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|---|---------------------|--|
| 1 | Status              | Final Text                                 |
| 2 | Date of Last Update | 2019/03/23                                 |
| 3 | Person Assigned     | David Clunie                               |
| 4 |                     | mailto:dclunie@dclunie.com                 |
| 5 | Submitter Name      | Aaron Stearrett                            |
| 6 |                     | mailto:Aaron.Stearrett@LeicaBiosystems.com |
| 7 | Submission Date     | 2018/04/14                                 |

|    |   |  |
|----|---|--|
| 8  | Correction Number CP-1841   |  |
| 9  | Log Summary: Allow compressed RGB for WSI   |  |
| 10 | Name of Standard  |  |
| 11 | PS3.3, PS3.5 2019a  |  |
| 12 | Rationale for Correction:   |  |
| 13 | Compressed RGB components (rather than YBR) really are used by some WSI vendors in order to avoid the loss in conversion of |  |
| 14 | color spaces.   |  |
| 15 | Relax the constraints for WSI only, especially those applied by CP 1653.  |  |
| 16 | Correction Wording:   |  |

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

## C.8.12.4 Whole Slide Microscopy Image Module

Table C.8.12.4-1 specifies the Attributes that describe the Whole Slide Microscopy Image Module.

**Table C.8.12.4-1. Whole Slide Microscopy Image Module Attributes**

| Attribute Name             | Tag         | Type | Attribute Description   |
|----------------------------|-------------|------|---|
| ...                        | ...         | ...  | ...   |
| Photometric Interpretation | (0028,0004) | 1    | Specifies the intended interpretation of the pixel data.<br>See Section C.8.12.4.1.5 for Enumerated Values. |

### C.8.12.4.1 Whole Slide Microscopy Image Attribute Descriptions

#### C.8.12.4.1.5 Photometric Interpretation and Samples Per Pixel

See Section C.7.6.3.1.2.

#### Enumerated Values for Photometric Interpretation (0028,0004):

MONOCHROME2  
 RGB  
 YBR\_FULL\_422  
 YBR\_ICT  
 YBR\_RCT

The value shall be appropriate to the compression Transfer Syntax used, if any, and shall be MONOCHROME2 or RGB for uncompressed or lossless compressed Transfer Syntaxes that do not have defined color space transformations, YBR\_ICT **or RGB** for irreversible JPEG 2000 Transfer Syntaxes, YBR\_RCT **or RGB** for reversible JPEG 2000 Transfer Syntaxes, and YBR\_FULL\_422 **or RGB** for JPEG lossy compressed Transfer Syntaxes.

#### Note

- Future lossless and lossy Transfer Syntaxes may lead to the need for new definitions and choices for Photometric Interpretation. The Enumerated Values may therefore be extended with additional Photometric Interpretation values directly associated with new Transfer Syntaxes that are negotiated, and hence do not render existing implementations non-conformant.
- Motion compression Transfer Syntaxes are not expected to be used for Whole Slide Imaging, so the use of YBR\_PARTIAL\_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes is not permitted.
- The prohibition of a value of 1 for Planar Configuration (0028,0006) prevents the use of the RLE Transfer Syntax.
- The use of RGB with JPEG and JPEG 2000 is only intended to allow for conversion to DICOM of images from proprietary formats for which no color transformation from RGB to YBR was performed and the encoded components really are RGB. The value of Photometric Interpretation (0028,0004) describes what is actually encoded, so a value of RGB is not used when the compressed components are actually YBR.**

Multi-spectral images may be encoded as a single wavelength band (color) in each frame using MONOCHROME2, or with up to three bands in each frame using one of the color Photometric Interpretations.

#### Enumerated Values for Samples per Pixel (0028,0002) when Photometric Interpretation (0028,0004) is MONOCHROME2:

1

**Enumerated Values for Samples per Pixel (0028,0002) when Photometric Interpretation (0028,0004) is not MONOCHROME2:**

**3**

*Amend DICOM PS3.5 as follows (changes to existing text are bold and underlined for additions and ~~struckthrough~~ for removals):*

## 8.2.1 JPEG Image Compression

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS3.3 Section C.7.6.3.1.2) are specified in Table 8.2.1-1 and Table 8.2.1-2. No other Standard Photometric Interpretation values shall be used.

**Table 8.2.1-1. Valid Values of Pixel Data Related Attributes for JPEG Lossy Transfer Syntaxes using Standard Photometric Interpretations**

| Photometric Interpretation | Transfer Syntax | Transfer Syntax UID    | Samples per Pixel | Planar Configuration | Pixel Representation | Bits Allocated | Bits Stored | High Bit |
|----------------------------|-----------------|------------------------|-------------------|----------------------|----------------------|----------------|-------------|----------|
| MONOCHROME1<br>MONOCHROME2 | JPEG Baseline   | 1.2.840.10008.1.2.4.50 | 1                 | absent               | 0                    | 8              | 8           | 7        |
| MONOCHROME1<br>MONOCHROME2 | JPEG Extended   | 1.2.840.10008.1.2.4.51 | 1                 | absent               | 0                    | 8              | 8           | 7        |
| MONOCHROME1<br>MONOCHROME2 | JPEG Extended   | 1.2.840.10008.1.2.4.51 | 1                 | absent               | 0                    | 16             | 12          | 11       |
| YBR_FULL_422<br><b>RGB</b> | JPEG Baseline   | 1.2.840.10008.1.2.4.50 | 3                 | 0                    | 0                    | 8              | 8           | 7        |

**Table 8.2.1-2. Valid Values of Pixel Data Related Attributes for JPEG Lossless Transfer Syntaxes using Standard Photometric Interpretations**

| Photometric Interpretation | Transfer Syntax                      | Transfer Syntax UID    | Samples per Pixel | Planar Configuration | Pixel Representation | Bits Allocated | