

DICOM Correction Proposal

STATUS	Final Text
Date of Last Update	2012/08/22
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Correction Number	CP-1198
Log Summary: Clarify encoding of Surface Segmentation Point Indices	
Name of Standard PS 3.3, 3.5 2011	
<p>Rationale for Correction:</p> <p>The Surface Mesh Primitives Macro (PS 3.3 C.27.4) contains Point Index Lists, e.g., Triangle Point Index List (0066,0023), which are used as integer indices to the actual (floating point) coordinates. Their use is illustrated by example in PS 3.17 Annex JJ. The starting index value is specified to be 1.</p> <p>The VR in PS 3.6 is specified as OW, from which it may be assumed that the intention is that the indices be unsigned 16 bit integers, and hence limited to a maximum number of 65535 points, despite the fact that the indexed Point Coordinates Data (0066,0016) with an OF VR with a 32 bit length field can theoretically encode $((2^{32})-1)/(3*2)$, that is 715827882, (x,y,z) coordinates.</p> <p>The intended interpretation of the OW encoding for the index attributes, and the consequent limits on the size of what can be represented, are clarified.</p>	
Correction Wording:	

Amend PS 3.3:

C.27.1 Surface Mesh Module

Table C.27-1 specifies the Attributes of the Surface Mesh Module.

**Table C.27-1
SURFACE MESH MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Number of Surfaces	(0066,0001)	1	Number of surfaces contained in the Instance. Shall be 1 or more. Shall be the same as the number of Items in Surface Sequence (0066,0002).
Surface Sequence	(0066,0002)	1	The surfaces that are described within the data. One or more Items shall be included in this sequence. There shall be Number of Surfaces (0066,0001) Items in the sequence. See C.27.1.1.1.
...

>Surface Points Sequence	(0066,0011)	1	The point positions representing vertices of the surface. Only a single item shall be included in this sequence.
>> <i>Include 'Points Macro' Table C.27-2</i>			
>Surface Points Normals Sequence	(0066,0012)	2	The normals on the surface for each point. Zero or one item shall be included in this sequence. See C.27.1.1.6.
>> <i>Include 'Vectors Macro' Table C.27-3</i>			<i>The Number of Vectors (0066,001E) shall equal Number of Surface Points (0066,0015) in this Surface Sequence Item.. The Vector Dimensionality (0066,001F) shall be 3. If Finite Volume (0066,000E) is YES, the normals of the vertices shall point toward the outside of the object. If Finite Volume (0066,000E) is not YES, the direction of the normals shall be consistent where possible.</i>
>Surface Mesh Primitives Sequence	(0066,0013)	1	Only a single item shall be included in this sequence.
>> <i>Include 'Surface Mesh Primitives Macro Table' C.27-4</i>			<i>The primitives' indices shall not exceed Number of Surface Points (0066,0015) in this Surface Sequence Item..</i>

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C.27.2 Points Macro

Table C.27-2 specifies the Attributes of the Points Macro.

**Table C.27-2
POINTS MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Number Of Surface Points	(0066,0015)	1	Specifies the number of points in the point set. <u>Shall be less than or equal to 65535, if there are indexes into Points Coordinates Data (0066,0016) that are limit in length. See C.27.2.1.1.</u>
Point Coordinates Data	(0066,0016)	1	See C.27.2.1.1
...

C.27.2.1 Points Macro Attribute Descriptions

All Attributes within this module containing points or vectors are in x-y-z order. If multiple elements are encoded, the ordering is $x_1, y_1, z_1, \dots, x_n, y_n, z_n$.

The points are in the coordinate system identified by the Frame of Reference UID (0020,0052). To map these points into the coordinate system of another SOP Instance a Spatial Registration Instance can be used.

C.27.2.1.1 Point Coordinates Data

When referencing individual points the index of the first point shall be 1.

Note: For the Attributes (defined in C.27.4 Surface Mesh Primitives Macro) that index the coordinates, the OW VR imposes the limitation to 65535 coordinates.

C.27.3 Vectors Macro

Table C.27-3 specifies the attributes of the Vectors Macro.

