Data (7FE0,0009) is present:** **64**
Bits Stored	(0028,0101)	1C	Number of bits stored for each pixel sample. **Enumerated Values:** **16** Required if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present.
High Bit	(0028,0102)	1C	Most significant bit for pixel sample data. **Enumerated Values:** **15** Required if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present.
Presentation LUT Shape	(2050,0020)	1	Specifies an identity transformation for the Presentation LUT such that the output of all grayscale transformations are defined to be in P-Values. **Enumerated Values:** **IDENTITY** output is in P-Values. **Note** The intent of specifying this Attribute for Parametric Maps is only to achieve consistency of rendering when displayed as grayscale, not to imply that grayscale contrast of the displayed image is meaningful. It is not applicable when the image is rendered with pseudo-color, for example.

Attribute Name	Tag	Type	Attribute Description
Lossy Image Compression	(0028,2110)	1	Specifies whether an Image has undergone lossy compression (at a point in its lifetime), or is derived from lossy compressed images. **Enumerated Values:** **00** Image has NOT been subjected to lossy compression. **01** Image has been subjected to lossy compression. Once this value has been set to 01 it shall not be reset. See Section C.8.32.2.1 and Section C.7.6.1.1.5.
Lossy Image Compression Ratio	(0028,2112)	1C	Describes the approximate lossy compression ratio(s) that have been applied to this image. See Section C.7.6.1.1.5 for further explanation. May be multivalued if successive lossy compression steps have been applied. **Note** 1. For example, a compression ratio of 30:1 would be described in this Attribute with a single value of 30. 2. For historical reasons, the lossy compression ratio may also be described in Derivation Description (0008,2111). Required if present in the source images or this IOD instance has been compressed.
Lossy Image Compression Method	(0028,2114)	1C	A label for the lossy compression method(s) that have been applied to this image. See Section C.7.6.1.1.5 for further explanation. May be multivalued if successive lossy compression steps have been applied; the value order shall correspond to the values of Lossy Image Compression Ratio (0028,2112). **Note** For historical reasons, the lossy compression method may also be described in Derivation Description (0008,2111). Required if present in the source images or this IOD instance has been compressed. See Section C.8.32.2.1.
Burned In Annotation	(0028,0301)	1	Indicates whether or not image contains sufficient burned in annotation to identify the patient and date the image was acquired. **Enumerated Values:** **NO**
Recognizable Visual Features	(0028,0302)	1	Indicates whether or not the image contains sufficiently recognizable visual features to allow the image or a reconstruction from a set of images to identify the patient. **Enumerated Values:** **YES** **NO**

Attribute Name	Tag	Type	Attribute Description
Content Qualification	(0018,9004)	1	Content Qualification Indicator **Enumerated Values:** **PRODUCT** **RESEARCH** **SERVICE** See Section C.8.13.2.1.1 for further explanation.

C.8.32.2.1 Lossy Image Compression and Lossy Image Compression Method

If Lossy Image Compression (0028,2110) in any of the source images is "01", the value shall be "01" for the Parametric Map instance.

The process of derivation of a Parametric Map itself is defined not to be lossy compression, even though it involves loss. If the Parametric Map instance is encoded using a lossy compression transfer syntax, then the value shall be set to "01".

Note

To state the obvious, it is not advisable to lossy compress a Parametric Map SOP Instance, since that will alter the quantitative values that are the intent of the object.

C.8.32.3 Parametric Map Functional Group Macros

The following sections contain Functional Group Macros specific to the Parametric Map 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.8.32.3.1 Parametric Map Frame Type Macro

Table C.8.32-3 specifies the attributes of the Parametric Map Frame Type Functional Group Macro.

Table C.8.32-3. Parametric MapFrame Type Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Parametric Map Frame Type Sequence	(0040,9092)	1	Identifies the characteristics of this Parametric Map frame. Only a single Item shall be included in this sequence.
>Frame Type	(0008,9007)	1	Type of Frame. A multi-valued attribute analogous to Image Type (0008,0008). Enumerated Values and Defined Terms are the same as those for the four values of Image Type (0008,0008), except that the value MIXED is not allowed. See Section C.8.32.2.

DICOM PS3.4 Service Class Specifications

B Storage Service Class (Normative)

Amend DICOM PS 3.4 - Service Class Specifications - Annex B - Storage Service Class (Normative) as follows:

B.5 Standard SOP Classes

...

Table B.5-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)
...	...	...
Parametric Map Storage	**1.2.840.10008.5.1.4.1.1.30**	**Parametric Map IOD**
...	...	...

I Media Storage Service Class (Normative)

Amend DICOM PS 3.4 - Service Class Specifications - Annex I - Media Storage Service Class (Normative) as follows:

I.4 Media Storage Standard SOP Classes

...

Table I.4-1. Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)
...	...	...
Parametric Map Storage	**1.2.840.10008.5.1.4.1.1.30**	**Parametric Map IOD**
...	...	...

