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Digital Imaging and Communications in Medicine (DICOM)

8 *Supplement 222: Microscopy Bulk Simple Annotations Storage SOP Class*

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28 # **Table of Contents**

48 **Document History**

2020/07/03	01	DAC	Initial version derived from Tractography Results.
2020/07/07	02	DAC	Working draft at t/con discussion.
2020/07/17	03	DAC	Factor out Z when possible; add simple geometric shapes; add algorithm identification, open issue about OF/FL precision.
2020/09/01	04	DAC	Add optical path identifier and applies to all optical paths, add applies to all Z depths, include Leica, Sectra comments,
2020/09/15	05	DAC	Change Set to Group, don't re-use Segmentation Property data elements but define new similar ones.
2020/11/09	06	DAC	Prep for WG 6 first read
2020/11/25	07	DAC	Incorporate WG 6 feedback and assigned number.
2021/01/04	08	DAC	Clean up measurements text, add annotation group UID, add example with measurements, clean up open issues for public comment
2021/01/05	09	DAC	Prepare for release by WG 6 for public comment
2021/01/12	10	DAC	Public comment draft
2021/03/16	11	DAC	Incorporate public comments
2021/03/16	12	DAC	WG26 prepare for LB review
2021/03/22	13	DAC	More public comments; prepare for LB review by WG 6
2021/03/22	14	DAC	More public comments; prepare for LB review by WG 6
2021/03/26	15	DAC	Letter Ballot

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Closed Issues

1	Mechanisms for specifying geometric shapes are provided. These only need to be 2D rather than 3D (rectangle, not cuboid).
2	For the very common no Z-stack single "slice" WSI, references to the Z planes are factored out (constant Z in a separate attribute). They may also apply to multiple planes, each explicitly listed (no range from-to though, an excessively complicated optimization). A means for indicating that an annotation applies to all Z planes is also provided.
3	Points for polylines are required to be coplanar, but are not required to be in the same plane as the Z plane, though this complicates definitions of such things as rectangles and circles, and it is not clear that there are actually microscopy use cases annotations not parallel to the Z plane.
4	Z coordinates are related to the Z offset of frames Z Offset in Slide Coordinate System (0040,074A). The Z offset is only nominal and only has local meaning. Regardless of reality, the slide coordinates system defined by a frame of reference is nominally Cartesian and usable for reference purposes.
5	Neither holes nor Boolean operations nor nested/recursive annotations are supported in this IOD, since it is intended specifically for very large numbers of very simple annotations only, and would add excessive complexity for simple use cases; May revisit this in a future more complex object.
6	The limited measurement capabilities provided are thought to be necessary and sufficient. relationships between measurements and post-coordinate concepts are not provided.
7	By policy, all colors specified are in CIELab ICC Profile Connection Space (PCS) (not RGB) to allow them to be color managed, though the ICC Profile is optional.
8	New (but similar) attributes are created for property category, etc. rather than reusing those from SEG, since annotations may not be segmentations.
9	The items of the sequence can be used to logically group common annotations, not just based on geometric shape but also properties.
10	The term "set", which has an explicit meaning in computer science in the context of abstract data types has been avoided, so we refer to Annotation Groups.
11	The scope is limited to microscopy, though not specifically whole slide imaging (WSI). The underlying mechanisms could theoretically be reused for other types of imaging in future if there are use cases that required large numbers of annotations that cannot be readily satisfied by SR, but there is a strong desire to avoid proliferation of competing annotation mechanisms that undermine interoperability; specifically, the intent is not to compete with SR for small numbers of annotations.
12	OD/FD (64-bit IEEE float) is needed in addition to OF/FL (32-bit IEEE float, i.e., 23-bit mantissa + sign bit) 3D coordinates for super-resolution microscopy and electron microscopy.

13	Both 2D and 3D coordinates are allowed, since there are many 2D sources and applications. Provide 2D total matrix relative coordinates, +/- 2D frame relative + frame number using the same approach (still floating point to allow sub-pixel resolution).
	This allows lossless transformation from a source of 2D coordinates (such as might be needed for regulatory purposes that cannot tolerate loss during format conversion from 2D to 3D, which might be affected by the 32-bit IEEE float precision), and removes dependence on a reliable 3D frame of reference. It is understood that 2D coordinates are required to be specified relative to the pixel matrix of an actual image, which needs to be explicitly referenced and requires selection of a resolution level to reference, but this is commonly done and sufficient.
14	Tiled frame indices are not provided for 3D coordinates or 2D Total Matrix relative coordinates.
15	Property category and type are thought to be sufficient attributes to provide anatomic information. Future work (beyond the scope of this Supplement) will flesh out the context groups provided, e.g., by considering incorporation of the transitive closure of children of 4421005 Cell Structure in SNOMED for examples (http://snomed.info/id/4421005), as well as other coding schemes. Specimen preparation description (e.g., staining) is not intended to be described in this object but in the referenced images, and is being extended in
	CP 2082 "Add acquisition codes and template for fluorescence and immunohistochemistry in microscopy" to address other types of preparation.
16	No baseline algorithm identification mechanisms (or family CIDs) are needed for this use case.
17	No rendering related attributes are included (other than color) in what is primarily a semantic object.
18	No mechanism to specify the semantics of interpolation of contours or polygons is provided, consistent with other contour-based mechanisms in DICOM.
19	An API for DICOMweb to retrieve a subset of annotations (e.g., on a subset of frames) is thought to be desirable, but is beyond the scope of this work. WG 26 Annotation AHG will coordinate with WG 23 and 27 to begin new joint work on this subject.
20	No separate JSON representation of the this IOD or subsets of it are defined. The existing PS3.18 JSON representation of the metadata allows for separate encoding of the large binary coordinate array by reference, if the Base64 encoded value (for OF and OD coordinates) is too large. There has been no interest expressed in an alternative JSON representation with all the coordinates as numeric strings (rather than binary or Base64).
21	Image and frame reference mechanisms are provided for 2D coordinates, and an optional image reference is allowed for 3D annotations. For 3D annotations, no particular acquisition to series relationship is assumed, but in future it may be desirable to reference a particular acquisition rather than applying to any acquisition in the same Frame of Reference, which otherwise serves as a proxy for this (in the absence of registered separate acquisitions). A
	separate CP to create an Acquisition Information Entity and UID has been started, since the concept has more generic semantics that are also applicable to other modalities.
22	References to the optical path are multi-valued, so that more than one may be referenced.
23	The encoding of a rectangle follows the encoding of a closed polygon; two points (TLHC, BRHC) are not sufficient in 3D space if a plane is not defined.

