Digital Imaging and Communications in Medicine (DICOM)

Sup 243 - Label Map Segmentation

DICOM Standards Committee - Working Group 6 - Base Standard

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Document History

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To Do

1	? hyphenate "8-bit" everywhere?
2	Consider factoring out the bits allocated stuff into a separate section or table as for some other images IODs. Also, should the HighBit be predicated on BitsStored or BitsAllocated?
3	Add sub-headings for each type to C.8.20.2.3.
4	Consider extending PS3.17 Annex HH example to describe differences in LABELMAP attribute encoding +/- picture comparing them.

Closed Issues

1	The existing IOD is modified and two SOP Classes are defined in the same manner as used for Digital X-Ray for processing and for presentation, and conditions specified in the IOD and included Modules as necessary, based on the SOP Class or the Segmentation Type (in the same manner as Presentation Intent Type for DX).
2	There is thought to be no need for a mechanism to specify that different ranges of bits within the pixel data value (index) are used to specify different things (e.g., class vs. instance, different classes, or overlap of classes), including using different ranges of bits for the labels and other bits for fractional weights
3	Only a single label map is allowed in each SOP Instance. Overlap of different segments can be addressed by encoding multiple label maps in separate SOP Instances.
4	The size of the Per-Frame Functional Group Sequence (in which, for every frame, geometry is specified) are not addressed in this Supplement, except to the extent that for a label map, the Segmentation Macro is not required since the referenced segment is specified by the pixel value instead.
5	The proposal is designed to support segmenting classes of structure, and also adequately supports small to moderate numbers of instances of a single class (with great redundancy of coded description of such instances, since the category/property needs to be repeated for every numbered segment). There is no mechanism for efficiently describing very large number of instances of a class segmentation, and to do so we would probably need to re-factor the Segment Description Macro to use the category/property for the class, and specify that it applied to multiple instances identified by the encoded index value.
6	16 bits per pixel are a sufficient number of indices for the use cases considered
7	The matter of having to describe every pixel value implies that the value 0, if present, will also be described (which might serve as the background) is in conflict with the existing requirement to start Segment Number at 1 not zero. It is sufficient to relax the sequential numbering constraint for LABELMAP types, and retain it for existing BINARY and FRACTIONAL. No new limits are placed on the Segment Number values (such as ordering).
8	Given that a labelmap may contain many segments, and each pixel value is an index, it makes sense to allow using the existing Palette Color LUT mechanism that is used in ultrasound, etc., which supports the use of 8 or 16 bit indices, the use of 8 or 16 bit color entries (theoretically), and which implies use of the dedicated PALETTE COLOR Photometric Interpretation, and irrelevance of any color specified within each Segment Description Item, and the use of an ICC Profile to achive color consistency. Color tables entries are allowed to be 8 bits or 16 bits. A well-known UID may be specified, but the LUT is still required to be encoded with each instance. The use of the so-called "Segmented" definition of the color tables (by equation rather than literally, not to be confused with Segmentation of images) is forbidden, since the incremental complexity provides little utility for the use case?
9	For multiple labelmaps in separate instances applying to the same images, there is no need (beyond grouping them in a Series) to signal that they are in some way related, and commonality of other attribute values (such as those that are creator-related) suffices.
10	When converting from (non-overlapping) binary to labelmap representation or vice versa, the predecessor can be referenced (in a manner that is distinct from referencing the images that were segmented in the first place) by using the Source Instance Sequence (0042,0013) from the General Reference Module be used for this purpose, and the Purpose of Reference Code Sequence (0040,A170) in Section A.51.4 referenced CID 7019 extended accordingly.
11	Both MONOCHROME2 and PALETTE COLOR Photometric Interpretation are allowed when Segmentation Type is LABELMAP.
12	Pixel Padding Value or a similar mechanism be re-used in some way to identify which segments are used as background, if any, but this is deferred to a potential future separate CP, since there is value in considering how to handle "background" for existing SEGs regardless of the labelmap additions. It is noted that currently the presence of Pixel Padding Value is prohibited per A.51.4 Segmentation IOD Content Constraints, and this constraint would need to be relaxed as well.

Scope and Field of Application

This Supplement describes addition of a Label Map Segmentation IOD to DICOM to encode classification of entities.

Currently, the DICOM standard supports an IOD and SOP Class for pixel- or voxel-based segmentation encoding (as distinct from the representation of segmented objects as surfaces in the surface segmentation and encapsulated 3D object IODs and SOP Classes), in which each segmented property is represented as a binary bit plane (or an 8 bit probabilistic or occupancy value). While this allows for overlapping of segments, it is inefficient and difficult to encode large numbers of non-overlapping segmentations, as they require non-trivial processing both to extract from the bit plane encoded data, to assure there is no overlap, and to convert to the label map form that is very commonly used internally and persistently for clinical applications.