DICOM PS3.5 Data Structures and Encoding

3 Definitions

Amend DICOM PS 3.5 - Data Structures and Encoding - Section 3 - Definitions as follows:

3.10 DICOM Data Structures and Encoding Definitions

The following definitions are commonly used in this Standard:

...

Pixel Cell: The container for a single Pixel Sample Value that may include unused bits ~~**or bits for data other than the Pixel Sample Value (e.g., overlay planes)**~~. The size of a Pixel Cell shall be specified by the Bits Allocated (0028, 0100) Data Element.

Pixel Data: Graphical data (e.g., images ~~**or overlays**~~) of variable pixel-depth encoded in the Pixel Data**, Float Pixel Data or Double Float Pixel Data** Element~~**, with Value Representation OW or OB**~~. ~~**Additional descriptor Data Elements are often used to describe the contents of the Pixel Data element.**~~

Pixel Sample Value: A value associated with an individual pixel. An individual pixel consists of one or more Pixel Sample Values (e.g., color images).

...

PS3.5_6

For reference DICOM PS 3.5 - table defining OF and OD VR:

PS3.5_6.2 Value Representation (VR)

...

Table 6.2-1. DICOM Value Representations

VR Name	Definition	Character Repertoire	Length of Value
...	...	...	...
...			
OD Other Double String	A string of 64-bit IEEE 754:1985 floating point words. OD is a VR that requires byte swapping within each 64-bit word when changing between Little Endian and Big Endian byte ordering (see Section 7.3).	not applicable	2^{32}-8 bytes maximum
OF Other Float String	A string of 32-bit IEEE 754:1985 floating point words. OF is a VR that 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 bytes maximum

PS3.5_7 The Data Set

Amend DICOM PS 3.5 - Data Structures and Encoding - Section 7 - The Data Set as follows:

7.8.2 Encoding of Private Elements

...

For a Standard Extended SOP Class the Attributes Pixel Data (07FE,0010)**, Float Pixel Data (7FE0,0008), Double Float Pixel Data (7FE0,0009)**, Waveform Data (5400,1010), and Overlay Data (60xx,3000) shall not be included within a Private Sequence Item, nor within a standard Sequence Item nested directly or indirectly within a Private Sequence Item.

8 Encoding of Pixel, Overlay and Waveform Data

Amend DICOM PS 3.5 - Data Structures and Encoding - Section 8 - Encoding of Pixel, Overlay and Waveform Data as follows:

8.1 Pixel and Overlay Data, and Related Data Elements

~~The~~ Pixel Data ~~Element~~ (7FE0,0010)**, Float Pixel Data (7FE0,0008), Double Float Pixel Data (7FE0,0009)** and Overlay Data ~~Element~~ (60xx,3000) shall be used for the exchange of encoded graphical image data. These elements along with additional Data Elements, specified as Attributes of the Image Information Entities defined in PS3.3, shall be used to describe the way in which the Pixel Data and Overlay Data are encoded and shall be interpreted. Finally, depending on the negotiated Transfer Syntax (see Section 10 and Annex A), Pixel Data may be compressed.

~~The~~ Pixel Data ~~Element~~ (7FE0,0010) and Overlay Data ~~Element~~ (60xx,3000) have a VR of OW or OB, depending on the negotiated Transfer Syntax (see Annex A). The only difference between OW and OB being that OB, a string of bytes, shall be unaffected by Byte Ordering (see Section 7.3).

Float Pixel Data (7FE0,0008) has a Value Representation of OF.

Double Float Pixel Data (7FE0,0009) has a Value Representation of OD.

For Pixel Data values encoded in OF and OD, any value that is permitted by the IEEE 754:1985 may be used, including NaN, +ve Infinity and -ve Infinity. See Table 6.2-1

Note

Float and double float pixel data values are not arbitrarily constrained to finite numbers, since it may be important for the application to signal that the result of a calculation that produced a pixel is an infinite value or not a number.

8.1.1 Pixel Data Encoding of Related Data Elements

Encoded Pixel Data of various bit depths shall be accommodated. The following three Data Elements shall define the Pixel structure:

- Bits Allocated (0028,0100)
- Bits Stored (0028,0101)
- High Bit (0028,0102)

Each Pixel Cell shall contain a single Pixel Sample Value. The size of the Pixel Cell shall be specified by Bits Allocated (0028,0100). Bits Stored (0028,0101) defines the total number of these allocated bits that will be used to represent a Pixel Sample Value. Bits Stored (0028,0101) shall never be larger than Bits Allocated (0028,0100). High Bit (0028,0102) specifies where the high order bit of the Bits Stored (0028,0101) is to be placed with respect to the Bits Allocated (0028,0100) specification. ~~**Bits not used for Pixel Sample Values can be used for overlay planes described further in PS3.3**~~.