24	The information content is similar to SR, but the idea is to leverage the (compact) "binary" nature of objects like Surface Seg and Tractography and re-use the Point Coordinates Data only when required for vast numbers of annotations. Though each set of coordinates is not dissimilar in size encoded separately or together, the many other attributes required in SR to describe each individual annotation adds a very significant overhead (measure in hundreds of bytes per annotation) in order to repeat the same information. For the special case supported by this IOD, the dramatic difference in size justifies a different mechanism. Trying to stuff the "bulk" annotation concept into the existing IOD would require new content items, IODs and templates that would not be compatible with the existing SR implementations and would create yet more patterns within SR to do the same thing. A clean break with a new dedicated, narrowly-purposed, IOD is thought to be a preferrable solution.
24	Enhanced General Equipment is mandatory because WG 6 policy is to require Manufacturer etc. in all new IODs.
25	No "Apply to Extended Focus: YES or NO" flag is provided, assuming that "Extended Focus" means "Extended Depth of Field", which is defined as "Image pixels were created through combining of image acquisition at multiple focal planes (focus stacking)". For 3D annotations, the definition of this would not differ from Annotation Applies to All Z Planes. For 2D annotations, this is inherent in the reference image.
26	Referenced Optical Path Identifier (gggg,ee20) is used instead of Optical Path Identifier (0048,0106), because a VM of more than one is needed, so couldn't use the existing single-valued Attribute (without having to qualify every existing use where it needs to remain single valued).
27	A clockwise winding order and simple polygons only are specified, since the objective is to satisfy the use case (encoding annotations) with a consistent and unambiguous representation. Allowing complex polygons or alternative winding orders potentially creates the potential for misinterpretation. This may be more burdensome for convertors but is then less so for recipients, and de novo creators can get it right in the first place.
28	Since Concatenations are potentially transient (used for communication only and reassembled), clarified that annotations should be against the SOP Instance UID of Concatenation Source.
29	CIRCLE is encoded as a degenerate ELLIPSE, which is fully defined when not parallel to the Z (slide) plane. This would not be a problem if annotations were required to be parallel to slide.
30	The Specimen Module isn't necessary for this IOD (the FoR UID and/or image references defining the specimen/slide to which the annotations are applied). Arguably some identifiers and descriptions would save retrieving the referenced image metadata (in an Image Library like manner).

52

54   **Scope and Field**

This Supplement to the DICOM Standard specifies a new DICOM Information Object and Storage SOP
56   Class for storing Microscopy Bulk Simple Annotations (points, open polylines, closed polygons and simple
geometric shapes without relationships), which is referred to as the Microscopy Bulk Simple Annotations
58   IOD.

60   Microscopy Bulk Simple Annotations are usually created by machine algorithms from high resolution
images of entire tissue sections, e.g., encoded as DICOM Whole Slide Microscopy images. These
62   annotations are distinct from alternative representations appropriate for different use-cases, such as
segmented bit planes (which are encoded in DICOM Segmentation Images), and more tractable size
64   human or machine generated contour-based annotations on selected high-power fields or lower resolution
or gross specimen images (which are encoded in DICOM Structured Reports using standard templates
66   like TID 1500).

No new image encoding mechanism is introduced. The annotations are either 2D image relative (frame or
68   Total Pixel Matrix) or in a 3D Frame of Reference that is shared with a Microscopy Image Storage
instance.

70   No new composition mechanism is added. The annotations are basic ("simple") and it is anticipated that in
future mechanisms such as the Radiotherapy Conceptual Volume mechanism may be re-used to describe
72   boolean relationships, etc., that reference instances of bulk simple annotations, or embed more complex
relationships.

74

DICOM PS 3.2 Conformance

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

78
Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.sss	**Microscopy Bulk Simple Annotations Storage**	**Transfer**
…		

80 **DICOM PS 3.3: Information Object Definitions**

Item: Add definitions:

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82 # 3.8 DICOM Information Object

Annotation   Additional information associated with an object.

84 **Region of Interest (ROI)**   A selected subset of samples within a dataset identified for a particular purpose.

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

Structure Set   A set of areas of significance.

