Digital Imaging and Communications in Medicine (DICOM)

Supplement 252: For Processing CT SOP Classes

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VERSION: Draft Final Text

Developed pursuant to DICOM Work Item: 2025-09-A

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Scope and Field of Application

This Supplement adds “For Processing” storage SOP Classes based on the existing CT Image IOD, Enhanced CT Image IOD, and Legacy Converted Enhanced CT Image IOD.

“For Processing” storage SOP Classes in DICOM facilitate the exchange and storage of images needed for processing while distinguishing them from those for presentation. This supports appropriate data pipelines while not disrupting reading workflow with images not intended for presentation.

These new SOP Classes mirror existing Mammography, Intra-Oral X-ray, and Digital X-ray For Processing SOP Classes.

One application of the “For Processing” storage SOP Classes is to store and exchange CT basis images created by the multi-energy decomposition process. These are not typically diagnostic themselves, but can be processed to generate an extensive variety of diagnostic images (iodine maps, virtual non-contrast images, virtual monoenergetic images at various energy levels, calcium maps, etc.). Hanging Protocols would typically ignore these For Processing images.

Changes to NEMA Standards Publication PS 3.3

Modify Table A.1-1a to add a row for the CT Series Module (for Enhanced CT IODs) and add a row for the Single-Frame CT Series Module (for CT IODs)

Modify the CT Image IOD to add the new Single-Frame CT Series Module

A.3.3 CT Image IOD Module Table

…

Table A.3-1. CT Image IOD Modules

IE	Module	Reference	Usage
…			
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Single-Frame CT Series	**C.8.2.X**	**C - Required if the SOP Class UID of this instance is 1.2.840.10008.5.1.4.1.1.2.XXUID (CT Image Storage - For Processing)**
…			

Modify C.8.2.1.1.1. to add codes for Basis and Noisemap images to Image Type for single-frame CT

C.8.2.1.1 CT Image Module Attribute Descriptions

C.8.2.1.1.1 Image Type

…

Defined Terms for Value 4 for Multi-energy CT Images:

VMI

a Virtual Monoenergetic Image. Each real-world value mapped pixel represents CT Hounsfield units and is analogous to a CT image created by a monoenergetic (of a specific keV value) X-Ray beam.

MAT_SPECIFIC

a Material-Specific Image. Each real-world value mapped pixel value represents a property of a material such as attenuation, concentration or density.

MAT_REMOVED

An image with the attenuation contribution of one or more materials removed. For pixels that did not contain any of the removed material(s), the pixel values are unchanged.

MAT_FRACTIONAL

a Material-Fractional Image. Each real-world value mapped pixel represents the fraction of a voxel occupied by a material.

EFF_ATOMIC_NUM

an Effective Atomic Number Image. Each real-world value mapped pixel represents Effective Atomic Number of the materials in the voxel.

ELECTRON_DENSITY

an Electron Density Image. Each real-world value mapped pixel represents the number of electrons per unit volume or the electron density relative to water.

MAT_MODIFIED

a Material-Modified Image. CT ~~I~~image where real-world value mapped pixels have been modified to highlight a certain target material (either by partially suppressing the background or by enhancing the target material), or to partially suppress the target material.

MAT_VALUE_BASED

a Value-Based Image. CT ~~I~~image where real-world value mapped pixels represent a certain value for a specified material

BASIS

a Basis Image. CT image generated by multi-energy decomposition and used to generate spectral images.

NOISE_MAP

a Noise Map Image. An image that represents the presence of noise in pixels of a CT image.

Note

Multi-energy CT images are not necessarily DERIVED and may be ORIGINAL\PRIMARY.

When an image is created by a generic transformation an implementation-specific Value 4 may be provided.

…

Add a new Single-Frame CT Series Module in PS3.3 with Presentation Intent

C.8.2.X Single-Frame CT Series Module

Table C.8-Y specifies the Attributes of the Single-Frame CT Series Module, which describe single-frame CT series.

Table C.8-Y. Single-Frame CT Series Module Attributes

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Type of device, process or method that originally acquired the data used to create the images in this Series. Enumerated Values: CT See Section C.7.3.1.1.1 for further explanation.
Presentation Intent Type	(0008,0068)	1C	Identifies the intent of the images that are contained within this Series. Enumerated Values: FOR PRESENTATION FOR PROCESSING Required if SOP Class UID (0008,0016) equals "1.2.840.10008.5.1.4.1.1.2.XXUID" (CT Image Storage - For Processing). May be present otherwise. See Section C.8.15.1.1.1 for further explanation.

120

121 ***Modify CT Series Module to add Presentation Intent for Enhanced CT***

122 **C.8.15.1 CT Series Module**

123 **…**

124 **Table C.8-113. CT Series Module Attributes**
125

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Type of device, process or method that originally acquired the data used to create the images in this Series. Enumerated Values: CT See Section C.7.3.1.1.1 for further explanation.
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 Attributes"			
Presentation Intent Type	**(0008,0068)**	**1C**	**Identifies the intent of the images that are contained within this Series.**

Attribute Name	Tag	Type	Attribute Description
			Enumerated Values: **FOR PRESENTATION** **FOR PROCESSING** **Required if SOP Class UID (0008,0016) equals "1.2.840.10008.5.1.4.1.1.2.YYUID" (Enhanced CT Image Storage - For Processing) or "1.2.840.10008.5.1.4.1.1.2.ZZUID" (Legacy Converted Enhanced CT Image Storage - For Processing).** **May be present otherwise.** **See Section C.8.15.1.1.1 for further explanation.**

Add Attribute description section to CT Series Module. Text mirrors DX Series Module text

C.8.15.1.1 CT Series Module Attribute Descriptions

C.8.15.1.1.1 Presentation Intent Type

Presentation Intent Type (0008,0068) shall identify the intent for the purposes of display or other presentation of all Images within this Series.

Notes

1. Since this is a Series level Attribute, all Images within a Series have the same Value for this Attribute.
2. The intent of this restriction is to ensure that FOR PRESENTATION and FOR PROCESSING images are placed in separate Series, so that no confusion can arise as to which images are suitable for diagnostic reading as determined by local policy.

A Series of Images intended for viewing by an observer, after application of any grayscale transformations specified in the image object such as VOI LUT, shall, if Presentation Intent Type (0008,0068) is present, have an Enumerated Value of FOR PRESENTATION.

Notes

1. These images may still be of Image Type (0008,0008) ORIGINAL rather than DERIVED despite the possibility that they may have undergone some processing. In this case a DERIVED image would have undergone yet further processing to make it substantially different from the original.
2. These images may still be subjected to processing or further processing, if appropriate, depending on the application.
3. These images are intended for display on a device, without (further) processing, since that device may not be capable of image processing. The quality of the displayed image or its suitability for any purpose is beyond the scope of the DICOM Standard.
4. The nature of the processing that may have been applied before sending an image of type FOR PRESENTATION is not specified.

Images that are intended to be further processed before being displayed shall have an Enumerated Value of FOR PROCESSING.

Notes

1. This type is provided to allow the functions of image acquisition and image processing for presentation to be separated and yet have images conveyed between the two processes using a DICOM object. Individual sites or users may choose to substitute their own specialized processing in place of that supplied by the implementer.

2. Images available at this stage of processing may be useful for quality control and problem solving purposes, as well as academic research.
3. Images of this type may also be archived, retrieved and processed with different algorithms or parameters in order to alter the appearance of specific features for clinical purposes.

Whether or not the spatial locations of all pixels are preserved during the processing of the source image that resulted in the current image can be indicated by Spatial Locations Preserved (0028,135A) in a Source Image Sequence (0008,2112) reference from the FOR PRESENTATION image to a FOR PROCESSING predecessor.

If images from the same exposure exist with different Values of Presentation Intent Type (0008,0068), then they shall have different SOP Instance UIDs.

