

## DICOM Correction Item

Correction Number	CP-626
Log Summary: Clarify pixel spacing row and column order	
Type of Modification	Name of Standard
Clarification	PS 3.3 2006
<p>Rationale for Correction</p> <p>The description of pixel spacing related attributes does not make it entirely clear that the first value (row spacing) is the spacing between the center of adjacent rows, and the second value (column spacing) is the spacing between the center of adjacent columns.</p> <p>It is proposed to clarify and illustrate this, in a similar manner to Pixel Aspect Ratio.</p> <p>It is not expected that this has ever been actually been misinterpreted, since practically all implementations affected by the pixel spacing attributes use square pixels.</p>	
Sections of documents affected	
PS 3.3 10.7, C.7.6.2, C.7.6.16.2.1, C.7.6.16.2.2.4, C.8.4.7, C.8.6.2, C.8.6.3, C.8.7.2, C.8.8.2, C.8.8.14, C.8.8.25, C.8.11.4, C.8.15.3.7, C.8.17.2, C.10.4, C.13.13, C.8.19.3, C.8.19.6.9	
Correction Wording:	

*Amend PS 3.3 Section 10.7:*

**10.7 BASIC PIXEL SPACING CALIBRATION MACRO**

Table 10-10 defines the Attributes for the Basic Pixel Spacing Calibration Macro.

**Table 10-10  
 BASIC PIXEL SPACING CALIBRATION MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Pixel Spacing	(0028,0030)	1C	Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. See 10.7.1.1 <b>and</b> 10.7.1.3.
...	...	...	...

**10.7.1 Basic Pixel Spacing Calibration Macro Attribute Descriptions**

**10.7.1.1 Pixel Spacing**

The Pixel Spacing (0028,0030) attribute specifies the physical distance in the patient between the center of each pixel.

If the image has not been calibrated to correct for the effect of geometric magnification, the values of this attribute shall be the same as in Imager Pixel Spacing (0018,1164) or Nominal Scanned Pixel Spacing (0018,2010), if either of those attributes are present.

If the values are different from those in Imager Pixel Spacing (0018,1164) or Nominal Scanned Pixel Spacing (0018,2010), then the image has been corrected for known or assumed geometric magnification or calibrated with respect to some object of known size at known depth within the patient.

If Pixel Spacing Calibration Type (0028,0402) and Imager Pixel Spacing (0018,1164) and Nominal Scanned Pixel Spacing (0018,2010) are absent, then it cannot be determined whether or not correction or calibration have been performed.

- Notes: 1. Imager Pixel Spacing (0018,1164) is a required attribute in DX family IODs.  
 2. Nominal Scanned Pixel Spacing (0018,2010) is a required attribute in Multi-frame SC family IODs

**10.7.1.2 Pixel Spacing Calibration Type**

...

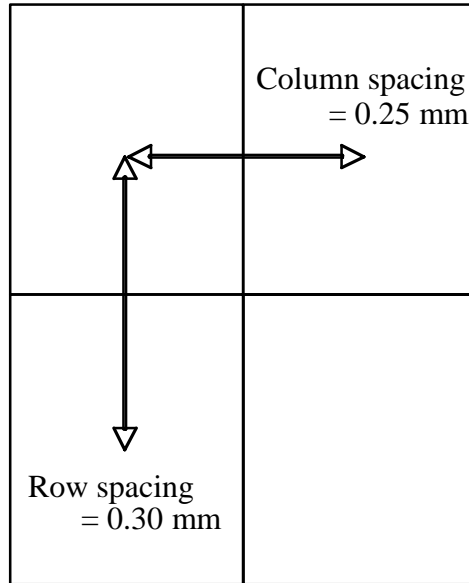
**10.7.1.3 Pixel Spacing Value Order**

**All pixel spacing related attributes are encoded as the physical distance between the centers of each two-dimensional pixel, specified by two numeric values.**

**The first value is the row spacing in mm, that is the spacing between the centers of adjacent rows, or vertical spacing.**

**The second value is the column spacing in mm, that is the spacing between the centers of adjacent columns, or horizontal spacing.**

**To illustrate, consider the following example:**



**Pixel Spacing = Row Spacing \ Column Spacing = 0.30 mm \ 0.25 mm.**

**This description applies to:**

- **Pixel Spacing (0028,0030)**
- **Imager Pixel Spacing (0018,1164)**
- **Nominal Scanned Pixel Spacing (0018,2010)**
- **Image Plane Pixel Spacing (3002,0011)**
- **Compensator Pixel Spacing (300A,00E9)**
- **Detector Element Spacing (0018,7022)**
- **Presentation Pixel Spacing (0070,0101)**
- **Printer Pixel Spacing (2010,0376)**
- **Object Pixel Spacing in Center of Beam (0018,9404)**

*Amend PS 3.3 Section C.7.6.2:*

**C.7.6.2 Image Plane Module**

...