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Item: Change Figure 7-1a. DICOM Model of the Real World:

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90 *Add "Microscopy Bulk Simple Annotations" to be contained in the Series.*

Item: Change Figure A.1-1 DICOM Composite Instance IOD Information Model:

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92 *Add "Microscopy Bulk Simple Annotations" to the same level as Surface.*

Item: Add in Section A.1.4, rows and column to Table A.1-2

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94 **A.1.4   Overview of the Composite IOD Module Content**

IODs Modules	WS Bulk Smpl Ann
Patient	**M**
Clinical Trial Subject	**U**
General Study	**M**
Patient Study	**U**
Clinical Trial Study	**U**
General Series	**M**
Microscopy Bulk Simple Annotations Series	**M**
Clinical Trial Series	**U**
Frame of Reference	**C**
Microscopy Bulk Simple Annotations	**M**

General Equipment	**M**
Enhanced General Equipment	**M**
ICC Profile	**U**
Common Instance Reference	**M**
SOP Common	**M**

96

98 | **Item: Add in the following new section in Annex A**

A.X1   MICROSCOPY BULK SIMPLE ANNOTATIONS IOD

100 **A.X1.1   Microscopy Bulk Simple Annotations IOD Description**

The Microscopy Bulk Simple Annotations IOD encodes Microscopy Bulk Simple Annotations into a
102 collection of points, closed polygons, open polylines and simple geometric shapes. Polygons and polylines
are defined by the coordinates of each point. Simple geometric shapes are defined by parameters.

104 Numeric quantities and color may be associated with annotations.

A.X1.2   Microscopy Bulk Simple Annotations IOD Entity-Relationship Model

106 The E-R Model in Section A.1.2 depicts those components of the DICOM Information Model that directly
reference the Microscopy Bulk Simple Annotations IOD.

108 **A.X1.3   Microscopy Bulk Simple Annotations IOD Module Table**

Table A.X1-1. Microscopy Bulk Simple Annotations 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
	Microscopy Bulk Simple Annotations Series	C.8.Y1.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	C - Required if Annotation Coordinate Type (gggg,eee0) is 3D
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Annotation	Microscopy Bulk Simple Annotations	C.8.Y1.2	M
	ICC Profile		U
	Common Instance Reference	C.12.2	M
	SOP Common	C.12.1	M

110

Item: Amend Section C.7.3.1.1 to add new modality

112 **C.7.3.1.1 General Series Attribute Descriptions**

C.7.3.1.1.1 Modality

114   Defined Terms:

ANN   Annotation

116

Item: Add in the following new sections in C

118

C.8.Y1   Microscopy Bulk Simple Annotations Modules

120   This Section describes Microscopy Bulk Simple Annotations Modules.

C.8.Y1.1   Microscopy Bulk Simple Annotations Series Module

122

Table C.8.Y1-1 specifies the Attributes that identify and describe general information about a Microscopy
124   Bulk Simple Annotations Series.

Table C.8.Y1-1
126   **MICROSCOPY BULK SIMPLE ANNOTATIONS SERIES MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Modality	(0008,0060)	1	Type of equipment that originally acquired the data used to create the instances in this Series. Enumerated Values: ANN See Section C.7.3.1.1.1 for further explanation.
Series Number	(0020,0011)	1	A number that identifies this Series.
Referenced Performed Procedure Step Sequence	(0008,1111)	1C	Uniquely identifies the Performed Procedure Step SOP Instance to which the Series is related. Only a single Item shall be included in this Sequence. Required if a Performed Procedure Step SOP Class was involved in the creation of this Series.
>*Include Table 10-11 "SOP Instance Reference Macro Attributes"*			

128

C.8.Y1.2   Microscopy Bulk Simple Annotations Module

130   Table C.8.Y1-2 specifies the Attributes that describe the Microscopy Bulk Simple Annotations.

Table C.8.Y1-2
MICROSCOPY BULK SIMPLE ANNOTATIONS MODULE ATTRIBUTES

132

Attribute Name	Tag	Type	Attribute Description
Include Table 10-12 "Content Identification Macro Attributes"			
Content Date	(0008,0023)	1	The date the content creation started.
Content Time	(0008,0033)	1	The time the content creation started.
Annotation Coordinate Type	(gggg,eee0)	1	Whether coordinates are image-relative (2D) or volume-relative (3D). **Enumerated Values:** **2D** relative to individual frame or total image matrix **3D** relative to a Cartesian coordinate system defined by a Frame of Reference
Pixel Origin Interpretation	(0048,0301)	1C	For image-relative coordinates, specifies whether coordinates are to be interpreted relative to the individual frame pixel origins, or relative to the Total Pixel Matrix origin (see Section C.8.12.4.1.4). Required if Annotation Coordinate Type (gggg,eee0) is 2D. **Enumerated Values:** **FRAME** relative to individual frame **VOLUME** relative to Total Image Matrix Note: The use of the term "VOLUME" to refer to the Total Image Matrix is historical and inherited from Presentation States, and does not refer to 3D coordinates.
Referenced Image Sequence	(0008,1140)	1C	The image to which this annotation object applies. Only a single Item shall be included in this Sequence. Required if Annotation Coordinate Type (gggg,eee0) is 2D. May be present otherwise.
>*Include Table 10-3 "Image SOP Instance Reference Macro Attributes"*			
Annotation Group Sequence	(gggg,eee1)	1	Groups of annotations sharing common characteristics, such as graphic type, properties or measurements. One or more Items shall be included in this Sequence.
>Annotation Group UID	(gggg,ee19)	1	Unique identifier of the Annotation Group.