The current DICOM bit-plane-based segmentation methods have proven to be awkward both for 3D cross-sectional imaging applications when there are very large numbers of slices and/or structures, and for whole slide microscopy imaging, when there are very large numbers of tiles and/or property classes. They are also typically large and sparse and should compress well but there are very few single bit compression schemes supported by the standard and they do not do well with these types of images.

This Supplement defines a label map segmentation enhanced multi-frame IOD that specifies a data structure that provides, for each pixel or voxel in 2D, 3D or tiled pyramidal space, an index value conveying the non-overlapping segment for each pixel. Existing data elements for describing segmentations are reused where appropriate. Bit depth is sufficient (8, 16) to encode large numbers of segments but allow for more compact encoding. The existing palette color photometric interpretation may be used (instead of monochrome) if colors are to be suggested, to leverage the widespread implementations in toolkits, and to allow for the use of existing lossless compression schemes. Segment properties are conveyed in the existing segment description structure so as to be compatible with the existing bit plane segment descriptions. Re-using the segment description does not prevent the use of separately encoded or well-known DICOM color palette objects.

The scope is confined to label maps for "classes" (what "class" a segment represents) but not "instances' (which "instance" of a "class" is represented), where classes and instances are separately communicated by the pixel value (e.g., if one wants to individually identify nuclei rather than treat them all as being of one class). This might be the subject of a future extension.

The scope is confined to a single label map, which does not allow for overlap of different segments. If overlapping of multiple label maps is required, separate SOP Instances may be created.

Issues related to the efficient representation (or avoidance) of the Per-Frame Functional Group Sequence (in which, for every frame, the Referenced Segment Number is specified) are out of scope, and may be addressed in a separate Supplement or CP if necessary.

PS3.3 DICOM PS3.3 - Information Object Definitions

PS3.3 for reference:

3.8 DICOM Information Object

Segment	A part of a whole, such as the classification of pixels in an image.

PS3.3 DICOM PS3.3 - Information Object Definitions

*Amend PS3.3 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

Table A.1-1e. Composite Information Object Modules Overview - More Images

IODs **Modules**	**IVOCT**	**Seg**
Patient	M	M
Clinical Trial Subject	U	U
General Study	M	M
Patient Study	U	U
Clinical Trial Study	U	U
General Series	M	M
Clinical Trial Series	U	U
Segmentation Series	M	M
Frame of Reference	C	C
General Equipment	M	M
Enhanced General Equipment	M	M
Acquisition	U	U
Multi-Resolution Pyramid	U	U
General Image	M	M
General Reference	U	U
Microscope Slide Layer Tile Organization	C	C
Image Pixel	M	M
Palette Color Lookup Table		**C**
Multi-frame Functional Groups	M	M
Multi-frame Dimension	M	M
Specimen	U	U
Segmentation Image	M	M
Common Instance Reference	C	C
ICC Profile		**C**
SOP Common	M	M
Frame Extraction	C	C

A.51 Segmentation IOD

A.51.1 Segmentation IOD Description

The Segmentation IOD specifies a multi-frame image representing a classification of pixels in one or more referenced images. Segmentations are **~~either~~** binary**~~,~~ ~~or~~** fractional**, or label map**. If the referenced images have a defined Frame of Reference, the Segmentation Instance shall have the same Frame of Reference and is not required to have the same spatial sampling or extent as the referenced

images. If the referenced image does not have a defined Frame of Reference, the Segmentation Instance shall have the same spatial sampling and extent as the referenced image.

The Segmentation IOD does not include the full set of acquisition parameters of the referenced images, e.g., cardiac phase. An application rendering or processing the ~~s~~**S**egmentation **Instance** may need to access the referenced images for such information.

The Segmentation IOD is used in two SOP Classes as defined in Section B.5.1.n1 Storage Service Class, a SOP Class for storage of BINARY and FRACTIONAL segmentations, and a SOP Class for storage of LABELMAP segmentations. These are distinguished by their SOP Class UID and by the Enumerated Value of the Segmentation Type (0062,0001) of the Segmentation Image Module.

A.51.2 Segmentation IOD Entity-Relationship Model

This IOD uses the E-R Model in Section A.1.2 , with only the Image IE below the Series IE.

A.51.3 Segmentation IOD Module Table

Table A.51-1 specifies the Modules of the Segmentation IOD.