**Table C.27-3
VECTORS MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Number of Vectors	(0066,001E)	1	The number of vectors in the Vector Coordinate Data (0066,0021). See C.27.3.1.
Vector Dimensionality	(0066,001F)	1	The dimensionality of the underlying vector field. See C.27.3.1.
Vector Accuracy	(0066,0020)	3	A single standard deviation for all the vectors' coordinates. The units shall be the same as the units of the coordinate system in which the vector coordinates are specified. See C.27.3.1.
Vector Coordinate Data	(0066,0021)	1	A data stream of coordinates encoded as floats. See C.27.3.1.

C.27.3.1 Vectors Macro Attribute Descriptions

All Attributes within this module containing points or vectors are encoded as multi-valued floats in an x-y-z ordering. If multiple elements are encoded, the ordering is $x_1, y_1, z_1, \dots, x_n, y_n, z_n$.

The vectors encoded in this macro can be anything from 1D to nD objects. The vectors are encoded as a stream of values in the Vector Coordinate Data (0066,0021) Attribute. Vector Dimensionality (0066,001F) defines how many subsequent entries in Vector Coordinate Data (0066,0021) describe one element. Vector Coordinate Data (0066,0021) shall have (Number of Vectors) x (Vector Dimensionality) values.

For measured vectors, the Vector Accuracy Attribute (0066,0020) describes the error per dimension in a multi-valued float attribute.

Notes: 1. The vectors are located at the points specified by the table including this macro.
2. Though not explicitly limited, so that the macro may be of general use, the Number of Vectors (0066,001E) is implicitly limited by the number of points specified by the table including this macro, which in the case of C.27.1 Surface Mesh Module, is the Number of Surface Points (0066,0015), which is limited to 65535, because of the limit on the number of index values.

C.27.4 Surface Mesh Primitives Macro

Table C.27-4 specifies the attributes of the Surface Mesh Primitives Macro.

**Table C.27-4
SURFACE MESH PRIMITIVES MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Vertex Point Index List	(0066,0025)	2	Contains n point indices describing Vertices. See C.27.4.1.
Edge Point Index List	(0066,0024)	2	Contains 2n point indices describing unconnected Edges.

			See C.27.4.1.
Triangle Point Index List	(0066,0023)	2	Contains 3n point indices describing unconnected Triangles. See C.27.4.1.
Triangle Strip Sequence	(0066,0026)	2	All Triangle Strips in this Surface. Zero or more Items shall be included in this sequence.
>Primitive Point Index List	(0066,0029)	1	See C.27.4.1.
Triangle Fan Sequence	(0066,0027)	2	All Triangle Fans in this Surface. Zero or more Items shall be included in this sequence.
>Primitive Point Index List	(0066,0029)	1	See C.27.4.1.
Line Sequence	(0066,0028)	2	All Lines in this Surface. Zero or more Items shall be included in this sequence.
>Primitive Point Index List	(0066,0029)	1	See C.27.4.1.
Facet Sequence	(0066,0034)	2	All Facets in this Surface. Each sequence Item describes one facet. Zero or more Items shall be included in this sequence.
>Primitive Point Index List	(0066,0029)	1	See C.27.4.1.

C.27.4.1 Surface Mesh Primitives Macro Attribute Descriptions

The Surface Mesh Primitives Macro uses point indices to reference the point rather than repeating point coordinates. All of the point coordinates used are specified within the Surface Points Sequence (0066,0011) of the same Surface Sequence (0066,0002) item. Point indices are described in C.27.2.1.1.

A Surface Mesh shall contain one or more of the following primitive types:

Vertex	a single Vertex, referencing a single point
Edge	an Edge, referencing two points
Line	a series of connected points describing a path
Triangle	a Triangle, referencing three points:
Triangle Strip	a Triangle Strip with n triangles, referencing n+2 points. The first three referenced points describe the first triangle, the second, third and fourth referenced points describe the second triangle.
Triangle Fan	a Triangle Fan with n triangles, referencing n+2 points. The first referenced point is in the center of the fan. Together with two subsequent referenced points, it describes a complete triangle.
Facet	a closed planar polygon, referencing n points. The final point in the point index list shall be connected to the first point in the point index list to close the facet.