>Annotation Group Number	(gggg,eee2)	1	Identification number of the Annotation Group. Uniquely identifies a Annotation Group within this SOP Instance. Shall start at a value of 1, and increase monotonically by 1.
>Annotation Group Label	(gggg,eee3)	1	User-defined label identifying this Annotation Group. This may be the same as Code Meaning (0008,0104) of Annotation Property Category Code Sequence (gggg,ee17).
>Annotation Group Description	(gggg,eee4)	3	User-defined description for this Annotation Group.
>Annotation Group Generation Type	(gggg,ee13)	1	Type of algorithm used to generate the Annotations. **Enumerated Values:** AUTOMATIC - generated by algorithm without human user assistance SEMIAUTOMATIC - generated by algorithm with human user assistance MANUAL - generated by human user
>Annotation Algorithm Identification Sequence	(gggg,ee12)	1C	The algorithms used to create the annotations in this group. One or more Items shall be included in this Sequence. Required if Annotation Generation Type (gggg,ee13) is AUTOMATIC or SEMIAUTOMATIC.
>>*Include Table 10-19 "Algorithm Identification Macro Attributes"*			*No Baseline CIDs are defined.*
>Annotation Property Category Code Sequence	(gggg,ee16)	1	Sequence defining the general category of the property the Annotation Group represents. Only a single Item shall be included in this Sequence.
>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			*BCID 7150 "Segmentation Property Categories".*
>Annotation Property Type Code Sequence	(gggg,ee17)	1	Sequence defining the specific property the Annotation Group represents. Only a single Item shall be included in this Sequence.
>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			*BCID ccc1 "Microscopy Annotation Property Types".*
>>Annotation Property Type Modifier Code Sequence	(gggg,ee18)	3	Sequence defining the modifier of the property type of this Annotation Group. One or more Items are permitted in this Sequence.

>>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			*No Baseline CID is defined.*
>Number of Annotations	(gggg,eee5)	1	The number of Annotations in this Annotation Group. Each point, polyline or polygon, ellipse or rectangle is counted as one Annotation.
>Graphic Type	(0070,0023)	1	The shape of the Annotations in this Annotation Group. See Section C.8.Y1.2.1.1. Enumerated Values: **POINT** a single location denoted by a single coordinate **POLYLINE** a series of connected line segments with ordered vertices denoted by coordinates forming an open polyline; the points shall be coplanar **POLYGON** a series of connected line segments with ordered vertices denoted by coordinates, where the first and last vertices are not the same but are implicitly joined to form a closed polygon; the points shall be coplanar **ELLIPSE** an ellipse defined by four coordinates, the first two points specifying the endpoints of the major axis and the second two points specifying the endpoints of the minor axis of an ellipse; the points shall be coplanar **RECTANGLE** a rectangle defined by four coordinates, the first being the top left hand corner (when viewed from the top surface of the slide towards the bottom), then the top right hand corner, then the bottom right hand corner and finally the bottom left hand corner; the points shall be coplanar Note: Individual annotations in the same group are not required to be in the same plane.
>Annotation Applies to All Optical Paths	(gggg,ee15)	1	Whether the annotations in this Annotation Group apply to all the optical paths within the corresponding images. Enumerated Values: **YES** the annotations apply to all optical paths **NO** the annotations apply only to the specified optical path(s)

>Referenced Optical Path Identifier	(gggg,ee20)	1C	Identifies one or more optical paths to which this annotation applies.
			Refers to the same value in Optical Path Identifier (0048,0106) within the Optical Path Sequence (0048,0105) in the images to which this annotation applies.
			More than one value may be present if the annotations apply to more than one (but not all) Optical Paths.
			Required if Annotation Applies to All Optical Paths (gggg,ee15) is NO.
>Annotation Applies to All Z Planes	(gggg,ee14)	1C	Whether the annotations in in this Annotation Group apply to the full thickness of the tissue on the slide. I.e., they are applicable regardless of the focal plane, in the case that images were acquired with multiple focal planes (Z-stacks).
			Enumerated Values:
			YES the annotations apply to the full thickness
			NO the annotations apply only to the specified Z plane
			Note: When the value is NO, the Z plane will be specified either in Common Z Coordinate Value (gggg,eee7) if all the coordinates are in the same Z plane(s), or in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0) if not.
			Required if Annotation Coordinate Type (gggg,eee0) is 3D.

>Common Z Coordinate Value	(gggg,eee7)	1C	The Z coordinate(s) common to all points in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0), in mm in the Slide Coordinate System (Section C.8.12.2.1.1) associated with the Frame of Reference. More than one value may be present if the annotations apply to more than one (but not all) Z planes. Required if Annotation Coordinate Type (gggg,eee0) is 3D, and all points in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0) are in the same Z plane(s). Note: This requirement means that it is mandatory to factor out the commonality, i.e., it is not permitted to send Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0) with (X, Y, Z) triplets where all the Z values are the same. For annotations of images that only have a single Z plane, or where all the points in an annotation group are coplanar and in the same Z plane, this condition will always be satisfied. Annotations in different Z planes can be separated into separate Annotation Groups in order to allow this condition to be satisfied, but using separate Annotation Groups is not required. See Section C.8.Y1.2.1.1.
>Point Coordinates Data	(0066,0016)	1C	The coordinates of one or more points that define the annotations (whether single points or polygons), encoded in (X, Y) or (X, Y, Z) order. Required if Double Point Coordinates Data (0066,eee0) is not present. For each point, two coordinates (X, Y) shall be encoded if Common Z Coordinate Value (gggg,eee7) is present, otherwise three coordinates (X, Y, Z) shall be encoded. See Section C.8.Y1.2.1.1.

