Digital Imaging and Communications in Medicine (DICOM)

Supplement 103: Real World Value Mapping SOP Class

Prepared by:

DICOM Working Group 3 – Nuclear Medicine/PET

This is a draft document. Do not circulate, quote, or reproduce it except with the approval of NEMA

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

1300 N. 17th Street Suite 1847

Rosslyn, Virginia 22209 USA

VERSION: Final Text, 2005/08/23.

Table of Contents

Foreword

This Supplement to the DICOM Standard introduces a new IODs and SOP Class for mapping stored image pixel values into real world physical units.

This Supplement proposes changes to the following Parts of the DICOM Standard:

5

PS 3.2 - Conformance

PS 3.3 - Information Object Definitions

PS 3.4 - Service Class Specifications

PS 3.6 - Data Dictionary

PS 3.16 - Content Mapping Resource

10

Scope and Field of Application

Some image modalities produce images whose stored pixel values can be mapped into some real world value in defined units. An obvious example is CT, for which the units are almost always Hounsfield Units, and this is known when an instance of the image is created. However, the choice of units is not always known at the time of image creation, and there indeed can be
15 multiple choices of units, and these may be determined after the image has been further processed. A new and separate composite storage SOP Class is defined to capture such retrospectively determined mappings.

Several of the image objects to which real world value mapping is relevant contain a mechanism to encode such a mapping, and this includes the CT and PET IODs, which use the Rescale Slope
20 and Intercept and specify the output units as Units in the case of PET. The MR IOD does not, though physical units are rarely defined for MR. The NM IOD lacks any such mechanism. Furthermore, the use of Rescale Slope and Intercept is incorporated in the grayscale pipeline, and hence Window Center and Width are defined in rescaled units, and this may pose problems when those units are very small and/or fractional. For example, PET SUV scaling may result in a
25 Rescale Slope of 0.000025 and make it necessary to use Window Centers and Widths that are less than 1.0. Only the more recent Enhanced CT and MR IODs offer the possibility of specifying a real world value mapping independent of the grayscale transformation pipeline, and of specifying more than one real world value mapping for the same pixels. The latter is particularly desirable for some applications, which are currently satisfied by sending entire images multiple
30 times with different mappings, e.g., PET as counts, concentration and SUVs.

Just as the Grayscale Presentation State Storage and Spatial Registration IODs are encoded as separate SOP Instances that reference images, rather than replicate the pixel data, a separate IOD is defined to incorporate the Real World Value Mapping Sequence introduced in the Enhanced CT and MR IODs, which may be applied by the SCP to a list of referenced image SOP
35 Instances. This object allows for more than one mapping of the same stored pixel values (multiple Real World Value Mapping Sequence Items), and it allows for different mapping parameters for each referenced image and potentially frame or set of frames. A referencing mechanism similar to that used in Grayscale Presentation State Storage and Spatial Registration is used. The object is separate from any Presentation State, since these may need to be generated and applied
40 independently.

Part 2 Additions

Add new SOP Class to overview table.

45

Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.67	Real World Value Mapping Storage	Transfer
…		

Part 3 Additions

50	*Add Real World Value Mapping IE to Figure 7-1a and 7-2a in Section 7, with accompanying description*