If the Surface Points Normals Sequence (0066,0012) is not present, the default normals can be derived from the Surface Mesh Primitives.

For the Triangle Strip, Triangle Fan, Line, and Facet the Primitive Point Index List (0066,0029) the ordering of the point references implies the direction of the primitive's normal: The normal points in the

direction from which the referenced points are specified in a counterclockwise order. For finite volumes this shall be the outward direction.

For Primitives of type Triangle Strip or Triangle Fan, the orientation of the normals is given by the order of the points in the first triangle.

Note: These points may be used to compute normals to the primitive. (See section C.27.1.1.6.) The order these point references are presented in the Primitive Point Index List (0066,0029) will affect the direction the computed normal points. If the order of the point references is reversed, the direction of the normals will be reversed as well.

A.1 DICOM IMPLICIT VR LITTLE ENDIAN TRANSFER SYNTAX

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Implicit VR Little Endian Transfer Syntax the following requirements shall be met:

- a) ...
- b) ...
- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:
 - For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
 - For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
 - Data Element (7FE0,0010) Pixel Data has the Value Representation OW and shall be encoded in Little Endian.
 - Data Element (60xx,3000) Overlay Data has the Value Representation OW and shall be encoded in Little Endian.
 - Data Element (5400,1010) Waveform Data shall have Value Representation OW and shall be encoded in Little Endian.
 - Data Elements (0028,1201), (0028,1202), (0028,1203) , (0028,1204) Red, Green, Blue, Alpha Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.

Note: Previous versions of the Standard either did not specify the encoding of Data Elements (0028,1201), (0028,1202), (0028,1203) in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the values and their byte order would be identical in each case.
 - Data Elements (0028,1101), (0028,1102),(0028,1103) Red, Green, Blue Palette Lookup Table Descriptor have the Value Representation SS or US (depending on rules specified in the IOD in PS 3.3), and shall be encoded in Little Endian. The first and third values are always interpreted as unsigned, regardless of the Value Representation.
 - Data Elements (0028,1221),(0028,1222),(0028,1223) Segmented Red, Green, Blue Palette Color Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.
 - Data Element (0028,3006) LUT Data has the Value Representation US or OW and shall be encoded in Little Endian.

Note: Previous versions of the Standard did not specify the encoding of these Data Elements in this Part, but specified a VR of US or SS in PS 3.6 (1998). A VR of OW has been added to support explicit VR transfer syntaxes. Moreover this element is always unsigned, therefore the VR of SS has been removed. The actual encoding of the values and their byte order would be identical in each case.
 - Data Element (0028,3002) LUT Descriptor has the Value Representation SS or US (depending on rules specified in the IOD in PS 3.3), and shall be encoded in Little Endian. The first and third values are always interpreted as unsigned, regardless of the Value Representation.
 - Data Element (0028,1408) Blending Lookup Table Data has the Value Representation OW and shall be encoded in Little Endian.
 - **Data Elements (0066,0025) Vertex Point Index List, (0066,0024) Edge Point Index List, (0066,0023) Triangle Point Index List and (0066,0029) Primitive Point Index List have the Value Representation OW and shall be encoded in Little Endian and are always interpreted as unsigned.**

Note: Encoding of Curve Data and Audio Sample Data was previously defined but has been retired. See PS 3.5 2004.

This DICOM Implicit VR Little Endian Transfer Syntax shall be identified by a UID of Value "1.2.840.10008.1.2".