Note

1. For example, in Pixel Data with 16 bits (2 bytes) allocated, 12 bits stored, and bit 15 specified as the high bit, one pixel sample is encoded in each 16-bit word, with the 4 least significant bits of each word not containing Pixel Data. See Annex D for other examples of the basic encoding schemes.
2. **Formerly, bits not used for Pixel Sample Values were described as being usable for overlay planes, but this usage has been retired. See PS3.5-2004.**

Restrictions are placed on acceptable Values for Bits Allocated (0028,0100), Bits Stored (0028,0101), and High Bit (0028,0102) **for Pixel Data (7FE0,0010)** and are specified in the Information Object Definitions in PS3.3.

Restrictions are placed on acceptable Values for Bits Allocated (0028,0100) for Float Pixel Data (7FE0,0008) and Double Float Pixel Data (7FE0,0009), such that only a single Pixel Cell entirely occupies the allocated bits specified by Bits Allocated (0028,0100), hence Bits Stored (0028,0101) and High Bit (0028,0102) are not sent.

Also, the Value Field containing Pixel Data, like all other Value Fields in DICOM, shall be an even number of bytes in length. This means that the Value Field may need to be padded with data that is not part of the image and shall not be considered significant. If needed, the padding bits shall be appended to the end of the Value Field, and shall be used only to extend the data to the next even byte increment of length.

In a multi-frame object that is transmitted in Native Format, the individual frames are not padded. The individual frames shall be concatenated and padding bits (if necessary) apply to the complete Value Field.

Note

Receiving applications should be aware that some older applications may send Pixel Data with excess padding, which was not explicitly prohibited in earlier versions of the Standard. Applications should be prepared to accept such Pixel Data elements, but may delete the excess padding. In no case should a sending application place private data in the padding data.

The field of bits representing the value of a Pixel Sample shall be a binary 2's complement integer or an unsigned integer, as specified by the Data Element Pixel Representation (0028,0103). The sign bit shall be the High Bit in a Pixel Sample Value that is a 2's complement integer. The minimum actual Pixel Sample Value encountered in the Pixel Data is specified by Smallest Image Pixel Value (0028,0106) while the maximum value is specified by Largest Image Pixel Value (0028,0107).

8.1.2 Overlay Data Encoding of Related Data Elements

Encoded Overlay Planes always have a bit depth of 1, and are encoded separately from the Pixel Data in Overlay Data (60xx,3000). The following two Data Elements shall define the Overlay Plane structure:

- Overlay Bits Allocated (60xx,0100)
- Overlay Bit Position (60xx,0102)

Note

1. There is no Data Element analogous to Bits Stored (0028,0101) since Overlay Planes always have a bit depth of 1.
2. Restrictions on the allowed values for these Data Elements are defined in PS3.3. Formerly overlay data stored in unused bits of Pixel Data (7FE0,0010) was described, and these attributes had meaningful values but this usage has been retired. See PS3.5-2004. For overlays encoded in Overlay Data Element (60xx,3000), Overlay Bits Allocated (60xx,0100) is always 1 and Overlay Bit Position (60xx,0102) is always 0.

For Overlay Data Element (60xx,3000)...

...

8.2 Native or Encapsulated Format Encoding

Pixel data conveyed in the Pixel Data Element (7FE0,0010) may be sent either in a Native (uncompressed) Format or in an Encapsulated Format (e.g., compressed) defined outside the DICOM standard.

Pixel Data conveyed in the Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) shall be in a Native (uncompressed) Format if encoded in a Standard Transfer Syntax.

Note

1. **In future, if Standard Transfer Syntaxes are defined for compression of Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009), this constraint may be relaxed and Encapsulated Format permitted.**
2. **This constraint does not apply to Private Transfer Syntaxes.**

If Pixel Data **(7FE0,0010)** is sent in a Native Format, the Value Representation OW is most often required. The Value Representation OB may also be used for Pixel Data **(7FE0,0010)** in cases where Bits Allocated has a value less than or equal to 8, but only with Transfer Syntaxes where the Value Representation is explicitly conveyed (see Annex A).

Note

The DICOM default Transfer Syntax (Implicit VR Little Endian) does not explicitly convey Value Representation and therefore the VR of OB may not be used for Pixel Data **(7FE0,0010)** when using the default Transfer Syntax.

Float Pixel Data (7FE0,0008) is sent in Native Format; the Value Representation shall be OF, Bits Allocated (0028,0100) shall be 32, Bits Stored (0028,0101), High Bit (0028,0102) and Pixel Representation (0028,0103) shall not be present.

Double Float Pixel Data (7FE0,0009) is sent in Native Format; the Value Representation shall be OD, Bits Allocated (0028,0100) shall be 64, Bits Stored (0028,0101) and High Bit (0028,0102) and Pixel Representation (0028,0103) shall not be present.

It is not permitted to have more than one of Pixel Data Provider URL (0028,7FE0), Pixel Data (7FE0,0010), Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) in the top level Data Set.

Note

Pixel Data encoded in Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) can be considered as consisting of Pixel Cells that entirely occupy the allocated bits, and therefore do not cross word boundaries.