Figure 7-1a

```
                          ┌──────────────┐
                          │  Study IOD   │
                          └──────────────┘
                                 │
                                 │
                                 ▼
                              ╱──────╲         1
                             ⟨ references ⟩
                              ╲──────╱
                                 │
          ┌──────────────────────┼──────────────┐
          │                      │          0-n  ▼
          │                      │       ┌─────────────────┐
          │                      │       │ Real World Value│
          │                      │       │  mapping IOD    │
          │                      │       └─────────────────┘
                          0-n    ▼
                          ┌──────────────┐
                          │   … IOD      │
                          └──────────────┘
```
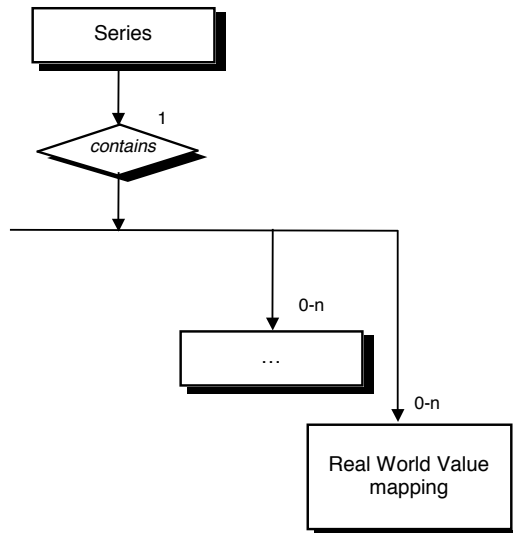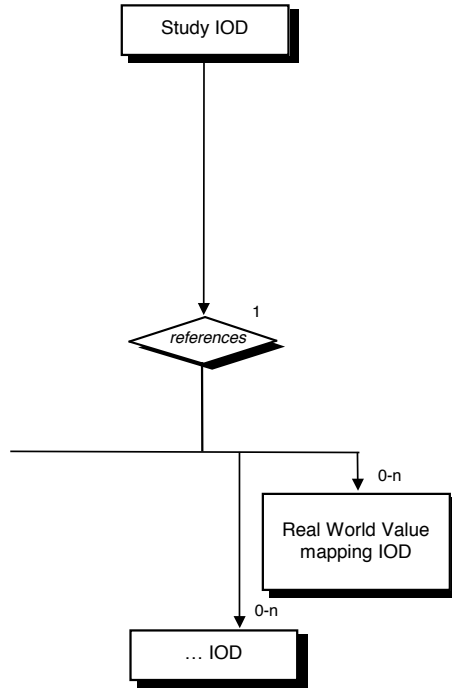
55

Figure 7-2a

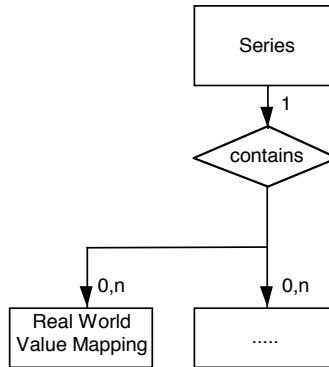60   *Add Real World Value mapping IE to Figure A.1-1*

Figure A.1-1

A.1.2.X Real World Value Mapping IE

The Real World Value Mapping IE defines the attributes that describe the mapping of stored pixel
65   data to real world values.

Modify PS3.3 Table A.1-2 to add new IODs and Modules for Real World Value Mapping

IODs Modules	Real World Value Mapping
Patient	**M**
Patient Summary	
Specimen Identification	**U**
Clinical Trial Subject	**U**
General Study	**M**
Patient Study	**U**
Clinical Trial Study	**U**
Study Content	
General Series	**M**
Clinical Trial Series	**U**
Real World Value Mapping Series	**M**
Spatial	

Registration Series	
Spatial Fiducials Series	
PET Series	
PET Isotope	
PET Multi-gated Acquisition	
RT Series	
Presentation Series	
SR Document Series	
Key Object Document Series	
Frame Of Reference	
Synchronization	
Cardiac Synchronization	
Respiratory Synchronization	
Bulk Motion Synchronization	
General Equipment	**M**
General Image	
Image Plane	
Image Pixel	
Multi-frame	
Multi-frame Functional Groups	
Multi-frame Dimension	
Mask	
Display Shutter	
Bitmap Display Shutter	
Raw Data	
MR Spectroscopy	
MR Spectroscopy Pulse Sequence	
MR Spectroscopy Data	

RT Dose	
RT DVH	
Structure Set	
ROI Contour	
RT Dose ROI	
RT ROI Observations	
RT General Treatment Record	
RT Treatment Machine Record	
Measured Dose Reference Record	
Calculated Dose Reference Record	
RT Beams Session Record	
RT Brachy Session Record	
RT Treatment Summary Record	
RT General Plan	
RT Prescription	
RT Tolerance Tables	
RT Patient Setup	
RT Fraction Scheme	
RT Beams	
RT Brachy Application Setups	
Approval	
SR Document General	
SR Document Content	
Key Object Document	
Overlay Identification	
Overlay Plane	
Multi-frame Overlay	
Curve Identification	
Curve	
PET Curve	