Table A.51-1. Segmentation 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
	Segmentation Series	C.8.20.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is not present. May be present otherwise.
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Acquisition	General Acquisition	C.7.10.1	U
Multi-Resolution Pyramid	Multi-Resolution Pyramid	C.7.11.1	U
Image	General Image	C.7.6.1	M
	General Reference	C.12.4	U
	Microscope Slide Layer Tile Organization	C.8.12.14	C - Required if Dimension Organization Type (0020,9311) is present with a value of TILED_FULL. May be present otherwise.
	Image Pixel	C.7.6.3	M
	Segmentation Image	C.8.20.2	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Palette Color Lookup Table	**C.7.9**	**C - Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR.**
	Specimen	C.7.6.22	U

IE	Module	Reference	Usage
	Common Instance Reference	C.12.2	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is present.
	ICC Profile	**C.11.15**	**C - Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR.**
	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

Note

The Specimen Identification Module (Retired) was previously included in this IOD but has been retired, and its functionality replaced by the Specimen Module. See PS3.3-2008.

A.51.4 Segmentation IOD Content Constraints

The VOI LUT Module shall not be present.

The Modality LUT Module shall not be present.

The Overlay Plane Module shall not be present.

Pixel Padding Value (0028,0120) shall not be present.

For Purpose of Reference Code Sequence (0040,A170) within Source Instance Sequence (0042,0013) in the General Reference Module DCID 7019 “Segmentation Non-Image Source Purpose of Reference” shall be used.

A.51.5 Segmentation Functional Groups

Table A.51-2 specifies the use of the Functional Group Macros used in the Multi-frame Functional Groups Module for the Segmentation IOD.

Table A.51-2. Segmentation Functional Group Macros

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is not present and the Frame of Reference is defined in the patient-relative Reference Coordinate System. May be present otherwise if the Frame of Reference is defined in the patient-relative Reference Coordinate System. See Section A.51.5.1
Plane Position (Patient)	C.7.6.16.2.3	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is not present and the Frame of Reference is defined in the patient-relative Reference Coordinate System. May be present otherwise if the Frame of Reference is defined in the patient-relative Reference Coordinate System. See Section A.51.5.1
Plane Orientation (Patient)	C.7.6.16.2.4	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is not present and the Frame of Reference is defined in the patient-relative Reference Coordinate System. May be present otherwise if the Frame of Reference is defined in the patient-relative Reference Coordinate System. See Section A.51.5.1
Plane Position (Slide)	C.8.12.6.1	C - Required if Derivation Image Functional Group (C.7.6.16.2.6) is not present and the Frame of Reference is defined in the Slide Coordinate System and Dimension Organization Type (0020,9311) is not TILED_FULL. May be present otherwise if the Frame of Reference is defined in the Slide Coordinate System. See Section A.51.5.1.

Functional Group Macro	Section	Usage
Derivation Image	C.7.6.16.2.6	C - Required if Pixel Measures (C.7.6.16.2.1) or either Plane Position (Patient) (C.7.6.16.2.3) or Plane Orientation (Patient) (C.7.6.16.2.4) (if the Frame of Reference is defined in the patient-relative Reference Coordinate System), or Plane Position (Slide) (C.8.12.6.1) (if the Frame of Reference is defined in the Slide Coordinate System) Functional Groups are not present. May be present otherwise. See Section A.51.5.1
Frame Content	C.7.6.16.2.2	M
Segmentation	C.8.20.3.1	~~M~~**C - Required if Segmentation Type (0062,0001) is not LABELMAP.**

A.51.5.1 Segmentation Functional Groups Description

When a Frame of Reference UID is present the **S~~s~~**egment shall be specified within that coordinate system, using the Pixel Measures and either the Plane Position (Patient) and Plane Orientation (Patient), or the Plane Position (Slide) Functional Groups. Since this defines the spatial relationship of the **S~~s~~**egment, the size of the segmentation frames need not be the same size, or resolution, as the image data used to generate the segment data. The Derivation Image Functional Group may also be present, to specify on which images the segmentation was actually performed (since there may be others in the same Frame of Reference that are spatially co-located, but were not used to perform the segmentation).

If the Frame of Reference UID is not present, each pixel of the segmentation shall correspond to a pixel in a referenced image, using the Derivation Image Functional Group. Hence, the rows and columns of each referenced image will match the segmentation image. If both the Frame of Reference UID and the Derivation Image Functional Group are present, the segmentation and referenced image pixels need not correspond.

The value of Purpose of Reference Code Sequence (0040,A170) in the Derivation Image Macro shall be (121322, DCM, "Source Image for Image Processing Operation"). The value of Derivation Code Sequence (0008,9215) shall be (113076, DCM, "Segmentation").

Note

Non-image source Instances used during segmentation, such as Real World Value maps, can be described in the top level Data Set in the Source Instance Sequence (0042,0013) of the General Reference Module and are implied to have been used for the derivation of all frames. I.e., there is no mechanism for selectively specifying on a per-frame basis which non-Image Instances were used. Real World Value Map Instances already contain a means of selectively applying different scale factors to different frames.

C.8.20 Segmentation

This section describes the specific Modules for the Segmentation IOD.

C.8.20.1 Segmentation Series Module

Table C.8.20-1 specifies the Attributes of the Segmentation Series Module.

Table C.8.20-1. Segmentation Series Module Attributes

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Type of device, process or method that created the Instances in this Series. **Enumerated Values:** **SEG**
Series Number	(0020,0011)	1	A number that identifies this Series.

Attribute Name	Tag	Type	Attribute Description
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"			

C.8.20.2 Segmentation Image Module

Table C.8.20-2 specifies the Attributes of the Segmentation Image Module.

Table C.8.20-2. Segmentation Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	**Image identification characteristics.** Value 1 shall be DERIVED. Value 2 shall be PRIMARY. No other values shall be present.
Include Table 10-12 "Content Identification Macro Attributes"			
Samples Per Pixel	(0028,0002)	1	**Number of samples (planes) in this image.** **Enumerated Values:** **1**
Photometric Interpretation	(0028,0004)	1	**Specifies the intended interpretation of the pixel data.** **Enumerated Values if Segmentation Type (0062,0001) is BINARY or FRACTIONAL:** **MONOCHROME2** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP:** **MONOCHROME2** **PALETTE COLOR**
Pixel Representation	(0028,0103)	1	**Data representation of pixel samples.** **Enumerated Values:** **0**

Attribute Name	Tag	Type	Attribute Description
Bits Allocated	(0028,0100)	1	**Number of bits allocated for each pixel sample.** See Section C.8.20.2.1. **Enumerated Values if Segmentation Type (0062,0001) is BINARY:** **1** **Enumerated Values if Segmentation Type (0062,0001) is ~~not BINARY~~FRACTIONAL:** **8** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP:** **8** **16**
Bits Stored	(0028,0101)	1	**Number of bits stored for each pixel sample.** See Section C.8.20.2.1. **Enumerated Values if Segmentation Type (0062,0001) is BINARY:** **1** **Enumerated Values if Segmentation Type (0062,0001) is ~~not BINARY~~FRACTIONAL:** **8** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP and Bits Allocated (0028,0100) is 8:** **8** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP and Bits Allocated (0028,0100) is 16:** **16**

Attribute Name	Tag	Type	Attribute Description
High Bit	(0028,0102)	1	**Most significant bit for pixel sample data.** See Section C.8.20.2.1. **Enumerated Values if Segmentation Type (0062,0001) is BINARY:** **0** **Enumerated Values if Segmentation Type (0062,0001) is ~~not BINARY~~FRACTIONAL:** **7** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP and Bits Allocated (0028,0100) is 8:** **7** **Enumerated Values if Segmentation Type (0062,0001) is LABELMAP and Bits Allocated (0028,0100) is 16:** **15**
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.8.20.2.2 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.7.6.1.1.5.2 . 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.7.6.1.1.5.1 . Required if present in the source images or this IOD Instance has been compressed. See Section C.8.20.2.2.

Attribute Name	Tag	Type	Attribute Description
Segmentation Type	(0062,0001)	1	The type of encoding used to indicate the presence of the segmented property at a pixel/voxel location. **Enumerated Values:** **BINARY** **FRACTIONAL** **LABELMAP** See Section C.8.20.2.3.
Segmentation Fractional Type	(0062,0010)	1C	For fractional segmentation encoding, the meaning of the fractional value. Required if Segmentation Type (0062,0001) is FRACTIONAL. See Section C.8.20.2.3 for Enumerated Values.
Maximum Fractional Value	(0062,000E)	1C	Specifies the value that represents a probability of 1 or complete occupancy. There shall be no values in Pixel Data (7FE0,0010) greater than this value. Required if Segmentation Type (0062,0001) is FRACTIONAL.
Segments Overlap	(0062,0013)	3	Whether or not any **Ss**egments in this Instance overlap. I.e., whether or not any pixel is or might be in more than one **Ss**egment. **Enumerated Values:** **YES** Some **Ss**egments overlap **UNDEFINED** Some **Ss**egments might overlap **NO** No **Ss**egments overlap See Section C.8.20.2.3. **If present, shall be NO if Segmentation Type (0062,0001) is LABELMAP.** **Note** If the value is NO, then a receiving application to which this matters can be assured that no **Ss**egments overlap and does not need to check every pixel. If the value is UNDEFINED or YES, or the Attribute is absent, then a receiving application might need to check every pixel in every **Ss**egment.
Segment Sequence	(0062,0002)	1	Describes the **Ss**egments that are contained within the data. One or more Items shall be included in this Sequence. **Note** **The Items of this Sequence are not required to be in any particular order, i.e., are not required to be ordered by Segment Number (0062,0004).**
>Include Table C.8.20-4 "Segment Description Macro Attributes"			
>Segment Algorithm Name	(0062,0009)	1C	The name(s) of algorithm(s) used to generate the **Ss**egment. Required if Segment Algorithm Type (0062,0008) is not MANUAL.

Attribute Name	Tag	Type	Attribute Description
>Segmentation Algorithm Identification Sequence	(0062,0007)	3	A description of how this **Ss**~~s~~egment was derived. Algorithm Name (0066,0036) within this Sequence may be identical to Segment Algorithm Name (0062,0009). One or more Items are permitted in this Sequence. **Note** Previously, the Segment Surface Generation Algorithm Identification Code Sequence (0066,002D) was used, but it has been replaced in this Module, since not all segmentation algorithms involve surface generation. See PS3.3-2016d.
>>Include Table 10-19 "Algorithm Identification Macro Attributes"			*BCID 7162 "Surface Processing Algorithm Family".*
>Recommended Display Grayscale Value	(0062,000C)	3	A default single gray unsigned value in which it is recommended that the maximum pixel value in this **Ss**~~s~~egment be rendered on a monochrome display. The units are specified in P-Values from a minimum of 0000H (black) up to a maximum of FFFFH (white). **Note** The maximum P-Value for this Attribute may be different from the maximum P-Value from the output of the Presentation LUT, which may be less than 16 bits in depth.
>Recommended Display CIELab Value	(0062,000D)	3	A default triplet value in which it is recommended that **Ss**~~s~~egment be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1. **Shall not be present if Segmentation Type (0062,0001) is LABELMAP and Photometric Interpretation (0028,0004) is PALETTE COLOR.**

C.8.20.2.1 Bits Allocated ~~and~~, Bits Stored, and High Bit

As a consequence of the ~~e~~**E**numerated **Values for** Bits Allocated ~~**and,**~~ Bits Stored**, and High Bit** Attribute ~~**value**~~s, single bit pixels shall be packed 8 to a byte as defined by the encoding rules in PS3.5.

C.8.20.2.2 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 Segmentation Instance.

The process of segmentation itself is defined not to be lossy compression, even though it involves loss. If the Segmentation Instance is encoded using a lossy compression Transfer Syntax, then the value shall be set to "01".

Note

It is not advisable to lossy compress a Segmentation ~~**SOP**~~ Instance. In particular, ~~**a binary**~~ **BINARY or LABELMAP Ss**~~s~~egmentation **Instances** should not be lossy compressed.

C.8.20.2.3 Segmentation Type, Segmentation Fractional Type and Segments Overlap

A Segmentation Type (0062,0001) of BINARY indicates **that** the segmented property is present with a value of 1 and absent with a value of 0.

For a Segmentation Type (0062,0001) of FRACTIONAL the segmented property is defined as a value from zero to the Maximum Fractional Value (0062,000E). A FRACTIONAL segmentation shall be further specified via Segmentation Fractional Type (0062,0010).

Enumerated Values of Segmentation Fractional Type (0062,0010):

PROBABILITY Defines the probability, as a ratio of the pixel value to the Maximum Fractional Value, that the segmented property occupies the spatial area defined by the voxel.

OCCUPANCY Defines the proportion of the pixel volume occupied by the segmented property as the ratio of the pixel value to the Maximum Fractional Value.

A Segmentation Type (0062,0001) of LABELMAP indicates that the presence of the segmented property is conveyed by the integer value of the Pixel Data (7FE0,0010), which is one of the values of Segment Number (0062,0004).

Note

~~Binary~~BINARY Segmentation Instances may be transformed into or from **"**label maps**"**, **~~in which each pixel contains a coded value that indicates the segment, rather than the Segmentation IOD representation that encodes separate bit planes for each segment~~**. This conversion is facilitated by knowing whether or not any **S~~s~~**egment bi**t**planes overlap. **By definition, each pixel value in a single LABELMAP Segmentation Instance can only represent one Segment. and cannot overlap.** A Segments Overlap (0062,0013) value of NO indicates **that** they can be converted into (or may have been converted from) a label map representation without the need to check every pixel.

For a Segmentation Type (0062,0001) of LABELMAP, every pixel value actually encoded in Pixel Data (7FE0,0010) is required to be described in an Item of Segment Sequence (0062,0002).