Native format Pixel Cells are encoded as the direct concatenation of the bits of each Pixel Cell, the least significant bit of each Pixel Cell is encoded in the least significant bit of the encoded word or byte, immediately followed by the next most significant bit of each Pixel Cell in the next most significant bit of the encoded word or byte, successively until all bits of the Pixel Cell have been encoded, then immediately followed by the least significant bit of the next Pixel Cell in the next most significant bit of the encoded word or byte. The number of bits of each Pixel Cell is defined by the Bits Allocated (0028,0100) Data Element Value. When a Pixel Cell crosses a word boundary in the OW case, or a byte boundary in the OB case, it shall continue to be encoded, least significant bit to most significant bit, in the next word, or byte, respectively (see Annex D). For Pixel Data **(7FE0,0010)** encoded with the Value Representation OW, the byte ordering of the resulting 2-byte words is defined by the Little Endian or Big Endian Transfer Syntaxes negotiated at the Association Establishment (see Annex A).

Note

1. For Pixel Data **(7FE0,0010)** encoded with the Value Representation OB, the Pixel Data **(7FE0,0010)** encoding is unaffected by Little Endian or Big Endian byte ordering.

2. If encoding Pixel Data **(7FE0,0010)** with a Value for Bits Allocated (0028,0100) not equal to 16 be sure to read and understand Annex D.

If sent in an Encapsulated Format ...

...

8.4 Pixel Data Provider Service

Specific Transfer Syntaxes allow for the pixel data of the message to be replaced with a reference to a pixel data provider service. The pixel data provider service that is referenced supplies the pixel data using a network protocol that is defined outside DICOM.

Note

The Pixel Data Provider Service is not applicable to Pixel Data encoded as Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009).

...

A Transfer Syntax Specifications (Normative)

Amend DICOM PS 3.5 - Data Structures and Encoding - Annex A - Transfer Syntax Specifications (note that few changes are necessary since the new Data Elements have OF and OD VR and are not affected by OB/OW concerns):

A.1 DICOM Implicit VR Little Endian Transfer Syntax

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Implicit VR Little Endian Transfer Syntax the following requirements shall be met:

a. The Data Elements contained in the Data Set structure shall be encoded with Implicit VR (without a VR Field) as specified in Section 7.1.3.

b. The encoding of the overall Data Set structure (Data Element Tags, Value Length, and Value) shall be in Little Endian as specified in Section 7.3.

c. The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

- For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
- Data Element (7FE0,0010) Pixel Data has the Value Representation OW and shall be encoded in Little Endian.
- ...

...

A.2 DICOM Little Endian Transfer Syntax (Explicit VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Little Endian Transfer Syntax the following requirements shall be met:

a. The Data Elements contained in the Data Set structure shall be encoded with Explicit VR (with a VR Field) as specified in Section 7.1.2.

b. The encoding of the overall Data Set structure (Data Element Tags, Value Length, and Value) shall be in Little Endian as specified in Section 7.3.

c. The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

- For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
  - Data Element (7FE0,0010) Pixel Data
    - where Bits Allocated (0028,0100) has a value greater than 8 shall have Value Representation OW and shall be encoded in Little Endian;
    - where Bits Allocated (0028,0100) has a value less than or equal to 8 shall have the Value Representation OB or OW and shall be encoded in Little Endian.
  - ...

...

A.3 DICOM Big Endian Transfer Syntax (Explicit VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Big Endian Transfer Syntax the following requirements shall be met:

a. The Data Elements contained in the Data Set structure shall be encoded with Explicit VR (with a VR Field) as specified in Section 7.1.2.

b. The encoding of the overall Data Set structure (Data Element Tags, Value Length, and Value) shall be in Big Endian as specified in Section 7.3.

c. The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

- For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Big Endian as specified in Section 7.3.
- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
  - Data Element (7FE0,0010) Pixel Data
    - where Bits Allocated (0028,0100) has a value greater than 8 shall have Value Representation OW and shall be encoded in Big Endian;
    - where Bits Allocated (0028,0100) has a value less than or equal to 8 shall have the Value Representation OB or OW and shall be encoded in Big Endian.
  - ...

...

A.4 Transfer Syntaxes For Encapsulation of Encoded Pixel Data

These Transfer Syntaxes apply to the encoding of the entire DICOM Data Set, even though the image Pixel Data (7FE0,0010) portion of the DICOM Data Set is the only portion that is encoded by an encapsulated format. **These Transfer Syntaxes shall only be used when Pixel Data (7FE0,0010) is present in the top level Data Set, and hence shall not be used when Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) are present.** This implies that when a DICOM Message is being encoded according to an encapsulation Transfer Syntax the following requirements shall be met:

...

A.5 DICOM Deflated Little Endian Transfer Syntax (Explicit VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set.

The entire Data Set is first encoded according to the rules specified in Section A.2.

The entire byte stream is then compressed using the "Deflate" algorithm defined in Internet RFC 1951.

If the deflate algorithm produces an odd number of bytes then a single trailing NULL byte shall be added after the last byte of the deflated bit stream.

