

# **Digital Imaging and Communications in Medicine (DICOM)**

*Supplement 141: Enhanced MR Color Image Storage SOP Class*

**DICOM Standards Committee, Working Group 16, Magnetic Resonance**

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## Scope and Application

DICOM WG 16 has determined that there is a need for a new Enhanced MR Color Image Storage SOP Class to meet the needs of state of the art MR technology that has evolved to include color information.

New applications in brain MRI require more sophisticated support of color than is provided by the existing Enhanced MR or Secondary Capture SOP Classes. For example:

1. fixed coloring per diffusion direction,
2. fixed coloring for successive fMRI studies of the same patient,
3. fixed coloring for combinations of fMRI and diffusion studies of the same patient.

The existing MR SOP Classes either do not support color at all (MR Image), or support only Supplemental Palette Color (Enhanced MR Image); the latter only provides for a limited number of color entries to replace underlying grayscale information and is insufficient. The single and multi-frame Secondary Capture SOP Classes do support true color, but do not provide a standard mechanism to encode the MR technique attributes that are important for the use and interpretation of the color MR images.

This Supplement describes the Enhanced MR Color Image Storage SOP Class, based on the Enhanced MR Image Storage SOP Class (rather than extending the Multi-frame True Color Secondary Capture Image Storage SOP Class with full MR functional groups). The photometric interpretation of the pixel data is true color RGB rather than a monochrome (quantitative) component in the pixel values.

This allows display systems that already handle the Enhanced MR SOP Class to adapt their display pipeline with little additional work, and those systems that handle MultiFrame True Color Secondary Capture SOP Class to display MR images with virtually no additional work. It is not the intention that this new SOP class replaces the Enhanced MR SOP Class by encoding grayscale pixel values code as RGB.

It does not add new services, messaging or encoding.

**Changes to NEMA Standards Publication PS 3.2-2008**

**Digital Imaging and Communications in Medicine (DICOM)**

**Part 2: Conformance**

**Item #1: Add SOP Class to Table A.1-2**

**Table A.1-2  
UID VALUES**

<b>UID Value</b>	<b>UID NAME</b>	<b>Category</b>
...		
<u><b>1.2.840.10008.5.1.4.1.1.4.3</b></u>	<u><b>Enhanced MR Color Image Storage SOP Class</b></u>	<u><b>Transfer</b></u>
...		

**Changes to NEMA Standards Publication PS 3.3-2008**

**Digital Imaging and Communications in Medicine (DICOM)**

**Part 3: Information Object Definitions**

**Item #2: Add a column for the new IOD to Section A.1.4, Table A.1-1**

IODs Modules	Enh MR	Enh MR Col
Patient	M	<u>M</u>
Clinical Trial Subject	U	<u>U</u>
General Study	M	<u>M</u>
Patient Study	U	<u>U</u>
Clinical Trial Study	U	<u>U</u>
General Series	M	<u>M</u>
MR Series	M	<u>M</u>
Clinical Trial Series	U	<u>U</u>
Frame Of Reference	M	<u>M</u>
Synchronization	C	<u>C</u>
Cardiac Synchronization	C	<u>C</u>
Respiratory Synchronization	C	<u>C</u>
Bulk Motion Synchronization	C	<u>C</u>
General Equipment	M	<u>M</u>
Enhanced General Equipment	M	<u>M</u>
Image Pixel	M	<u>M</u>
Supplemental PaletteColor Lookup Table	C	
Enhanced Contrast/ Bolus	C	<u>C</u>
Multi-frame Functional Groups	M	<u>M</u>
Multi-frame Dimension	M	<u>M</u>
Device	U	<u>U</u>
Enhanced MR Image	M	<u>M</u>
MR Pulse Sequence	C	<u>C</u>
Acquisition Context	M	<u>M</u>
Specimen	M	<u>M</u>
<b>ICC Profile</b>		<u>M</u>

SOP Common	M	<u>M</u>
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**Add constraint to existing Enhanced MR Image IOD to factor out Photometric Interpretation from Enhanced MR Image Module:**

**A.36.2.3.1 Enhanced MR Image IOD Content Constraints**

...