Audio	
Waveform Identification	
Waveform	
Waveform Annotation	
Displayed Area	
Overlay/Curve Activation	
Graphic Annotation	
Real World Value Mapping	**M**
Spatial Transformation	
Graphic Layer	
Modality LUT	
VOI LUT	
Softcopy VOI LUT	
Softcopy Presentation LUT	
Image Histogram	
Presentation State	
LUT Identification	
Spatial Registration	
Spatial Fiducials	
Common Instance Reference	**M**
Acquisition Context	
SOP Common	**M**

70

Modify PS3.3 Section A.X to add new IOD for Real World Value Mapping

A.X REAL WORLD VALUE MAPPING IOD MODULE TABLE

Table A.X-1 Real World Value Mapping IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
	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
	Clinical Trial Series	C.7.3.2	U
	Real World Value Mapping Series	**C.X.0**	**M**
Equipment	General Equipment	C.7.5.1	M
Real World Value Mapping	**Real World Value Mapping**	**C.X.1**	**M**
	Common Instance Reference	C.12.2	M
	SOP Common	C.12.1	M

75

The following Modules and Macros already exist in PS 3.3 and are used by this IOD. They must be read to understand how this IOD works. For example, the Referenced Real World Value Mapping SOP Instance Sequence must be single valued because the existing Real World Value Mapping Macro defines the sequence that lists all of the referenced images.

80   *C.12.2   Common Instance Reference Module*

10.3   Image SOP Instance Reference Macro

10.4   Series and Instance Reference Macro

C.7.6.16.2.11   Real World Value Mapping Macro

85   *Modify PS3.3 Section C.X to add new Modules for Real World Value Mapping*

C.X REAL WORLD VALUE MAPPING MODULES

C.X.0 Real World Value Mapping Series Module

Table C.X.0-1 defines the general Attributes of the Real World Value Mapping Series Module.

90
Table C.X.0-1
REAL WORLD VALUE MAPPING SERIES MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Modality type. Enumerated Value: RWV

C.X.1 Real World Value Mapping Module

Table C.X.1-1 defines the general Attributes of the Real World Value Mapping Module.

95

Table C.X.1-1
REAL WORLD VALUE MAPPING MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Content Date	(0008,0023)	1	The date the content creation started.
Content Time	(0008,0033)	1	The time the content creation started.
Instance Number	(0020,0013)	1	A number that identifies this instance
Content Label	(0070,0080)	1	A label that is used to identify this registration.
Content Description	(0070,0081)	2	A description of this real world value mapping.
Content Creator's Name	(0070,0084)	2	Name of the person who created the real world value mapping.
Content Creator's Identification Sequence	(0070,0086)	3	Identification of the person who created the real world value mapping. Only a single item shall be present in this sequence.
> Include Person Identification Macro Table 10-1			
Referenced Image Real World Value Mapping Sequence	(0040,9094)	1	A sequence of one or more real world value mapping items. Each item defines a single mapping and a list of images to which the mapping applies.
>Include Real World Value Mapping Macro Table C.7.6.16-12, overriding the Defined Context ID for Measurement Units Code Sequence with DCID 83.			
>Referenced Image Sequence	(0008,1140)	1	A sequence listing the images to which the mapping applies. One or more items shall be present.
>>Include 'Image SOP Instance Reference Macro' Table 10-3			

Modify PS3.3 Section C.18.4 to include references in Structured Reports to Real World Value Mapping objects together with image references:

100

C.18.4 Image Reference Macro

Table C.18.4-1 specifies the Attributes that convey a reference to a DICOM image.

Table C.18.4-1
IMAGE REFERENCE MACRO ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Include 'Composite Object Reference Macro' Table C.18.3-1			
>Referenced Frame Number	(0008,1160)	1C	Identifies the frame numbers within the Referenced SOP Instance to which the reference applies. The first frame shall be denoted as frame number 1. Note: This Attribute may be multi-valued. Required if the Referenced SOP Instance is a multi-frame image and the reference does not apply to all frames.
>Referenced SOP Sequence	(0008,1199)	3	Reference to a Softcopy Presentation State SOP Class/SOP Instance pair. Only a single Item shall be permitted in this sequence.
>>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class. ~~Shall be the same for all Images referenced by this presentation state.~~
>>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.
>Referenced Real World Value Mapping Instance Sequence	**(0008,114B)**	**3**	**Reference to a Real World Value Mapping SOP Class/SOP Instance pair. Only a single Item shall be permitted 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.**
>Icon Image Sequence	(0088,0200)	3	This Icon Image is representative of the Image. The Icon Image may be no greater than 128 rows by 128 columns.
>> Include 'Image Pixel Macro' Table C.7-11b			See Section F.7.