Note

1. The Pixel Data **in Pixel Data** (7FE0,0010)**, Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009)** is not handled in any special manner. The pixel data is first encoded as sequential uncompressed frames without encapsulation, and then is handled as part of the byte stream fed to the "deflate" compressor in the same manner as the value of any other attribute.
2. This transfer syntax is particularly useful for compression of objects without pixel data, such as structured reports. It is not particularly effective at image compression, since any benefit obtained from compressing the non-pixel data is offset by less effective compression of the much larger pixel data.
3. ...

...

A.6 DICOM JPIP Referenced Transfer Syntax (Explicit VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. **This Transfer Syntax shall only be used when Pixel Data (7FE0,0010) is present in the top level Data Set, and hence shall not be used when Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) are present.** This implies that when a DICOM Data Set is being encoded with the DICOM Little Endian Transfer Syntax the following requirements shall be met:

a. The Data Elements contained in the Data Set structure shall be encoded with Explicit VR (with a VR Field) as specified in Section 7.1.2.

b. The encoding of the overall Data Set structure (Data Element Tags, Value Length, and Value) shall be in Little Endian as specified in Section 7.3.

c. The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:

- For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
  - Data Element (7FE0,0010) Pixel Data shall not be present, but rather pixel data shall be referenced via Data Element (0028,7FE0) Pixel Data Provider URL
  - Overlay data, if present, shall only be encoded in the Overlay Data attribute (60xx,3000), which shall have the Value Representation OB or OW and shall be encoded in Little Endian.
  - Data Element (0028,0004) Photometric Interpretation shall be limited to the values: MONOCHROME1, MONOCHROME2, YBR_ICT and YBR_RCT.

This DICOM JPIP Referenced Transfer Syntax shall be identified by a UID of Value "1.2.840.10008.1.2.4.94 ".

A.7 DICOM JPIP Referenced Deflate Transfer Syntax (Explicit VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set.

The entire Data Set is first encoded according to the rules specified in Section A.6.

The entire byte stream is then compressed using the "Deflate" algorithm defined in Internet RFC 1951.

This DICOM JPIP Referenced Deflate Transfer Syntax shall be identified by a UID of Value "1.2.840.10008.1.2.4.95".

D Examples of Various Pixel Data and Overlay Encoding Schemes (Informative)

Amend DICOM PS 3.5 - Data Structures and Encoding - Annex D - Examples of Various Pixel Data and Overlay Encoding Schemes as follows:

D.3 Examples of Float and Double Float Pixel Data

Float Pixel Data having the Value Representation OF always has 32 bits allocated; the resulting byte streams pictured in Figure D.3-1 are as they would be transmitted across a network and/or stored on media.

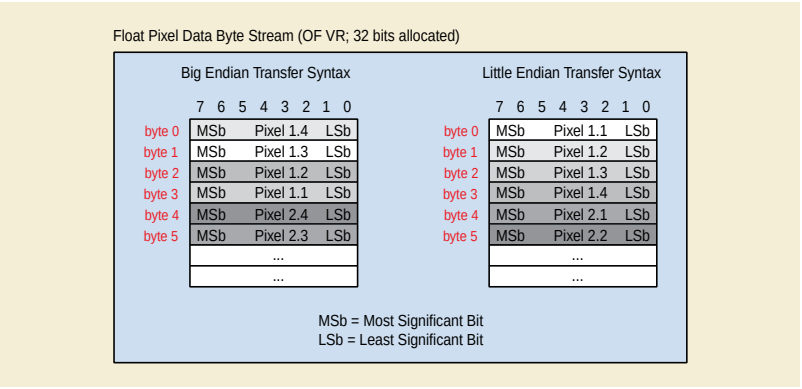

Figure D.3-1. Sample Float Pixel Data Byte Streams for VR = OF

Double Float Pixel Data having the Value Representation OD always has 64 bits allocated; the resulting byte streams pictured in Figure D.3-2 are as they would be transmitted across a network and/or stored on media.

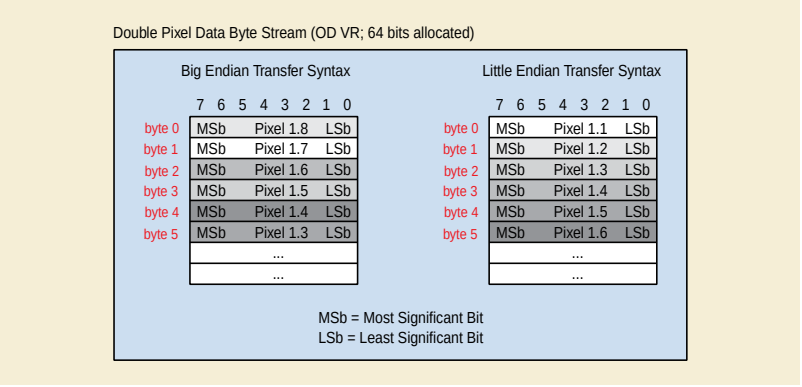

Figure D.3-2. Sample Float Pixel Data Byte Streams for VR = OD

DICOM PS3.6 Data Dictionary

6 Registry of DICOM Data Elements

Amend DICOM PS 3.6 - Data Dictionary - Section 6 - Registry of DICOM Data Elements as follows:

Table 6-1. Registry of DICOM Data Elements

Tag	Name	Keyword	VR	VM	
...	...	...	...	...	
(0040,9220)	**Quantity Definition Sequence**	**QuantityDefinitionSequence**	**SQ**	**1**	
(0040,9092)	**Parametric Map Frame Type Sequence**	**ParametricMapFrameType Sequence**	**SQ**	**1**	
...	...	...	...	...	
(0028,0122)	**Float Pixel Padding Value**	**FloatPixelPaddingValue**	**FL**	**1**	
(0028,0123)	**Double Float Pixel Padding Value**	**DoubleFloatPixelPaddingValue**	**FD**	**1**	
(0028,0124)	**Float Pixel Padding Range Limit**	**FloatPixelPaddingRangeLimit**	**FL**	**1**	
(0028,0125)	**Double Float Pixel Padding Range Limit**	**DoubleFloatPixelPaddingRange Limit**	**FD**	**1**	
(7FE0,0010)	Pixel Data	PixelData	OB or OW	1	
(7FE0,0008)	**Float Pixel Data**	**FloatPixelData**	**OF**	**1**	
(7FE0,0009)	**Double Float Pixel Data**	**DoubleFloatPixelData**	**OD**	**1**	
(7FE0,0020)	*Coefficients SDVN*	*CoefficientsSDVN*	*OW*	*1*	*RET*

A Registry of DICOM Unique Identifiers (UIDs) (Normative)

Amend DICOM PS 3.6 - Data Dictionary - Annex A - Registry of DICOM Unique Identifiers (UIDs) as follows:

Table A-1. UID Values

UID Value	UID NAME	UID TYPE	Part
...	...	...	...
1.2.840.10008.5.1.4.1.1.30	**Parametric Map Storage**	**SOP Class**	**PS 3.4**
...	...	...	...

Table A-3. Context Group UID Values

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.1009	**7222**	**Parametric Map Derivation Image Purpose of Reference**

DICOM PS3.16 Content Mapping Resource

B DCMR Context Groups (Normative)

Amend DICOM PS 3.16 - Content Mapping Resource - Annex B - DCMR Context Groups (Normative) as follows, to add new Context Groups for Parametric Maps:

CID 7222 Parametric Map Derivation Image Purpose of Reference

Type: **Extensible**

Version: **20141110**

Table CID 7222. Parametric Map Derivation Image Purpose of Reference

Coding Scheme Designator	Code Value	Code Meaning
DCM	121322	Source Image for Image Processing Operation

DICOM PS3.17 Explanatory Information

Amend DICOM PS 3.17 - Explanatory Information to add new Annex QQQ - Parametric Maps as follows:

QQQ Parametric Maps (Informative)

Amend DICOM PS 3.17 - Explanatory Information to add new Annex XXX:

QQQ.1

This Annex contains examples of the use of the Parametric Map IOD.

QQQ.1.1

This Section contains an example of the use of the Parametric Map IOD to encode Ktrans for a Dynamic Contrast Enhanced (DCE) MR.

The frames comprise a single traversal of a regularly sampled 3D volume, described as a single stack and a single quantity, with dimensions of Stack ID, In-Stack Position Number and Quantity. A reference is also provided to the (single entire multi-frame) MR image from which the parametric map was derived. Only the Frame Content Sequence and Plane Position Sequence vary per-frame; all other functional groups are shared in this example.

Nesting	Attribute	Tag	VR	VL (hex)	Value
	Specific Character Set	(0008,0005)	CS	000a	ISO_IR 100
	Image Type	(0008,0008)	CS	0022	DERIVED\SECONDARY\PERFUSION\KTRANS
	Instance Creation Date	(0008,0012)	DA	0008	20140312
	Instance Creation Time	(0008,0013)	TM	000a	141900.944
	Instance Creator UID	(0008,0014)	UI	0016	1.3.6.1.4.1.5962.99.3
	SOP Class UID	(0008,0016)	UI	0016	1.3.6.1.4.1.5962.301.9
	SOP Instance UID	(0008,0018)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.2.0
	Study Date	(0008,0020)	DA	0008	20140312
	Series Date	(0008,0021)	DA	0008	20140312
	Content Date	(0008,0023)	DA	0008	20140312
	Study Time	(0008,0030)	TM	000a	141900.944
	Series Time	(0008,0031)	TM	000a	141900.944
	Content Time	(0008,0033)	TM	000a	141900.944
	Accession Number	(0008,0050)	SH	0000	
	Modality	(0008,0060)	CS	0002	MR
	Manufacturer	(0008,0070)	LO	0000	
	Referring Physician's Name	(0008,0090)	PN	0008	Doe^John
	Study Description	(0008,1030)	LO	002C	Dynamic magnetic resonance imaging of pelvis
	Procedure Code Sequence	(0008,1032)	SQ	ffffffff	