**The Photometric Interpretation (0028,0004) defined in C.8.13.1 Enhanced MR Image Module, shall be MONOCHROME2.**

**Modify Table A.36-2 as shown:**

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

Functional Group Macro	Section	Usage
...		
Pixel Value Transformation	C.7.6.16.2.9	<b><u>MC – Required if Photometric Interpretation (0028,0004) is MONOCHROME2.</u></b>
Frame VOI LUT	C.7.6.16.2.10	<b><u>U– May be used only if Photometric Interpretation (0028,0004) is MONOCHROME2.</u></b>
Real World Value Mapping	C.7.6.16.2.11	<b><u>U – May be used only if Photometric Interpretation (0028,0004) is MONOCHROME2.</u></b>
...		

**Add new section A.36.4:**

**A.36.4 Enhanced MR Color Image Information Object Definition**

**A.36.4.1 Enhanced MR Color Image IOD Description**

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

**A.36.4.2 Enhanced MR Color 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 Color Image IOD.



**A.36.4.3 Enhanced MR Color Image IOD Module Table**

**Table A.36-5  
ENHANCED MR COLOR IMAGE IOD MODULES**

<b>IE</b>	<b>Module</b>	<b>Reference</b>	<b>Usage</b>
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
	MR Series	C.8.13.6	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
	Enhanced General Equipment	C.7.5.2	M
Image	Image Pixel	C.7.6.3	M
	Enhanced Contrast/Bolus	C.7.6.4b	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
	Specimen	C.7.6.2x Supp 1222	C – Required if Imaging Subject is a specimen
	Device	C.7.6.12	U
	Enhanced MR Image	C.8.13.1	M
	MR Pulse Sequence	C.8.13.4	C – Required if Image Type (0008,0008) Value 1 is ORIGINAL or MIXED. May be present otherwise.
	ICC Profile	C.11.15.1	M
SOP Common	C.12.1	M	

#### A.36.4.3.1 Enhanced MR Color Image IOD Content Constraints

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

Note: In order to annotate images, whether during acquisition or subsequently, SOP Instances of the Color 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.

Color Softcopy Presentation State Storage Instances that are generated during acquisition may be referenced from the Image SOP Instance by using the Referenced Presentation State Sequence in the MR Image and Spectroscopy Instance Macro invoked from the Enhanced MR Image Module. See C.8.13.2.

The Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed transfer syntaxes that do not involve color space transformations, YBR\_ICT for irreversible JPEG2000 transfer syntaxes, YBR\_RCT for reversible JPEG2000 transfer syntaxes, YBR\_PARTIAL\_420 for MPEG2 transfer syntaxes and YBR\_FULL\_422 for other lossy compressed transfer syntaxes.

The Pixel Presentation (0008,9205) shall be TRUE\_COLOR.

#### A.36.4.4 Enhanced MR Color 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 Color Image IOD.

**Factor out the definition of the Photometric Interpretation to the invoking IOD.**

#### C.8.13.1 Enhanced MR Image Module

This section describes the Enhanced MR Image Module.

Table C.8-79 specifies the attributes of the Enhanced MR Image module.

**Table C.8-79  
ENHANCED MR IMAGE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
<i>Include 'MR Image and Spectroscopy Instance Macro' Table C.8-81</i>			
Image Type	(0008,0008)	1	Image characteristics. See C.8.16.1 and C.8.13.3.1.1.
<i>Include Common CT/MR Image Description Macro' Table C.8-131</i>			
<i>Include 'MR Image Description Macro' Table C.8-82</i>			
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. <b>This value shall be 1. For Enumerated Values see C.8.13.1.1.1.</b>
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the

			pixel data. Enumerated Values: <b>MONOCHROME2</b> are specified in the <b>IOD that invokes this Module</b> . See C.7.6.3.1.2 for definition of this term.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. <b>For</b> Enumerated Values: <del>8 and 16</del> see <b>C.8.13.1.1.1</b> .
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. <b>For</b> Enumerated Values: <del>8, 12 and 16</del> . See C.8.13.1.1.1 <b>for specialization</b> .
<b><u>Pixel Representation</u></b>	<b><u>(0028,0103)</u></b>	<b><u>1</u></b>	<b><u>Data representation of the pixel samples. Each sample shall have the same pixel representation. For Enumerated Values see C.8.13.1.1.1</u></b>
<b><u>Planar Configuration</u></b>	<b><u>(0028,0006)</u></b>	<b><u>1C</u></b>	<b><u>Indicates whether the pixel data are sent color-by-plane or color-by-pixel. Required if Samples per Pixel (0028,0002) has a value greater than 1. See C.7.6.3.1.3 and C.8.13.1.1.1 for further explanation.</u></b>
...	...	...	...
Presentation LUT Shape	(2050,0020)	<b><u>1C</u></b>	Specifies an identity transformation for the Presentation LUT, such that the output of all grayscale transformations defined in the IOD containing this Module are defined to be P-Values. Enumerated Values: IDENTITY - output is in P-Values. <b><u>Required if Photometric Interpretation (0028,0004) is MONOCHROME2.</u></b>
...	...	...	...

**C.8.13.1.1 Enhanced MR Image Module Attribute Description**

**C.8.13.1.1.1 Photometric Interpretation, Pixel Representation, Samples per Pixel, Planar Configuration, Bits Allocated and Bits Stored**

Table C.8-80 specifies the **Enumerated Values and** combinations of **Samples per Pixel (0028,0002), Planar Configuration (0028,0006), Pixel Representation (0028,0103)**, Bits Allocated (0028,0100) and Bits Stored (0028,0101) **for each allowable Photometric Interpretation allowed by the IOD that invokes this Module.**

**Table C.8-80**  
**ALLOWED COMBINATIONS OF ATTRIBUTE VALUES**  
**FOR PHOTOMETRIC INTERPRETATION, SAMPLES PER PIXEL, PLANAR**  
**CONFIGURATION, PIXEL REPRESENTATION, BITS ALLOCATED AND BITS STORED**

Photometric Interpretation	<u>Samples per Pixel</u>	<u>Planar Configuration</u>	<u>Pixel Representation</u>	Bits Allocated	Bits Stored
MONOCHROME2	<u>1</u>	:	<u>0 or 1</u>	8	8
MONOCHROME2	<u>1</u>	:	<u>0 or 1</u>	16	12, 16
<u>RGB</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>
<u>YBR ICT</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>
<u>YBR RCT</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>
<u>YBR PARTIAL 420</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>
<u>YBR FULL 422</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>8</u>	<u>8</u>

*Add TRUE COLOR to table C.8-132*

**C.8.16.2.1.1 Pixel Presentation**

**Table C.8-132**  
**PIXEL PRESENTATION ATTRIBUTE VALUES**

<b>Enumerated Value Name</b>	<b>Enumerated Value Description</b>
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.8.13.3.1.2.1.
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 or Enhanced CT 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 or CT Image Frame Type Functional Group.
<u>TRUE_COLOR</u>	<u>Image can be displayed in color only</u>

**Changes to NEMA Standards Publication PS 3.4-2008**

**Digital Imaging and Communications in Medicine (DICOM)**

**Part 4: Service Class Specifications**

**Add the following to Table B.5-1**

## B.5 STANDARD SOP CLASSES

**Table B.5-1  
STANDARD SOP CLASSES**

<b>SOP Class Name</b>	<b>SOP Class UID</b>	<b>IOD Specification (defined in PS 3.3)</b>
Enhanced MR Color Image Storage	1.2.840.10008.5.1.4.1.1.4.3	Enhanced MR Color Image

**Add the following section to Section B.5.1**

### **B.5.1.X Enhanced MR Color Image Storage SOP Class**

An SCP of the Enhanced MR Image Storage SOP Class shall also support the Color 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.

**Add the following to Table I.4-1**

## I.4 MEDIA STORAGE STANDARD SOP CLASSES

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

<b>SOP Class Name</b>	<b>SOP Class UID</b>	<b>IOD Specification</b>
Enhanced MR Color Image Storage	1.2.840.10008.5.1.4.1.1.4.3	Enhanced MR Color Image

**Add the following UID to Part 6 Annex A:**

**Annex A Registry of DICOM unique identifiers (UID)  
(Normative)**

**Table A-1  
UID VALUES**

<b>UID Value</b>	<b>UID NAME</b>	<b>UID TYPE</b>	<b>Part</b>
1.2.840.10008.5.1.4.1.1.4.3	Enhanced MR Color Image Storage	SOP Class	PS 3.4