**Table C.7-10  
 IMAGE PLANE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Pixel Spacing	(0028,0030)	1	Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. <b><u>See 10.7.1.3 for further explanation.</u></b>
...	...	...	...

*Amend PS 3.3 Section C.7.6.16.2.1:*

**C.7.6.16.2.1 Pixel Measures Macro**

...

**Table C.7.6.16-2  
 PIXEL MEASURES MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
Pixel Measures Sequence	(0028,9110)	1	Identifies the physical characteristics of the pixels of this frame. Only a single Item shall be permitted in this sequence.
>Pixel Spacing	(0028,0030)	1C	Physical distance in the patient between the centers of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. <b><u>See 10.7.1.3 for further explanation of the value order.</u></b>  Note: In the case of CT images with an Acquisition Type (0018,9302) of CONSTANT_ANGLE, the pixel spacing is that in a plane normal to the central ray of the diverging X-ray beam as it passes through the data collection center.  Required if Volumetric Properties (0008,9206) is other than DISTORTED or SAMPLED. May be present otherwise.
...	...	...	...

*Amend PS 3.3 Section C.7.6.16.2.2.4:*

**C.7.6.16.2.2.4 Concatenations and Stacks**

...

In order to allow interoperable operations on stacks, 2 different frames with the same Stack ID (0020,9056) can only have the same In-Stack Position Number (0020,9057) if they have the same values for the following attributes:

1. Dimension Organization UID (0020,9164) or if absent Concatenation UID (0020,9133) to qualify the Stack ID
2. Image Position (Patient) (0020,0032)
3. Image Orientation (Patient) (0020,0037)
4. Rows (0028,0010) \* **first value of** Pixel Spacing (0028,0030) (= field of view in the row direction)
5. Columns (0028,0011) \* **second value of** Pixel Spacing (0028,0030) (= field of view in the column direction)
6. Slice Thickness (0018,0050)

Amend PS 3.3 Section C.8.4.7:

**C.8.4.7 NM Image Pixel Module**

...

**Table C.8-6  
 NM IMAGE PIXEL MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Pixel Spacing	(0028,0030)	2	Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing, in mm. <b>See 10.7.1.3 for further explanation of the value order.</b>

Amend PS 3.3 Section C.8.6.2:

**C.8.6.2 SC Image Module**

Table C.8-25 contains IOD Attributes that describe Secondary Capture Images.

**Table C.8-25  
 SC IMAGE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Nominal Scanned Pixel Spacing	(0018,2010)	3	Physical distance on the media being digitized or scanned between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent

			column spacing in mm. <b>See 10.7.1.3 for further explanation of the value order.</b> Shall be consistent with Pixel Aspect Ratio (0028,0034), if present.
<i>Include Basic Pixel Spacing Calibration Macro (Table 10-10)</i>			

*Amend PS 3.3 Section C.8.6.3:*

**C.8.6.3 SC Multi-frame Image Module**

...

**Table C.8-25b  
 SC MULTI-FRAME IMAGE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Nominal Scanned Pixel Spacing	(0018,2010)	1C	Physical distance on the media being digitized or scanned between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. <b>See 10.7.1.3 for further explanation of the value order.</b> Required if Conversion Type (0008,0064) is DF (Digitized Film). May also be present if Conversion Type (0008,0064) is SD (Scanned Document) or SI (Scanned Image). Shall be consistent with Pixel Aspect Ratio(0028,0034), if present.
...	...	...	...

*Amend PS 3.3 Section C.8.7.2:*

**C.8.7.2 X-Ray Acquisition Module**

**Table C.8-27  
 X-RAY ACQUISITION MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Imager Pixel Spacing	(0018,1164)	3	Physical distance measured at the front plane of the Image Receptor housing between the center of each pixel specified by a numeric pair - row spacing value(delimiter) column spacing value in mm. <b>See 10.7.1.3 for further explanation of the value order.</b>
...	...	...	...

*Amend PS 3.3 Section C.8.8.2:*

**C.8.8.2 RT Image Module**

...

**Table C.8-38—RT IMAGE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Image Plane Pixel Spacing	(3002,0011)	2	Physical distance (in mm) between the center of each image pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing. See C.8.8.2.3 <b>and 10.7.1.3 for further explanation.</b>
...	...	...	...

...

**C.8.8.2.3 Image Plane Pixel Spacing and RT Image SID**

The Image Plane Pixel Spacing (3002,0011) attribute shall always be defined on the image plane, i.e. at the radiation machine source to image plane distance specified by RT Image SID (3002,0026). For images where the source-image distance is undefined or unknown (e.g. DRR images), RT Image SID (3002,0026) shall equal Radiation Machine SAD (3002,0022) and Image Plane Pixel Spacing (3002,0011) shall be defined on this common plane.

<i>Amend PS 3.3 Section C.8.8.14:</i>
---------------------------------------

**C.8.8.14 RT Beams Module**

...

**Table C.8-50—RT BEAMS MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
>>Compensator Pixel Spacing	(300A,00E9)	1C	Physical distance (in mm) between the center of each pixel projected onto machine isocentric plane. Specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing. <b>See 10.7.1.3 for further explanation of the value order.</b> Required if Compensator Sequence (300A,00E3) is sent.
...	...	...	...

<i>Amend PS 3.3 Section C.8.8.25:</i>
---------------------------------------

**C.8.8.25 RT Ion Beams Module**

...

**Table C.8.8.25-1**  
**RT ION BEAMS MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
>>Compensator Pixel Spacing	(300A,00E9)	1	Physical distance (in mm) between the center of each pixel projected onto machine isocentric plane. Specified by a numeric pair - adjacent row spacing followed by adjacent column spacing. <b>See 10.7.1.3 for further explanation of the value order.</b>

*Amend PS 3.3 Section C.8.11.4:*

**C.8.11.4 DX Detector Module**

...

**Table C.8-71a**  
**DX DETECTOR MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Imager Pixel Spacing	(0018,1164)	1	Physical distance measured at the front plane of the detector housing between the center of each image pixel specified by a numeric pair - row spacing value(delimiter) column spacing value in mm. <b>See 10.7.1.3 for further explanation of the value order.</b>  The value of this attribute shall never be adjusted to account for correction for the effect of geometric magnification or calibration against an object of known size; Pixel Spacing (0028,0030) is specified for that purpose.
...	...	...	...

**Table C.8-71b**  
**DIGITAL X-RAY DETECTOR MACRO ATTRIBUTES**

...	...	...	...
Detector Element Physical Size	(0018,7020)	3	Physical dimensions of each detector element that comprises the detector matrix, in mm.  Expressed as row dimension followed by column.  Note: This may not be the same as Detector Element Spacing (0018,7022) due to the presence of spacing material between detector elements.
Detector Element Spacing	(0018,7022)	3	Physical distance between the center of each detector element, specified by a



			numeric pair - row spacing value(delimiter) column spacing value in mm. <b>See 10.7.1.3 for further explanation of the value order.</b> Note: This may not be the same as the Imager Pixel Spacing (0018,1164), and should not be assumed to describe the stored image.
...	...	...	...

Amend PS 3.3 Section C.8.15.3.7:

**C.8.15.3.7 CT Reconstruction Macro**

...

**Table C.8-123  
CT RECONSTRUCTION MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
>Reconstruction Pixel Spacing	(0018,9322)	1C	Physical distance in the patient between the center of each reconstructed pixel, specified by a numeric pair – adjacent row spacing (delimiter) adjacent column spacing in mm. <b>See 10.7.1.3 for further explanation of the value order.</b> Required if Frame Type (0008,9007) Value 1 of this frame is ORIGINAL. May be present otherwise.
...	...	...	...

Amend PS 3.3 Section C.8.17.2:

**C.8.17.2 Ophthalmic Photography Image Module**

...

**Table C.8.17.2-1  
OPHTHALMIC PHOTOGRAPHY IMAGE MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...

Pixel Spacing	(0028,0030)	1C	<p>Nominal physical distance at the focal plane (in the retina) between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. <b><u>See 10.7.1.3 for further explanation of the value order.</u></b></p> <p>Note: These values are specified as nominal because the physical distance may vary across the field of the images and the lens correction is likely to be imperfect.</p> <p>Required when Acquisition Device Type Code Sequence (0022,0015) contains an item with the value (SRT, R-1021A,"Fundus Camera"). May be present otherwise.</p>
...	...	...	...

*Amend PS 3.3 Section C.10.4:*

**C.10.4            Displayed Area Module**

...

**Table C.10-4**  
**DISPLAYED AREA MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
>Presentation Pixel Spacing	(0070,0101)	1C	<p>Physical distance between the center of each pixel in the referenced image (before spatial transformation), specified by a numeric pair – adjacent row spacing (delimiter) adjacent column spacing in mm. <b><u>See 10.7.1.3 for further explanation of the value order.</u></b></p> <p>Notes: 1. This value may be different from Pixel Spacing (0028,0030) or Imager Pixel Spacing (0018,1164) specified in the referenced image, which are ignored, since some form of calibration may have been performed (for example by reference to an object of known size in the image).            2. If the row and column spacing are different, then the pixel aspect ratio of the image is not 1:1.</p> <p>Required if Presentation Size Mode (0070,0100) is TRUE SIZE, in which case the values will correspond to the physical distance between the center of each pixel on the display device.</p> <p>May be present if Presentation Size Mode (0070,0100) is SCALE TO FIT or MAGNIFY, in which case the values are used to compute the aspect ratio of the image pixels.</p>
>Presentation Pixel Aspect Ratio	(0070,0102)	1C	<p>Ratio of the vertical size and the horizontal size of the pixels in the referenced image, to be used to display the referenced image, specified by a pair of integer values where the first value is the vertical pixel size and the second value is the horizontal pixel size. See C.7.6.3.1.7.</p> <p>Required if Presentation Pixel Spacing (0070,0101) is not present.</p> <p>Notes: 1. This value may be different from the aspect ratio specified by Pixel Aspect Ratio (0028,0034) in the referenced image, or implied by the values of Pixel Spacing (0028,0030) or Imager Pixel Spacing (0018,1164) specified in the referenced image, which are ignored.            2. This value must be specified even if the aspect ratio is 1:1.</p>
...	...	...	...

Amend PS 3.3 Section C.13.13:

**C.13.13 Printer Configuration Module**

...

**Table C.13-13  
 PRINTER CONFIGURATION MODULE**

Attribute Name	Tag	Attribute Description
...	...	...
>>Printer Pixel Spacing	(2010,0376)	Physical distance on the printed film between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. <b>See 10.7.1.3 for further explanation of the value order.</b>
...	...	...

Amend PS 3.3 Section C.8.19.3:

**C.8.19.3 XA/XRF Acquisition Module**

...

**Table C.8.19.3-1  
 XA/XRF ACQUISITION MODULE ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...
Imager Pixel Spacing	(0018,1164)	1	Physical distance measured at the receptor plane of the detector between the centers of each pixel specified by a numeric pair – row spacing value (delimiter) column spacing value in mm. <b>See 10.7.1.3 for further explanation of the value order.</b>  Note: These values are the actual pixel spacing distances of the stored pixel values of an image.
...	...	...	...

Amend PS 3.3 Section C.8.19.6.9:

**C.8.19.6.9 X-Ray Projection Pixel Calibration Macro**

...

**Table C.8.19.6-9  
 X-RAY PROJECTION PIXEL CALIBRATION MACRO ATTRIBUTES**

Attribute Name	Tag	Type	Attribute Description
...	...	...	...

>Object Pixel Spacing in Center of Beam	(0018,9404)	1C	<p>Physical distance within the anatomic region of interest in the center of the beam and perpendicular to the beam between the center of each pixel, specified by a numeric pair adjacent row spacing (delimiter) adjacent column spacing in mm. See C.8.19.6.9.42. <b><u>See 10.7.1.3 for further explanation of the value order.</u></b></p> <p>Required if Distance Object to Table Top (0018,9403) is not empty.</p> <p>Note: This value is provided besides the values that are the input parameters of the calibration algorithm.</p>
...	...	...	...

...

**C.8.19.6.9.2 Object Pixel Spacing in Center of Beam**

The value provided for the Beam Angle (0018,9449) attribute shall correspond to the other attribute values within this module and according to the mathematic terms listed in section C.8.19.6.9.1.

The terms listed will result in infinite result when used with 90-degree beam angles.

It is outside the scope of this Standard to define reasonable limits for single input values in the above-mentioned terms, or to define the mathematical accuracy of applications using those terms.

Note: It may be reasonable to limit automatic calculations to a narrow range of +/- 60 degrees for Beam Angle and inform users about possible deviations in the calibration result when exceeding such range limits.

...