Nesting	Attribute	Tag	VR	VL (hex)	Value
%item					
	Code Value	(0008,0100)	SH	0008	P5-70694
	Coding Scheme Designator	(0008,0102)	SH	0004	SRT
	Code Meaning	(0008,0104)	LO	002C	Dynamic magnetic resonance imaging of pelvis
%enditem					
%endseq					
	Series Description	(0008,103E)	LO	0010	PK Model Results
	Patient's Name	(0010,0010)	PN	0008	Doe^Jane
	Patient ID	(0010,0020)	LO	0004	1234
	Patient's Birth Date	(0010,0030)	DA	0000	
	Patient's Sex	(0010,0040)	CS	0000	
	Study Instance UID	(0020,000d)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.4.0
	Series Instance UID	(0020,000e)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.3.0
	Study ID	(0020,0010)	SH	0004	5678
	Series Number	(0020,0011)	IS	0004	100
	Instance Number	(0020,0013)	IS	0002	1
	Patient Orientation	(0020,0020)	CS	0000	
	Frame of Reference UID	(0020,0052)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.5.0
	Position Reference Indicator	(0020,1040)	LO	0000	
	Dimension Organization Sequence	(0020,9221)	SQ	ffffffff	
%item					
	Dimension Organization UID	(0020,9164)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.6.0
%enditem					
%endseq					
	Dimension Index Sequence	(0020,9222)	SQ	ffffffff	
%item					
	Dimension Organization UID	(0020,9164)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.6.0
	Dimension Index Pointer	(0020,9165)	AT	0004	(0020,9056)
	Functional Group Pointer	(0020,9167)	AT	0004	(0040,9096)
	Dimension Description Label	(0020,9421)	LO	0008	Stack ID

Nesting	Attribute	Tag	VR	VL (hex)	Value
%enditem					
%item					
	Dimension Organization UID	(0020,9164)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.6.0
	Dimension Index Pointer	(0020,9165)	AT	0004	(0020,9057)
	Functional Group Pointer	(0020,9167)	AT	0004	(0020,9111)
	Dimension Description Label	(0020,9421)	LO	0018	In-Stack Position Number
%enditem					
%item					
	Dimension Organization UID	(0020,9164)	UI	003e	1.3.6.1.4.1.5962.99.1.3078904268.1788845519.1394648340940.6.0
	Dimension Index Pointer	(0020,9165)	AT	0004	(0040,9220) (the Quantity Definition Code Sequence (CP 1387))
	Functional Group Pointer	(0020,9167)	AT	0004	(0020,9111)
	Dimension Description Label	(0020,9421)	LO	0008	Quantity
%enditem					
%endseq					
	Samples per Pixel	(0028,0002)	US	0002	0001
	Photometric Interpretation	(0028,0004)	CS	000c	MONOCHROME2
	Number of Frames	(0028,0008)	IS	0002	14
	Rows	(0028,0010)	US	0002	256 dec
	Columns	(0028,0011)	US	0002	256 dec
	Bits Allocated	(0028,0100)	US	0002	0020 hex
	Burned In Annotation	(0028,0301)	CS	0002	NO
	Recognizable Visual Features	(0028,0302)	CS	0002	NO
	Lossy Image Compression	(0028,2110)	CS	0002	00
	Presentation LUT Shape	(2050,0020)	CS	0008	IDENTITY
	Shared Functional Groups Sequence	(5200,9229)	SQ	ffffffff	
%item					
	Derivation Image Sequence	(0008,9124)	SQ	ffffffff	
%item					
	Source Image Sequence	(0008,2112)	SQ	ffffffff	

Nesting	Attribute	Tag	VR	VL (hex)	Value
%item					
	Referenced SOP Class UID	(0008,1150)	UI	001C	1.2.840.10008.5.1.4.1.1.4.1
	Referenced SOP Instance UID	(0008,1155)	UI	002E	1.3.6.1.4.1.5962.1.1.0.0.0.1410021852.13877.0
	Spatial Locations Preserved	(0028,135A)	CS	0004	YES
	Purpose of Reference Code Sequence	(0040,A170)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	121322
	Coding Scheme Designator	(0008,0102)	SH	0004	DCM
	Code Meaning	(0008,0104)	LO	002C	Source image for image processing operation
%enditem					
%endseq					
%enditem					
%endseq					
	Derivation Code Sequence	(0008,9215)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	113066
	Coding Scheme Designator	(0008,0102)	SH	0004	DCM
	Code Meaning	(0008,0104)	LO	000C	Time Course of Signal
%enditem					
%endseq					
%enditem					
%endseq					
	Frame Anatomy Sequence	(0020,9071)	SQ	ffffffff	
%item					
	Anatomic Region Sequence	(0008,2218)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0008	T-9200B
	Coding Scheme Designator	(0008,0102)	SH	0004	SRT
	Code Meaning	(0008,0104)	LO	0008	Prostate
%enditem					
%endseq					
	Frame Laterality	(0020,9072)	CS	0002	U
%enditem					
%endseq					