Notes

1. The Source Image Sequence (0008,2112) in a FOR PRESENTATION image may reference the FOR PROCESSING image(s) from which it was generated to relate these images. Similarly, the Related Series Sequence (0008,1250) in a FOR PRESENTATION image may more generally reference series that contain the FOR PROCESSING images.
2. The SOP Class UIDs of the two images will also be different.
3. The Acquisition UID (0008,0017) can also be used to recognize that different instances are related to a shared acquisition event. For example, a FOR PROCESSING instance containing basis images might share an Acquisition UID with a conventional CT image instance that has been directly generated from the acquired data. The conventional CT image instance would not reference the basis instance in its Source Image Sequence (0008,2112). The basis images might also share an Acquisition UID with a derived spectral CT image instance, which could reference the basis instance in its Source Image Sequence (0008,2112).

Modify Value 5 table for multi-frame CT to add codes for Basis and Noisemap images

C.8.15.2.1.1.5 Multi-energy CT Images

Table C.8-116b specifies the Defined Terms for CT for Value 5 for Image Type (0008,0008) and Frame Type (0008,9007). Image Type (0008,0008) Value 5 shall be present if Multi-energy CT Acquisition (0018,9361) has a value of YES.

Table C.8-116b. Image Type and Frame Type Value 5 for CT

Defined Term Name	Code Meaning
VMI	Virtual Monoenergetic Image. Each real-world value mapped pixel represents CT Hounsfield units and is analogous to a CT image created by a monoenergetic (of a specific keV value) X-Ray beam.
MAT_SPECIFIC	Material-Specific Image. Each real-world value mapped pixel value represents a property of a material such as attenuation, concentration or density.
MAT_REMOVED	An image with the attenuation contribution of one or more materials removed. For pixels that did not contain any of the removed material(s), the pixel values are unchanged.
MAT_FRACTIONAL	Material-Fractional Image. Each real-world value mapped pixel represents the fraction of a voxel occupied by a material.
EFF_ATOMIC_NUM	Effective Atomic Number Image. Each real-world value mapped pixel represents Effective Atomic Number of the materials in the voxel.
ELECTRON_DENSITY	Electron Density Image. Each real-world value mapped pixel represents the number of electrons per unit volume or the electron density relative to water.
MAT_MODIFIED	Material-Modified Image. CT ~~I~~image where real-world value mapped pixels have been modified to highlight a certain target material (either by partially suppressing the background or by enhancing the target material), or to partially suppress the target material.

Defined Term Name	Code Meaning
MAT_VALUE_BASED	Value-Based Image. CT ~~I~~image where real-world value mapped pixels represent a certain value for a specified material
MIXED	Used only as a value in Image Type (0008,0008) if frames within the image SOP Instance contain different values for Value 5 in their Frame Type (0008,9007).
BASIS	**Basis image. CT image generated by multi-energy decomposition and used to generate spectral images.**
NOISE_MAP	**Noise Map Image. An image that represents the presence of noise in pixels of a CT image.**

Modify Table C.8.15.3.13-1 to allow single item series for basis images

C.8.15.3.13 Multi-energy CT Processing Macro

This Macro defines the Attributes for Multi-energy CT processing.

Table C.8.15.3.13-1. Multi-energy CT Processing Macro Attributes

Attribute Name	Tag	Type	Attribute Description
…			
>Decomposition Material Sequence	(0018,9381)	3	Basis materials used in the decomposition process. **Spectral images derived from two or more basis images record the corresponding materials. Basis images only have a single material.** **One~~Two~~** or more Items are permitted in this Sequence.
>>Material Code Sequence	(0018,937D)	1	Nominal material for Multi-energy CT processing. Only a single Item shall be included in this Sequence.
>>>Include Table 8.8-1 “Code Sequence Macro Attributes”			BCID 300 “Multi-energy Relevant Material”.
…			

Changes to NEMA Standards Publication PS 3.4

Add SOPs to Table B.5-1 in PS3.4 Annex B.5.

Table B.5-1 Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)	Specialization
…			

Digital Intra-Oral X-Ray Image Storage - For Presentation	1.2.840.10008.5.1.4.1.1.1.3	Digital Intra-Oral X-Ray Image IOD	B.5.1.3
Digital Intra-Oral X-Ray Image Storage - For Processing	1.2.840.10008.5.1.4.1.1.1.3.1	Digital Intra-Oral X-Ray Image IOD	B.5.1.3
CT Image Storage	1.2.840.10008.5.1.4.1.1.2	CT Image IOD	**B.5.1.XX**
CT Image Storage - For Processing	**1.2.840.10008.5.1.4.1.1.2.XXUID**	**CT Image IOD**	**B.5.1.XX**
Enhanced CT Image Storage	1.2.840.10008.5.1.4.1.1.2.1	Enhanced CT Image IOD	B.5.1.7 B.5.1.23 **B.5.1.XX**
Enhanced CT Image Storage - For Processing	**1.2.840.10008.5.1.4.1.1.2.YYUID**	**Enhanced CT Image IOD**	**B.5.1.XX**
Legacy Converted Enhanced CT Image Storage	1.2.840.10008.5.1.4.1.1.2.2	Legacy Converted Enhanced CT Image IOD	B.5.1.7 B.5.1.23 **B.5.1.XX**
Legacy Converted Enhanced CT Image Storage - For Processing	**1.2.840.10008.5.1.4.1.1.2.ZZUID**	**Legacy Converted Enhanced CT Image IOD**	**B.5.1.XX**
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3.1	Ultrasound Multi-frame Image Storage	
…			

Add Section B.5.1.XX to PS3.4 Annex B.5.
This text is patterned after the corresponding text for DX in B.5.1.1.
(Any suggestions to improve the form of this language should be a CP to fix the other corresponding sections too.)

B.5.1.XX CT Image Storage SOP Classes

The CT Image Storage SOP Class shall use the CT Image IOD, and if Presentation Intent Type (0008,0068) is present, shall have an Enumerated Value of FOR PRESENTATION.

The Enhanced CT Image Storage SOP Class shall use the Enhanced CT Image IOD, and if Presentation Intent Type (0008,0068) is present, shall have an Enumerated Value of FOR PRESENTATION.

The Legacy Converted Enhanced CT Image Storage SOP Class shall use the Legacy Converted Enhanced CT Image IOD, and if Presentation Intent Type (0008,0068) is present, shall have an Enumerated Value of FOR PRESENTATION.

The CT Image Storage - For Processing SOP Class shall use the CT Image IOD with an Enumerated Value of FOR PROCESSING for Presentation Intent Type (0008,0068).

The Enhanced CT Image Storage - For Processing SOP Class shall use the Enhanced CT Image IOD with an Enumerated Value of FOR PROCESSING for Presentation Intent Type (0008,0068).

The Legacy Converted Enhanced CT Image Storage - For Processing SOP Class shall use the Legacy Converted Enhanced CT Image IOD with an Enumerated Value of FOR PROCESSING for Presentation Intent Type (0008,0068).

An SCU or SCP of the CT Image Storage - For Processing SOP Class shall also support the CT Image Storage SOP Class in the same role.

An SCU or SCP of the Enhanced CT Image Storage - For Processing SOP Class shall also support the CT Image Storage SOP Class in the same role.

An SCU or SCP of the Legacy Converted Enhanced CT Image Storage - For Processing SOP Class shall also support the Legacy Converted Enhanced CT Image Storage SOP Class in the same role.

In the following notes, the CT Image Storage SOP Class, Enhanced CT Image Storage SOP Class, and Legacy Converted Enhanced CT Image Storage SOP Class will be collectively referred to as For Presentation SOP Classes.

Notes

1. The intent of the above requirements is to ensure a useful level of interoperability by avoiding the situation where an SCU might support only a given For Processing SOP Class and an SCP only the corresponding For Presentation SOP Class, or vice versa. The burden is therefore to support the corresponding For Presentation SOP Class as a "baseline".