Note

1. **The converse is not true, in that the Segment Sequence (0062,0002) can describe Segments that are not actually present in the pixel data, e.g., to allow for re-use of a common S~~s~~egment description across multiple instances, despite the inefficiency of encoding unused information.**

2. **The need to describe every pixel value implies that the value 0, if used, will also be described, which might serve as the background.**

C.8.20.2.4 Segment Number

Segment Number (0062,0004) shall be unique within each Instance**.**

If Segmentation Type (0062,0001) is BINARY or FRACTIONAL, **Segment Number (0062,0004) shall** start at a value of 1, and increase monotonically by 1.

Note

1. **When converting from LABELMAP Segmentation Instances to BINARY Segmentation Instances, care should be taken to reassign the Segment Number (0062,0004) values if necessary, such that the requirements in this section are complied with.**

2. **Requirements on the ascending order of the Segment Number (0062,0004) values do not imply an ordering of the Sequence Items of any enclosing Sequence.**

C.8.20.3 Segmentation Functional Group Macros

The following sections contain Functional Group Macros specific to the Segmentation 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.8.20.3.1 Segmentation Macro

Table C.8.20-3 specifies the Attributes of the Segmentation Macro.

Table C.8.20-3. Segmentation Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Segment Identification Sequence	(0062,000A)	1	Identifies the characteristics of this frame. Only a single Item shall be included in this Sequence.
>Referenced Segment Number	(0062,000B)	1	Uniquely identifies the **Ss**egment described in Segment Sequence (0062,0002) by reference to Segment Number (0062,0004). Referenced Segment Number (0062,000B) shall not be multi-valued.

C.8.20.4 Segmentation Macros

The following sections contain Macros specific to the Segmentation IOD.

C.8.20.4.1 Segment Description Macro

Table C.8.20-4 specifies the Attributes of the Segment Description Macro.

Table C.8.20-4. Segment Description Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Segment Number	(0062,0004)	1	Identification number of the **Ss**egment. The value of Segment Number (0062,0004) shall be unique within the Segmentation Instance in which it is created. See Section C.8.20.2.4.
Segment Label	(0062,0005)	1	User-defined label identifying this **Ss**egment. This may be the same as Code Meaning (0008,0104) of Segmented Property Type Code Sequence (0062,000F).
Segment Description	(0062,0006)	3	User-defined description for this **Ss**egment.
Segment Algorithm Type	(0062,0008)	1	Type of algorithm used to generate the **Ss**egment. **Enumerated Values:** **AUTOMATIC** calculated **Ss**egment **SEMIAUTOMATIC** calculated **Ss**egment with user assistance **MANUAL** user-entered **Ss**egment
Include Table 10-7b "Multiple Site General Anatomy Optional Macro Attributes"			*May not be necessary if the anatomy is implicit in the Segmented Property Type Code Sequence.* *More than one Item in Anatomic Region Sequence (0008,2218) may be used when a region of interest spans multiple anatomical locations and there is not a single pre-coordinated code describing the combination of locations. There is no requirement that the multiple locations be contiguous.*
Segmented Property Category Code Sequence	(0062,0003)	1	Sequence defining the general category of the property the **Ss**egment represents. Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*BCID 7150 “Segmentation Property Category”.*

Attribute Name	Tag	Type	Attribute Description
Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property the **Ss**~~s~~egment represents. **Note** "Property" is used in the sense of meaning "what the segmented voxels represent", whether it be a physical or biological object, be real or conceptual, having spatial, temporal or functional extent or not. I.e., it is what the **Ss**~~s~~egment "is" (as opposed to some feature, attribute, quality, or characteristic of it, like color or shape or size). Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*BCID 7151 "Segmentation Property Type".*
>Segmented Property Type Modifier Code Sequence	(0062,0011)	3	Sequence defining the modifier of the property type of this **Ss**~~s~~egment. One or more Items are permitted in this Sequence.
>>Include Table 8.8-1 "Code Sequence Macro Attributes"			*DCID 244 "Laterality".* **Note** *For Retinal Segmentation Surfaces, laterality is not typically specified.*
Tracking ID	(0062,0020)	1C	A text label used for tracking a finding or feature, potentially across multiple reporting objects, over time. This label shall be unique within the domain in which it is used. Required if Tracking UID (0062,0021) is present. **Note** 1. May or may not have the same value as Segment Label (0062,0005). 2. Related SR Instances may exist, for example, to record measurements related to this **Ss**~~s~~egment, but need not exist for this Attribute to be used. 3. This Attribute will have the same value as the value of the (112039, DCM, "Tracking Identifier") Content Item in SR Instances that reference this Segment in this Segmentation Instance.
Tracking UID	(0062,0021)	1C	A unique identifier used for tracking a finding or feature, potentially across multiple reporting objects, over time. Required if Tracking ID (0062,0020) is present. **Note** 1. Related SR Instances may exist, for example, to record measurements related to this **Ss**~~s~~egment, but need not exist for this Attribute to be used. 2. This Attribute will have the same value as the value of the (112040, DCM, "Tracking Unique Identifier") Content Item in SR Instances that reference this Segment in this Segmentation Instance.