Nesting	Attribute	Tag	VR	VL (hex)	Value
	Plane Orientation Sequence	(0020,9116)	SQ	ffffffff	
%item					
	Image Orientation (Patient)	(0020,0037)	DS	0064	0.99979773312597\-.0160528955995\.012115996823878\ .012116000683426\0.96149705857037\.274548008348208
%enditem					
%endseq					
	Pixel Measures Sequence	(0028,9110)	SQ	ffffffff	
%item					
	Slice Thickness	(0018,0050)	DS	0010	5.9999942779541
	Pixel Spacing	(0028,0030)	DS	0022	1.01559996604919\1.01560020446777
%enditem					
%endseq					
	Frame VOI LUT Sequence	(0028,9132)	SQ	ffffffff	
%item					
	Window Center	(0028,1050)	DS	0004	2.5
	Window Width	(0028,1051)	DS	0002	5
	VOI LUT Function	(0028,1056)	CS	000c	LINEAR_EXACT
%enditem					
%endseq					
	Pixel Value Transformation Sequence	(0028,9145)	SQ	ffffffff	
%item					
	Rescale Intercept	(0028,1052)	DS	0002	0
	Rescale Slope	(0028,1053)	DS	0002	1
	Rescale Type	(0028,1054)	LO	0002	US
%enditem					
%endseq					
	Real World Value Mapping Sequence	(0040,9096)	SQ	ffffffff	
%item					
	LUT Explanation	(0028,3003)	LO	0006	Ktrans
	Measurement Units Code Sequence	(0040,08ea)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0004	/min
	Coding Scheme Designator	(0008,0102)	SH	0004	UCUM
	Code Meaning	(0008,0104)	LO	0004	/min
%enditem					

Nesting	Attribute	Tag	VR	VL (hex)	Value
%endseq					
	LUT Label	(0040,9210)	SH	0006	Ktrans
	Real World Value Last Value Mapped	(0040,9211)	XS	0002	0005
	Real World Value First Value Mapped	(0040,9216)	XS	0002	0000
	Real World Value Intercept	(0040,9224)	FD	0008	0
	Real World Value Slope	(0040,9225)	FD	0008	1
	Quantity Definition Code Sequence (CP 1387)	(0040,9220)	SQ	ffffffff	
%item					
	Value Type	(0040,a040)	CS	0004	CODE
	Concept Name Code Sequence	(0040,a043)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	G-C1C6
	Coding Scheme Designator	(0008,0102)	SH	0004	SRT
	Code Meaning	(0008,0104)	LO	0008	Quantity
%enditem					
%endseq					
	Concept Code Sequence	(0040,a168)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	dd2d60 (CP1391)
	Coding Scheme Designator	(0008,0102)	SH	0004	DCM
	Code Meaning	(0008,0104)	LO	0006	Ktrans
%enditem					
%endseq					
%enditem					
%item					
	Value Type	(0040,a040)	CS	0004	CODE
	Concept Name Code Sequence	(0040,a043)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	G-C036
	Coding Scheme Designator	(0008,0102)	SH	0004	SRT
	Code Meaning	(0008,0104)	LO	0012	Measurement Method

Nesting	Attribute	Tag	VR	VL (hex)	Value
%enditem					
%endseq					
	Concept Code Sequence	(0040,a168)	SQ	ffffffff	
%item					
	Code Value	(0008,0100)	SH	0006	dd2d71 (CP1391)
	Coding Scheme Designator	(0008,0102)	SH	0004	DCM
	Code Meaning	(0008,0104)	LO	0014	Standard Tofts Model
%enditem					
%endseq					
%enditem					
%endseq					
%enditem					
%endseq					
	Parametric Map Frame Type Sequence	(0040,9092)	SQ	ffffffff	
%item					
	Frame Type	(0008,9007)	CS	0022	DERIVED\SECONDARY\PERFUSION\KTRANS
%enditem					
%endseq					
%enditem					
%endseq					
	Per-frame Functional Groups Sequence	(5200,9230)	SQ	ffffffff	
%item					
	Frame Content Sequence	(0020,9111)	SQ	ffffffff	
%item					
	Stack ID	(0020,9056)	SH	0002	1
	In-Stack Position Number	(0020,9057)	UL	0004	0001
	Dimension Index Values	(0020,9157)	UL	000C	00000001,00000001,00000001
%enditem					
%endseq					
	Plane Position Sequence	(0020,9113)	SQ	ffffffff	
%item					
	Image Position (Patient)	(0020,0032)	DS	0032	-153.28300476074\-111.93399810791\-54.366100311279
%enditem					
%endseq					

Nesting	Attribute	Tag	VR	VL (hex)	Value
%enditem					
%	...				
%endseq					
	Float Pixel Data	(7FE0,0008)	OF	380000	[]