A.2 DICOM LITTLE ENDIAN TRANSFER SYNTAX (EXPLICIT VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Little Endian Transfer Syntax the following requirements shall be met:

- a) ...
- b) ...
- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:
 - For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
 - For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
 - Data Element (7FE0,0010) Pixel Data
 - where Bits Allocated (0028,0100) has a value greater than 8 shall have Value Representation OW and shall be encoded in Little Endian;
 - where Bits Allocated (0028,0100) has a value less than or equal to 8 shall have the Value Representation OB or OW and shall be encoded in Little Endian.
 - ...
 - Data Element (0028,3002) LUT Descriptor has the Value Representation SS or US (depending on rules specified in the IOD in PS 3.3), and shall be encoded in Little Endian. The first and third values are always interpreted as unsigned, regardless of the Value Representation.
 - Data Element (0028,1408) Blending Lookup Table Data has the Value Representation OW and shall be encoded in Little Endian.
 - **Data Elements (0066,0025) Vertex Point Index List, (0066,0024) Edge Point Index List, (0066,0023) Triangle Point Index List and (0066,0029) Primitive Point Index List have the Value Representation OW and shall be encoded in Little Endian and are always interpreted as unsigned.**

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A.3 DICOM BIG ENDIAN TRANSFER SYNTAX (EXPLICIT VR)

This Transfer Syntax applies to the encoding of the entire DICOM Data Set. This implies that when a DICOM Data Set is being encoded with the DICOM Big Endian Transfer Syntax the following requirements shall be met:

- a) ...
- b) ...
- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:
 - For all Value Representations defined in this part, except for the Value Representations OB and OW, the encoding shall be in Big Endian as specified in Section 7.3.
 - For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
 - Data Element (7FE0,0010) Pixel Data
 - where Bits Allocated (0028,0100) has a value greater than 8 shall have Value Representation OW and shall be encoded in Big Endian;

- where Bits Allocated (0028,0100) has a value less than or equal to 8 shall have the Value Representation OB or OW and shall be encoded in Big Endian.
- ...
- Data Element (0028,1408) Blending Lookup Table Data has the Value Representation OW and shall be encoded in Big Endian.
- **Data Elements (0066,0025) Vertex Point Index List, (0066,0024) Edge Point Index List, (0066,0023) Triangle Point Index List and (0066,0029) Primitive Point Index List have the Value Representation OW and shall be encoded in Big Endian and are always interpreted as unsigned.**

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A.4 TRANSFER SYNTAXES FOR ENCAPSULATION OF ENCODED PIXEL DATA

These Transfer Syntaxes apply to the encoding of the entire DICOM Data Set, even though the image Pixel Data (7FE0,0010) portion of the DICOM Data Set is the only portion that is encoded by an encapsulated format. This implies that when a DICOM Message is being encoded according to an encapsulation Transfer Syntax the following requirements shall be met:

- a) ...
- b) ...
- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:
 - For all Value Representations defined in this part of the DICOM Standard, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
 - For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
 - Data Element (7FE0,0010) Pixel Data may be encapsulated or native.
 - ...
 - **Data Elements (0066,0025) Vertex Point Index List, (0066,0024) Edge Point Index List, (0066,0023) Triangle Point Index List and (0066,0029) Primitive Point Index List have the Value Representation OW and shall be encoded in Little Endian and are always interpreted as unsigned.**

JJ.2 ENCODING EXAMPLES

The following example demonstrates the usage of the Surface Mesh Module for a tetrahedron.

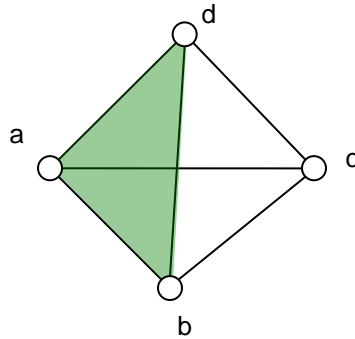


Figure JJ.2-1 – Surface Mesh Tetrahedron

	(0066,0015)	Number Of Surface Points	4	
	(0066,0016)	Point Coordinates Data	-5.\-3.727\ -4.757\ 5.\-3.707\ -4.757\ 0.\7.454\ -4.757\ 0.\0.\8.315	4 triplets. The points are marked a,b,c,d in the sketch.

	(0066,0013)	Surface Mesh Primitives Sequence		
	(0066,0025)	Vertex Point Index List	<empty>	
	(0066,0024)	Edge Point Index List	<empty>	
	(0066,0023)	Triangle Point Index List	1\3\2\1\2\4\2\3\4\ 3\1\4	The second triangle is the one marked green in the sketch.