Attribute Name	Tag	Type	Attribute Description
Definition Source Sequence	(0008,1156)	3	Instances containing the source of the Segment information. Only a single Item is permitted in this Sequence.
>Include Table 10-11 "SOP Instance Reference Macro Attributes".			
>Referenced ROI Number	(3006,0084)	1C	The value of ROI Number (3006,0022) in the referenced SOP Instance that identifies the ROI that is the origin of the Segment information. Required if Referenced SOP Class UID (0008,1150) is RT Structure Set Storage ("1.2.840.10008.5.1.4.1.1.481.3").
Include Table 10.9.3-1 "Content Creator Macro"			

C.7.9 Palette Color Lookup Table Module

Table C.7-22 specifies the Attributes of the Palette Color Lookup Table Module, which describe the Lookup table data for images with Palette Color photometric interpretation.

When the Palette Color Lookup Table Module is present in an Image IOD, the conditional requirements for the use of Palette Color Lookup Table Data (0028,1201-1203) and Segmented Palette Color Lookup Table Data (0028,1221-1223), described in Table C.7-22, shall take precedence over the conditional requirements described in the Image Pixel Module (see Section C.7.6.3). When the Palette Color Lookup Table Module is present in a Presentation State IOD, the Palette Color Lookup Table Data (0028,1201-1203) Attributes are mandatory and the Segmented Palette Color Lookup Table Data (0028,1221-1223) shall not be present. When the Palette Color Lookup Table Module is present in a Color Palette IOD, either the Palette Color Lookup Table Data (0028,1201-1203) or Segmented Palette Color Lookup Table Data (0028,1221-1223) Attributes may be used.

When the Palette Color Lookup Table Module is present in a Color Palette IOD, the 3rd value of Palette Color Lookup Table Descriptor (0028,1101-1103) (i.e, the number of bits for each entry in the Lookup Table Data) shall be 8.

Table C.7-22. Palette Color Lookup Table Module Attributes

Attribute Name	Tag	Type	Attribute Description
Include Table C.7-22a "Palette Color Lookup Table Macro Attributes"			

Table C.7-22a. Palette Color Lookup Table Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Red Palette Color Lookup Table Descriptor	(0028,1101)	1	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201). See Section C.7.6.3.1.5 for further explanation.
Green Palette Color Lookup Table Descriptor	(0028,1102)	1	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202). See Section C.7.6.3.1.5 for further explanation.
Blue Palette Color Lookup Table Descriptor	(0028,1103)	1	Specifies the format of the Blue Palette Color Lookup table Data (0028,1203). See Section C.7.6.3.1.5 for further explanation.
Palette Color Lookup Table UID	(0028,1199)	3	Palette Color Lookup Table UID. See Section C.7.9.1 for further explanation.
Red Palette Color Lookup Table Data	(0028,1201)	1C	Red Palette Color Lookup Table Data. Required if segmented data is NOT used in an Image IOD or Color Palette IOD, or if the IOD is a Presentation State IOD **or Segmentation IOD**. See Section C.7.6.3.1.6 for further explanation.
Green Palette Color Lookup Table Data	(0028,1202)	1C	Green Palette Color Lookup Table Data. Required if segmented data is NOT used in an Image IOD or Color Palette IOD, or if the IOD is a Presentation State IOD **or Segmentation IOD**. See Section C.7.6.3.1.6 for further explanation.

Attribute Name	Tag	Type	Attribute Description
Blue Palette Color Lookup Table Data	(0028,1203)	1C	Blue Palette Color Lookup Table Data. Required if segmented data is NOT used in an Image IOD or Color Palette IOD, or if the IOD is a Presentation State IOD **or Segmentation IOD**. See Section C.7.6.3.1.6 for further explanation.
Segmented Red Palette Color Lookup Table Data	(0028,1221)	1C	Segmented Red Palette Color Lookup Table Data. Required if segmented data is used in an Image IOD or Color Palette IOD; shall not be present in a Presentation State IOD **or Segmentation IOD**. See Section C.7.9.2 for further explanation.
Segmented Green Palette Color Lookup Table Data	(0028,1222)	1C	Segmented Green Palette Color Lookup Table Data. Required if segmented data is used in an Image IOD or Color Palette IOD; shall not be present in a Presentation State IOD **or Segmentation IOD** See Section C.7.9.2 for further explanation.
Segmented Blue Palette Color Lookup Table Data	(0028,1223)	1C	Segmented Blue Palette Color Lookup Table Data. Required if segmented data is used in an Image IOD or Color Palette IOD; shall not be present in a Presentation State IOD **or Segmentation IOD**. See Section C.7.9.2 for further explanation.