>Double Point Coordinates Data	(0066,eee0)	1C	The coordinates of one or more points that define the annotations (whether single points or polygons), encoded in (X, Y) or (X, Y, Z) order.
			Required if Point Coordinates Data (0066,0016) is not present.
			For each point, two coordinates (X, Y) shall be encoded if Common Z Coordinate Value (gggg,eee7) is present, otherwise three coordinates (X, Y, Z) shall be encoded.
			See Section C.8.Y1.2.1.1.
>Long Primitive Point Index List	(0066,0040)	1C	A list of point indices. See Section C.8.Y1.2.1.1.
			Required if Graphic Type (0070,0023) is POLYLINE or POLYGON.
>Recommended Display CIELab Value	(0062,000D)	3	Default triplet value in which it is recommended that the Annotation Group be rendered. The units are specified in PCS-Values, and the value is encoded as CIELab.
			See Section C.10.7.1.1.
>Measurements Sequence	(0066,0121)	3	Measurements for some or all Annotations in the Annotation Group. Each Item describes one type of measurement.
			See Section C.8.Y1.2.1.2.
			One or more Items are permitted in this Sequence.
>>Concept Name Code Sequence	(0040,A043)	1	Defines the type of measurement stored in this Item.
			Only a single Item shall be included in this Sequence.
>>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			DCID ccc2 "Slide Microscopy Measurement Types"
>>Measurement Units Code Sequence	(0040,08EA)	1	Units of measurement for the value in this Item.
			Only a single Item shall be included in this Sequence.
>>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			*DCID 82 "Units of Measurement".*

>>Measurement Values Sequence	(0066,0132)	1	The measurement values for the Annotation Group. One or more Items shall be included in this Sequence.
>>>Floating Point Values	(0066,0125)	1	Measurement values for annotations stored in this Annotation Group. If Annotation Index List (gggg,eee6) is present, measurement values are stored for a subset of annotations, and the number of values shall match the number and order of indices in Annotation Index List (gggg,eee6). If Annotation Index List (gggg,eee6) is absent, measurement values are stored for every annotation in Long Primitive Point Index List (0066,0040), if present, and the number of values shall match the number and order of annotations in Long Primitive Point Index List (0066,0040) . If Annotation Index List (gggg,eee6) and Long Primitive Point Index List (0066,0040) are absent, measurement values are stored for every annotation stored in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0), and the number of values shall match the value of Number of Annotations (gggg,eee5). See Section C.8.Y1.2.1.2.
>>>Annotation Index List	(gggg,eee6)	1C	List of indices referencing annotations identified in Long Primitive Point Index List (0066,0040) or successive points stored in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0) for which measurement values shall be stored. Required if Measurement Values stored in Floating Point Values (0066,0125) are associated with only a subset of annotations. See Section C.8.Y1.2.1.2.

134

C.8.Y1.2.1 Microscopy Bulk Simple Annotations Module Attributes

136 **C.8.Y1.2.1.1 Type, Points, Polygons, Parameterized and Rotated Shapes and Indices**

All the Annotations in a single Item of Annotation Group Sequence (gggg,eee1) share the same value for
138 Graphic Type (0070,0023).

If Annotation Coordinate Type (gggg,eee0) is 2D, then the coordinates are interpreted as image-relative,
140 either relative to an individual frame or the Total Pixel Matrix, with units of pixels, as defined in C.10.4
Displayed Area Module. If Pixel Origin Interpretation (0048,0301) is FRAME, then a single frame of a
142 single image shall be specified in Referenced Image Sequence (0008,1140). If Pixel Origin Interpretation

(0048,0301) is VOLUME, then a single image shall be specified in Referenced Image Sequence
144 (0008,1140) without a subset of frames designated, and the coordinates are relative to the Total Image
Matrix of that image. The referenced image shall not be an instance of a Concatenation; i.e., in the case of
146 Concatenations, references shall be relative to the SOP Instance UID of Concatenation Source
(0020,0242).

148 Notes: 1. The referenced image need not be any particular resolution layer of a WSI pyramid. I.e., it may
or may not be the highest resolution layer. The user may annotate images that are not at the
150 highest resolution, but such annotations may be projected onto any resolution layer that is
available (or computed). If the referenced image is no longer stored or accessible, the ability to
152 project the annotations onto other layers may be lost.

2. A reference to a single frame means that all annotations in this instance are on that frame; no
154 mechanism is provided to span frames, or to specify more than one frame.

If Annotation Coordinate Type (gggg,eee0) is 3D, then the coordinates are interpreted as volume relative,
156 with units of mm, in the Cartesian space defined by the Frame of Reference UID.

Note: A single referenced image may be specified even if Annotation Coordinate Type (gggg,eee0) is
158 3D. It need not be any particular resolution layer of a WSI pyramid, but may be interpreted as a
suitable layer on which to render, select from or otherwise apply the annotation. In particular, it
160 may not be the highest resolution layer. Regardless, the annotations are applicable to any image
in the same Frame of Reference.

162 If the Annotations are points, then

- Graphic Type (0070,0023) shall have a value of POINT.
164 - All the points in the group shall be encoded in Point Coordinates Data (0066,0016) or Double
Point Coordinates Data (0066,eee0), concatenated one after another, with Z factored out into
166 Common Z Coordinate Value (gggg,eee7), if common.
- Long Primitive Point Index List (0066,0040) shall not be present, because there is no need for a
168 separate index of each annotation.
- Number of Annotations (gggg,eee5) will contain the number of points, which shall also be the
170 number of coordinate tuples in Point Coordinates Data (0066,0016) or Double Point Coordinates
Data (0066,eee0).