105

> *Modify PS3.3 Annex F to include directory record for Real World Value Mapping object:*

F.3.2.2 Directory Information Module

110   …

Table F.3-3
DIRECTORY INFORMATION MODULE

Attribute Name	Tag	Type	Attribute Description
…	…	…	…
>Directory Record Type	(0004,1430)	1C	Defines a specialized type of Directory Record by reference to its position in the Media Storage Directory Information Model (see Section F.4). Required if the Directory Record Sequence (0004,1220) is not zero length. Enumerated Values (see Section F.5): PATIENT STUDY SERIES IMAGE OVERLAY MODALITY LUT VOI LUT CURVE TOPIC VISIT RESULTS INTERPRETATION STUDY COMPONENT STORED PRINT RT DOSE RT STRUCTURE SET RT PLAN RT TREAT RECORD PRESENTATION WAVEFORM SR DOCUMENT KEY OBJECT DOC SPECTROSCOPY RAW DATA REGISTRATION FIDUCIAL **<u>VALUE MAP</u>** PRIVATE = Privately defined record hierarchy position. Type shall be defined by Private Record UID (0004,1432). MRDR = Special Directory Record which allows indirect reference to a File by multiple Directory Records. Instead of directly referencing a File by its Referenced File ID (0004,1500), a Directory Record of any of the Types define above (except MRDR) may reference a Multi-Referenced File Directory Record which in turn will reference the File by its File ID. Note: Enumerated Values PRINT QUEUE, FILM SESSION, FILM BOX, and IMAGE BOX were previously defined in DICOM for this Attribute. They are now retired. See PS3.3-1998.
…	…	…	…

      …

F.4 BASIC DIRECTORY IOD INFORMATION MODEL

115   …

Table F.4-1
RELATIONSHIP BETWEEN DIRECTORY RECORDS

Directory Record Type	Section	Directory Record Types which may be included in the next lower-level directory Entity
(Root Directory Entity)	—	PATIENT, TOPIC, PRIVATE
PATIENT	F.5.1	STUDY, PRIVATE
STUDY	F.5.2	SERIES, VISIT, RESULTS, STUDY COMPONENT PRIVATE
SERIES	F.5.3	IMAGE, OVERLAY, MODALITY LUT, VOI LUT, CURVE, STORED PRINT, RT DOSE, RT STRUCTURE SET, RT PLAN, RT TREAT RECORD, PRESENTATION, WAVEFORM, SR DOCUMENT, KEY OBJECT DOC, SPECTROSCOPY, RAW DATA, REGISTRATION, FIDUCIAL, **VALUE MAP,** PRIVATE
IMAGE	F.5.4	PRIVATE
OVERLAY	F.5.5	PRIVATE
MODALITY LUT	F.5.6	PRIVATE
VOI LUT	F.5.7	PRIVATE
CURVE	F.5.8	PRIVATE
STORED PRINT	F.5.18	PRIVATE
RT DOSE	F.5.19	PRIVATE
RT STRUCTURE SET	F.5.20	PRIVATE
RT PLAN	F.5.21	PRIVATE
RT TREAT RECORD	F.5.22	PRIVATE
PRESENTATION	F.5.23	PRIVATE
WAVEFORM	F.5.24	PRIVATE
SR DOCUMENT	F.5.25	PRIVATE
KEY OBJECT DOC	F.5.26	PRIVATE
SPECTROSCOPY	F.5.27	PRIVATE
RAW DATA	F.5.28	PRIVATE
REGISTRATION	F.5.29	PRIVATE
FIDUCIAL	F.5.30	PRIVATE
VALUE MAP	**F.5.31**	**PRIVATE**
TOPIC	F.5.9	STUDY, SERIES, IMAGE, OVERLAY, MODALITY LUT, VOI LUT, CURVE, STORED PRINT, RT DOSE, RT STRUCTURE SET, RT PLAN, RT TREAT RECORD, PRESENTATION, WAVEFORM, SR DOCUMENT, KEY OBJECT DOC, SPECTROSCOPY, RAW DATA, REGISTRATION, FIDUCIAL, **VALUE MAP,** PRIVATE
VISIT	F.5.10	PRIVATE
RESULTS	F.5.11	INTERPRETATION, PRIVATE