C.7.9.1 Palette Color Lookup Table UID

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C.7.9.2 Segmented Palette Color Lookup Table Data

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C.7.6.3.1.5 Palette Color Lookup Table Descriptor

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When the Red, Green, or Blue Palette Color Lookup Table Descriptor (0028,1101-1103) are used as part of the Palette Color Lookup Table Module in the Segmentation IOD, the 3rd value of Palette Color Lookup Table Descriptor (0028,1101-1103) (i.e, the number of bits for each entry in the Lookup Table Data) shall be 8 or 16.

Note

1. A value of 16 indicates the Lookup Table Data will range from (0,0,0) minimum intensity to (65535,65535,65535) maximum intensity.

2. Since the Palette Color Lookup Table Descriptor (0028,1101-1104) Attributes are multi-valued, in an Explicit VR Transfer Syntax, only one value representation (US or SS) may be specified, even though the first and third values are always by definition interpreted as unsigned. The explicit VR actually used is dictated by the VR needed to represent the second value, which will be consistent with Pixel Representation (0028,0103).

C.7.6.3.1.6 Palette Color Lookup Table Data

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PS3.4 DICOM PS3.4 - Service Class Specifications

*Amend PS3.4 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

B.5 Standard SOP Classes

The SOP Classes in the Storage Service Class identify the Composite IODs to be stored. Table B.5-1 identifies Standard SOP Classes.

Table B.5-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)	Specialization
...			
Digital X-Ray Image Storage - For Presentation	1.2.840.10008.5.1.4.1.1.1.1	Digital X-Ray Image IOD	B.5.1.1
Digital X-Ray Image Storage - For Processing	1.2.840.10008.5.1.4.1.1.1.1.1	Digital X-Ray Image IOD	B.5.1.1
...			
Segmentation Storage	1.2.840.10008.5.1.4.1.1.66.4	Segmentation IOD	**B.5.1.n1**
Label Map Segmentation Storage	**1.2.840.10008.5.1.4.1.1.66.nn**	Segmentation IOD	**B.5.1.n1**
Surface Segmentation Storage	1.2.840.10008.5.1.4.1.1.66.5	Surface Segmentation IOD	
...			

B.5.1 Specialization for Standard SOP Classes

B.5.1.1 Digital X-Ray Image Storage SOP Classes

The Digital X-Ray Image Storage - For Presentation SOP Class shall use the DX IOD with an Enumerated Value of FOR PRESENTATION for Presentation Intent Type (0008,0068).

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

...

B.5.1.n1 Segmentation Storage SOP Classes

The Segmentation Storage SOP Class shall use the Segmentation IOD with an Enumerated Value of BINARY or FRACTIONAL for Segmentation Type (0062,0001).

The Label Map Segmentation Storage SOP Class shall use the Segmentation IOD with an Enumerated Value of LABELMAP for Segmentation Type (0062,0001).

PS3.6 DICOM PS3.6 - Data Dictionary

*Amend PS3.6 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

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

Table A-1. UID Values

UID Value	UID Name	UID Keyword	UID Type	Part
1.2.840.10008.5.1.4.1.1.66.nn	**Label Map Segmentation Storage**	**LabelMapSegmentation Storage**	**SOP Class**	**PS3.4**

PS3.16 DICOM PS3.16 - Content Mapping Resource

*Amend PS3.16 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

CID 7019 Segmentation Non-Image Source Purpose of Reference

Version: **~~20170914~~yyyymmdd**

Table CID 7019. Segmentation Non-Image Source Purpose of Reference

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-RT ID	UMLS Concept Unique ID
DCM	128227	Source real world value map		
DCM	**ddd001**	**Source segmentation**		

D DICOM Controlled Terminology Definitions (Normative)

Table D-1. DICOM Controlled Terminology Definitions (Coding Scheme Designator "DCM" Coding Scheme Version "01")

Code Value	Code Meaning	Definition	Notes
128227	Source real world value map	Real world value map used as the source for derivation. E.g., the map applied to source images before processing them, such as for a threshold based segmentation operation.	
ddd001	**Source segmentation**	**Segmentation used as the source for derivation. E.g., the binary segmentation that was converted to a labelmap segmentation, or vice versa.**	