172 If the Annotations are open polylines, then

- Graphic Type (0070,0023) shall have a value of POLYLINE.
174 - The points of each polyline shall be encoded in Point Coordinates Data (0066,0016) or Double
Point Coordinates Data (0066,eee0), concatenated one after another, with Z factored out into
176 Common Z Coordinate Value (gggg,eee7), if common.
- The order of the encoded points is from the first point to the last point of the polyline.
178 - The index in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0)
of each successive polyline is encoded in Long Primitive Point Index List (0066,0040), which shall
180 contain Number of Annotations (gggg,eee5) values.

If the Annotations are closed polygons, then

182 - Graphic Type (0070,0023) shall have a value of POLYGON.
- The points of each polygon shall be encoded in Point Coordinates Data (0066,0016) or Double
184 Point Coordinates Data (0066,eee0), concatenated one after another, with Z factored out into
Common Z Coordinate Value (gggg,eee7), if common.

186 • The order of the encoded points is from the first point to the last point of the polygon. The first point and the last point shall not be the same, but rather they are implicitly joined to close the
188 polygon.
• The index in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0)
190 of each successive polygon is encoded in Long Primitive Point Index List (0066,0040), which shall contain Number of Annotations (gggg,eee5) values.

192 Note: This closed polygon representation differs from that used in Presentation States (C.10.5.1.2 Graphic Data and Graphic Type) and Structured Reports (C.18.6.1 Spatial
194 Coordinates Macro Attribute Descriptions and C.18.9.1 3D Spatial Coordinates Macro Attribute Descriptions), none of which are implicitly closed, and required replication of the first point as the
196 last point.

If the Annotations are circles or ellipses, then

198 • Graphic Type (0070,0023) shall have a value of ELLIPSE.
• The end points of the major and minor axes of the ellipses in the group shall be encoded in Point
200 Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0), with Z factored out into Common Z Coordinate Value (gggg,eee7) if common.
202 • Long Primitive Point Index List (0066,0040) shall not be present, because the index of each annotation can be computed. Number of Annotations (gggg,eee5) will contain the number of
204 ellipses, which shall also be one quarter of the number of coordinate tuples in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0).

206 Note: If the length of the major and minor axes are the same, then the ellipse is a circle; a simpler (e.g., 2 point) encoding of a circle is not defined, since the plane of the circle would be unspecified
208 without a third point.

If the Annotations are squares or rectangles, then

210 • Graphic Type (0070,0023) shall have a value of RECTANGLE.
• All the corner points of the rectangles in the group shall be encoded in Point Coordinates Data
212 (0066,0016) or Double Point Coordinates Data (0066,eee0), with Z factored out into Common Z Coordinate Value (gggg,eee7) if common.
214 • Long Primitive Point Index List (0066,0040) shall not be present, because the index of each annotation can be computed. Number of Annotations (gggg,eee5) will contain the number of
216 rectangles, which shall also be one quarter of the number of coordinate tuples in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0).

218 Note: If the lengths of the perpendicular edges are the same, then the rectangle is a square. This rectangle representation is the same as if the rectangle were encoded as an implicitly closed
220 polygon, except that the number of points is fixed and Long Primitive Point Index List (0066,0040) is absent. A simpler (e.g., 2 point TLHC, BRHC) encoding of a rectangle is not defined, since the
222 plane of the rectangle would then be unspecified without a third point.

The index used in Long Primitive Point Index List (0066,0040) of the first value of the first coordinate tuple
224 in Point Coordinates Data (0066,0016) or Double Point Coordinates Data (0066,eee0) shall be 1.

The polylines and polygons encoded in Point Coordinates Data (0066,0016) or Double Point Coordinates
226 Data (0066,eee0) shall be in the same order as Long Primitive Point Index List (0066,0040). I.e., the values of Long Primitive Point Index List (0066,0040) are strictly increasing.

228 Note: This means that the first value of Long Primitive Point Index List (0066,0040) is always 1.

Open polylines and implicitly closed polygons shall have their vertices encoded in Point Coordinates Data
(0066,0016) or Double Point Coordinates Data (0066,eee0) in clockwise winding order when viewed from
the top surface of the slide towards the bottom, per C.8.12.2.1 Slide Coordinates Attribute Descriptions.
The line segments shall not cross (i.e., shall be simple polygons, not complex polygons), and shall not
contain holes (i.e., the keyhole technique described for RT Structure Sets C.8.8.6.3 Representing Inner
and Outer Contours on an Image, shall not be used).

The plane of the coplanar points is not required to correspond to an image plane or be parallel to the slide
surface; the points are only required to be coplanar in a geometric sense (i.e., they need not all have the
same Z coordinate value).

C.8.Y1.2.1.2 Measurements

For each Annotation Group, optionally one or more measurements may be defined, either for every
Annotation or a subset of Annotations. Measurements are described by coded type and unit.

When there is a measurement for every Annotation, then Floating Point Values (0066,0125) contains the
corresponding values for each of the Annotations. When there are measurements for only a subset of
Annotations, then Floating Point Values (0066,0125) contains measurement values for the Annotations
that are referenced in Annotation Index List (gggg,eee6).

More than one Measurements Sequence (0066,0121) Item may be used, for example to encode different
types of measurements, or to encode different components of a measurement that is a tuple.