2. Multi-frame For Processing SOP Class instances can contain multiple sets of frames, e.g. high-energy and low-energy basis images for spectral processing, and perhaps other related sets of frames such as noise maps. In such cases, all those sets of frames will share the same value for Stack ID (0020,9056) since they span the same space.

   The value of In-stack Position Number (0020,9057) will be the same for frames in different frame sets that are at the same spatial location.

   Another item in the Dimension Index Sequence (0020,9222) differentiates the sets of frames (e.g. basis vs noisemap) similar to the way temporal stacks are handled. The Dimension Index Pointer (0020,9165) can reference Frame Type (0008,9007), where value 5 distinguishes frames that are basis images from noise map images, and Functional Group Pointer (0020,9167) can reference CT Image Frame Type Sequence (0018,9329) where Frame Type (0008,9007) is located.

   Another item in the Dimension Index Sequence (0020,9222) will point to the Material Code Sequence (0018,937D) in the Decomposition Material Sequence (0018,9381), which distinguishes different basis materials, in the Multi-energy CT Processing Sequence (0018,9363).

   See PS3.3 C.7.6.17.1 for further discussion of Dimension Indices.

3. The term "support" is used in this section in the sense that an SCU or SCP must be capable of sending or receiving the For Presentation SOP Class. There is no intent to imply that an SCU must always send an instance of the For Presentation SOP Class when an instance of the For Processing SOP Class is sent.

   Nor is there any intent to imply that during Association establishment, that a Presentation Context for the For Presentation SOP Class has to be proposed by the initiator. However, an association acceptor may reject a For Presentation SOP Class Presentation Context if it accepts a For Processing SOP Class Presentation Context, and prefers that SOP Class, in which case it may no longer be able to "pass on" the object later as an SCU unless it is able to generate a For Presentation object.

   It is not possible for an SCP to determine from proposed Presentation Contexts whether or not an SCU "supports" (is capable of sending) both For Processing and For Presentation SOP Class Instances. Such a determination requires a priori knowledge of the information contained in the Conformance Statement for the SCU, as well as how the SCU is configured and operated. An SCU that supports both SOP Classes may well choose to only propose one or the other during Association establishment, depending on which Instances it actually intends to send over that particular association (although the SCU must be capable of sending instances of the For

Presentation SOP Class if the SCP does not accept the For Processing).

The intent of the requirement is that if an SCU is only capable of sending the For Presentation SOP Class, any SCP will be guaranteed to be able to receive it. Conversely, if an SCP is only capable of receiving the For Presentation SOP Class, any SCU will be guaranteed to be able to send it.

Sections PS3.4 B.5.1.7 and B.5.1.23. are included unchanged for reference

B.5.1.7 Enhanced CT Image Storage and Legacy Converted Enhanced CT Image Storage SOP Class

An SCP of the Enhanced CT Image Storage or Legacy Converted Enhanced CT Image Storage SOP Class shall also support the Grayscale Softcopy Presentation State Storage SOP Class as an SCP.

Note

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

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B.5.1.23 Enhanced Multi-Frame Image SOP Classes

An SCP of any of the Enhanced Multi-Frame Image SOP Classes that makes SOP Instances available through the Enhanced Multi-Frame Image Conversion Extended Negotiation of the Query/Retrieve Service Class (see Section C.3.5) shall support Storage Level 2 (Full).

Note

Effective use of the Image Conversion option requires the storage of Type 3 Attributes.