INTERPRETATION	F.5.12	PRIVATE
STUDY COMPONENT	F.5.13	PRIVATE
PRIVATE	F.6.1	PRIVATE, (any of the above as privately defined)
MRDR	F.6.2	(Not applicable)

Add PS3.3 F.5. Real World Value Mapping directory record:

120

F.5.xx   Real World Value Mapping directory record definition

The Directory Record is based on the specification of Section F.3. It is identified by a Directory Record Type of Value "VALUE MAP." Table F.5-31 lists the set of keys with their associated Types for such a Directory Record Type. The description of these keys may be found in the Modules
125   related to the Real World Value Mapping IE of Real World Value Mapping IOD. This Directory Record shall be used to reference a Real World Value Mapping SOP Instance. This type of Directory Record may reference a Lower-Level Directory Entity that includes one or more Directory Records as defined in Table F.4-2.

Table F.5-xx
130   **REAL WORLD VALUE MAPPING KEYS**

Key	Tag	Type	Attribute Description
Specific Character Set	(0008,0005)	1C	Required if an extended or replacement character set is used in one of the keys.
Content Date	(0008,0023)	1	The date the content creation started.
Content Time	(0008,0033)	1	The time the content creation started.
Instance Number	(0020,0013)	1	A number that identifies this instance
Content Label	(0070,0080)	1	A label that is used to identify this registration.
Content Description	(0070,0081)	2	A description of this registration.
Content Creator's Name	(0070,0084)	2	Name of operator performing the registration (such as a technologist or physician).
Any other Attribute of the Real World Value Mapping IE Modules		3	

Note: Because (0004,1511) Referenced SOP Instance UID in File may be used as a "pseudo" Directory Record Key (See Table F.3-3), it is not duplicated in this list of keys.

135

Part 4 Additions

Add to PS3.4 Annex B.5.

B.5 STANDARD SOP CLASSES

140

Table B.5-1
STANDARD SOP CLASSES

SOP Class Name	SOP Class UID	IOD (See PS 3.3)
…		
Real World Value Mapping Storage	**1.2.840.10008.5.1.4.1.1.67**	**Real World Value Mapping**

Add to PS3.4 Annex I.4.

145 **I.4 MEDIA STANDARD STORAGE SOP CLASSES**

Table I.4-1
Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD (See PS 3.3)
…		
Real World Value Mapping Storage	**1.2.840.10008.5.1.4.1.1.67**	**Real World Value Mapping**

150

Part 6 Additions

Add to PS3.6 Section 6

(0040,9094)	Referenced Image Real World Value Mapping Sequence	SQ	1
(0070,0086)	Content Creator's Identification Sequence	SQ	1
(0008,114B)	Referenced Real World Value Mapping Instance Sequence	SQ	1

Add to PS3.6 Annex A

155

UID Value	UID NAME	UID TYPE	Part
…			
1.2.840.10008.5.1.4.1.1.67	**Real World Value Mapping Storage**	**SOP Class**	**PS 3.4**

Part 16 Additions

Modify PS3.16 to add new Context Group for Units for Real World Value Mapping

160

CID 83 Units for Real World Value Mapping

CID 83
Units for Real World Value Mapping
Type: Extensible Version: 20050822

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
UCUM	[hnsf'U]	Hounsfield unit
UCUM	{counts}	Counts
UCUM	{counts}/s	Counts per second
UCUM	{SUVbw}g/ml	Standardized Uptake Value body weight
UCUM	{SUVlbm}g/ml	Standardized Uptake Value lean body mass
UCUM	{SUVbsa}cm2/ml	Standardized Uptake Value body surface area

165