Within one Annotation Group the types of measurements are the same for all Annotations within that
group.

Amend DICOM PS 3.3 Annex F.3.2.2 Directory Information Module:

Table F.3-3. Directory Information Module Attributes

Attribute Name	Tag	Type	Attribute Description
…	…	…	…
>Directory Record Type	(0004,1430)	1	… Enumerated Values: … **ANNOTATION** …

Amend DICOM PS 3.3 F.4 Basic Directory IOD Information Model as follows:

Table F.4-1. Relationship Between Directory Records

Directory Record Type	Section	Directory Record Types that may be included in the next lower-level directory Entity
(Root Directory Entity)		PATIENT, HANGING PROTOCOL, PALETTE, IMPLANT, IMPLANT ASSY, IMPLANT GROUP, PRIVATE
PATIENT	F.5.1	STUDY, HL7 STRUC DOC, PRIVATE
STUDY	F.5.2	SERIES, PRIVATE
SERIES	F.5.3	IMAGE, RT DOSE, RT STRUCTURE SET, RT PLAN, RT TREAT RECORD, PRESENTATION, WAVEFORM, SR DOCUMENT, KEY OBJECT DOC, SPECTROSCOPY, RAW DATA, REGISTRATION, FIDUCIAL, ENCAP DOC, VALUE MAP, STEREOMETRIC, PLAN, MEASUREMENT, SURFACE, **ANNOTATION,** PRIVATE
…	…	…
SURFACE	F.5.42	PRIVATE
SURFACE SCAN	F.5.43	PRIVATE
ANNOTATION	**F.5.44**	**PRIVATE**
…	…	…

256

Item: Change Figure F.4-1 Basic Directory IOD Information Model:

258 *Add "Annotation DR" to the same level as Surface Scan.*

Item: Add in the following new sections in F.5

---

260 F.5.44 Microscopy Bulk Simple Annotations 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
262 "ANNOTATION". Table F.5-42 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 related to the Microscopy Bulk Simple Annotations IE of the
264 Microscopy Bulk Simple Annotations IOD. This Directory Record shall be used to reference a Microscopy Bulk Simple
Annotations SOP Instance. This type of Directory Record may reference a Lower-Level Directory Entity that includes
266 one or more Directory Records as defined in Table F.4-1.

Table F.5-44. Microscopy Bulk Simple Annotations Keys
268

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.

Key	Tag	Type	Attribute Description
Include Table 10-12 "Content Identification Macro Attributes"			
Any other Attribute of the Microscopy Bulk Simple Annotations IE Modules		3	

Note

270 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.

272

274 # DICOM PS3.4: Service Class Specifications

Amend DICOM PS 3.4 Annex B.5 Standard SOP Classes as follows:

276 ## Table B.5-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)
…	…	…
Microscopy Bulk Simple Annotations Storage	**1.2.840.10008.5.1.4.1.1.sss**	**Microscopy Bulk Simple Annotations IOD**
…	…	…

278

DICOM PS 3.6: Data Dictionary

280

Table 6-1. Registry of DICOM Data Elements

284

Tag	Name	Keyword	VR	VM	
(0066,eee1)	Double Point Coordinates Data		OD	1	
(gggg,eee0)	Annotation Coordinate Type		CS	1	
(gggg,eee1)	Annotation Group Sequence		SQ	1	
(gggg,eee2)	Annotation Group Number		UL	1	
(gggg,eee3)	Annotation Group Label		LO	1	
(gggg,eee4)	Annotation Group Description		UT	1	
(gggg,eee5)	Number of Annotations		UL	1	
(gggg,eee6)	Annotation Index List		OL	1	
(gggg,eee7)	Common Z Coordinate Value		FD	1-n	
(gggg,ee12)	Annotation Group Algorithm Identification Sequence		SQ	1	
(gggg,ee13)	Annotation Group Generation Type		CS	1	
(gggg,ee14)	Annotation Applies to All Z Planes		CS	1	
(gggg,ee15)	Annotation Applies to All Optical Paths		CS	1	
(gggg,ee16)	Annotation Property Category Code Sequence		SQ	1	
(gggg,ee17)	Annotation Property Type Code Sequence		SQ	1	
(gggg,ee18)	Annotation Property Type Modifier Code Sequence		SQ	1	

Tag	Name	Keyword	VR	VM	
(gggg,ee19)	Annotation Group UID		UI	1	
(gggg,ee20)	Referenced Optical Path Identifier		SH	1-n	

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

288 ## Table A-1. UID Values

UID Value	UID Name	UID Type	Part
…	…	…	…
1.2.840.10008.5.1.4.1.1.sss	**Microscopy Bulk Simple Annotations Storage**	**SOP Class**	**PS 3.3**
…	…	…	…

290 ## Table A-3. Context Group UID Values

Context UID	Context Identifier	Context Group Name
…	…	…
1.2.840.10008.6.1.uuu1	**CID ccc1**	**Microscopy Annotation Property Types**
1.2.840.10008.6.1.uuu2	**CID ccc2**	**Microscopy Measurement Types**
…	…	…

292

DICOM PS 3.15: Security and System Management Profiles

294 | **Amend: C.2 Creator RSA Digital Signature Profile:**

…

296 | **xx.   any attributes of the Microscopy Bulk Simple Annotations Module that are present**