Changes to NEMA Standards Publication PS 3.6

Add the SOP Class UIDs for the new SOP Classes to Table A-1 PS3.6 Annex A

UID Value	UID Name	UID Keyword	UID Type	Part
…				
1.2.840.10008.5.1.4.1.1.2.XXUID	**CT Image Storage - For Processing**	**CTImageStorageForProcessing**	**SOP Class**	**PS3.4**
1.2.840.10008.5.1.4.1.1.2.YYUID	**Enhanced CT Image Storage - For Processing**	**EnhancedCTImageStorageForProcessing**	**SOP Class**	**PS3.4**
1.2.840.10008.5.1.4.1.1.2.ZZUID	**Legacy Converted Enhanced CT Image Storage - For Processing**	**LegacyConvertedEnhancedCTImageStorageForProcessing**	**SOP Class**	**PS3.4**
…				

Changes to NEMA Standards Publication PS 3.16

Modify CID 7202 Source Image Purpose of Reference to add a code for use in Source Image Sequence (0008,2112) to point to Basis instances from which spectral images were derived. See General Reference Module PS3.3 C.12-10.

CID 7202 Source Image Purpose of Reference

Resources: HTML | FHIR JSON | FHIR XML | IHE SVS XML
Keyword: SourceImagePurposeOfReference
FHIR Keyword: dicom-cid-7202-SourceImagePurposeOfReference
Type: Extensible
Version: ~~20170405~~yyyymmdd
UID: 1.2.840.10008.6.1.509

Table CID 7202. Source Image Purpose of Reference

Coding Scheme Designator	Code Value	Code Meaning
DCM	121320	Uncompressed predecessor
DCM	121321	Mask image for image processing operation
DCM	121322	Source image for image processing operation
DCM	121329	Source image for montage
DCM	121330	Lossy compressed predecessor
DCM	121358	For Processing predecessor
DCM	113130	Predecessor containing group of imaging subjects
DCM	128250	Structural image for image processing
DCM	128251	Flow image for image processing
DCM	**Newcode1**	**Basis image for spectral processing**

Modify CID 7203 to add code for use in Derivation Image Sequence (0008,9124).

CID 7203 Image Derivation

Resources: HTML | FHIR JSON | FHIR XML | IHE SVS XML
Keyword: ImageDerivation
FHIR Keyword: dicom-cid-7203-ImageDerivation
Type: Extensible
Version: ~~20200920~~yyyymmdd
UID: 1.2.840.10008.6.1.510

Table CID 7203. Image Derivation

Coding Scheme Designator	Code Value	Code Meaning
…		
DCM	113097	Multi-energy proportional weighting
DCM	**Newcode2**	**Basis image decomposition**

Coding Scheme Designator	Code Value	Code Meaning
…		

Modify CID 300 as shown. (This represents merging CP2576 into this Supplement)

CID 300 Multi-energy Relevant Material

Concepts for materials relevant to Multi-energy Imaging.

Resources: **HTML | FHIR JSON | FHIR XML | IHE SVS XML**
Keyword: **MultienergyRelevantMaterial**
FHIR Keyword: **dicom-cid-300-MultienergyRelevantMaterial**
Type: **Extensible**
Version: **yyyymmdd~~20190817~~**
UID: **1.2.840.10008.6.1.1208**

Table CID 300. Multi-energy Relevant Material

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-RT ID	UMLS Concept Unique ID
SCT	83881004	Aluminum Oxide	C-12013	C0002374
…				
DCM	**Newcode6**	**Compton Scattering**		
DCM	**Newcode7**	**Photoelectric Effect**		

Add definitions to PS 3.16 Annex D

Table D-1. DICOM Controlled Terminology Definitions

Code Value	Code Meaning	Definition	Notes
…			
Newcode1	**Basis image for spectral processing**	**Multi-energy CT basis image used as the source for derivation of a spectral image.**	
113097	Multi-energy proportional weighting	Image pixels created through proportional weighting of multiple acquisitions at distinct X-Ray energies.	
Newcode2	**Basis image decomposition**	**Image pixels created through decomposition of multi-energy acquisition data.**	
Newcode6	**Compton Scattering**	**The energy-dependent component of X-Ray attenuation that is due to Compton scattering.**	
Newcode7	**Photoelectric Effect**	**The energy-dependent component of X-Ray attenuation that is due to the photoelectric effect.**	