…

298 | **Amend: E.1 Application Level Confidentiality Profiles:**

Table E.1-1. Application Level Confidentiality Profile Attributes

300

Attribute Name	Tag	Retd. (from PS3.6)	In Std. Comp. IOD (from PS3.3)	Basic Prof.	Rtn. Safe Priv. Opt.	Rtn. UIDs Opt.	Rtn. Dev. Id. Opt.	Rtn. Inst. Id. Opt.	Rtn. Pat. Chars. Opt.	Rtn. Long. Full Dates Opt.	Rtn. Long. Modif. Dates Opt.	Clean Desc. Opt.	Clean Struct. Cont. Opt.	Clean Graph. Opt.
Annotation Group Label	(gggg,eee3)	N	Y	D								C		
Annotation Group Description	(gggg,eee4)	N	Y	X								C		
Annotation Group UID	(gggg, ee19)	N	Y	D		K								

302

DICOM PS 3.16: Content Mapping Resource

304 | **Item: Add in Section B DCMR Context Groups (Normative)**

CID ccc1 Microscopy Annotation Property Types

306 **Type:**   **Extensible**
Version: **yyyymmdd**

308   **Table CID ccc1. Microscopy Annotation Property Types**

Coding Scheme Designator	Code Value	Code Meaning
SCT	84640000	Nucleus
SCT	362837007	Entire cell

310   *Ed. Note. Add to DICOM SNOMED subset 84640000, 362837007, ...*

312   CID ccc2 Microscopy Measurement Types

Type: **Extensible**
314 **Version:**   **yyyymmdd**

Table CID ccc2. Microscopy Measurement Types

Coding Scheme Designator	Code Value	Code Meaning
SCT	42798000	Area

316

Item: Add +/- update definitions in Annex D

Code Value	Code Meaning	Definition	Notes
...			
ANN	**Annotation**	**A device, process or method that produces annotations.**	
RTSTRUCT	Radiotherapy Structure Set	A device, process or method that produces Radiotherapy Structure Sets.	
RWV	Real World Value Map	A device, process or method that produces mappings between image pixel values and some real-world values.	
SEG	Segmentation	An image processing device, process or method that performs segmentation.	
SM	Slide Microscopy	An acquisition device, process or method that performs slide microscopy.	
...			

318

320

DICOM PS 3.17: Explanatory Information

322 | **Item: Add the following Section**

324 **XXXX** **Microscopy Bulk Simple Annotations (Informative)**

XXXX.1 **Introduction**

326 An annotation algorithm produces individual annotations that are either:

- single points (e.g., centroids),
328 - open polylines
- closed polylines entirely enclosing a structure, or
330 - circles, ellipses or rectangles (e.g., bounding boxes).

XXXX.2 **Encoding Example**

332 This section illustrates the usage of the Microscopy Bulk Simple Annotations Module (PS 3.3 C.8.Y1.2) in the context of the Microscopy Bulk Simple Annotations IOD.

334 The example consists of:

- Group of Polygons "A" outlining nuclei, consisting of:
336
  - 86 polygons
338   - Point Coordinates Data (0066,0016) => describes the coordinates for all points in the polygon.
340   - Measurement for each polygon
    - On how the values are stored, see description in "Encoding of Measurement
342   Values" below.
- Encoding of Measurement Values
344   - For storing measurement values like area values on specific polygons ....
  - Measurements Sequence (0066,0121) ...
346   - Measurement Values Sequence (0066,0132) ...

348 The table XXXX-1 shows the encoding of the Microscopy Bulk Simple Annotations Module for the example above. In addition to the polygons the table XXXX-1 also encodes the following information:

350 - property is a cell structure that is a nucleus

352 **Table XXXX-1. Example of the Microscopy Bulk Simple Annotations Module**

Name	Tag	Value	Comment
...			
Frame of Reference UID	(0020,0052)	1.2.3.4....	
...			
Annotation Coordinate Type	(gggg,eee0)	3D	
Annotation Group Sequence	(gggg,eee1)		
>Annotation Group UID	(gggg,ee19)	1.2.3.4.5....	
> Annotation Group Number	(gggg,eee2)	1	
> Annotation Group Label	(gggg,eee3)	NUCLEI	
> Annotation Group Description	(gggg,eee4)	Nuclei detected on H&E	
> Number of Annotations	(gggg,eee5)	0x00000056	
> Common Z Coordinate Value	(gggg,eee7)	0	
> Annotation Group Generation Type	(gggg,ee13)	AUTOMATIC	
> Annotation Applies to All Z Planes	(gggg,ee14)	NO	
> Annotation Applies to All Optical Paths	(gggg,ee15)	YES	
> Annotation Property Category Code Sequence	(gggg,ee16)	(4421005, SCT, "Cell Structure")	
> Annotation Property Type Code Sequence	(gggg,ee17)	(84640000, SCT, "Nucleus")	
> Point Coordinates Data	(0066,0016)	0.66675,0.032,0.6665,0.03225,0.6665,0.03275,0.66675,0.033,0.66725,0.033,0.66725,0.03275,0.6675,0.0325,0.6675,0.03225,0.66725,0.032,...	
> Long Primitive Point Index List	(0066,0040)	0x00000000,0x00000012,0x0000008c,...	
> Measurements Sequence	(0066,0121)		
>> Measurement Units Code Sequence	(0040,08EA)	({pixels}, UCUM, "pixels")	
>> Concept Name Code Sequence	(0040,A043)	(42798000, SCT, "Area")	
>> Measurement Values Sequence	(0066,0132)		
>>>Floating Point Values	(0066,0125)	20.0,559.0,24.0, ...	
> Graphic Type	(0070,0023)	POLYGON	

354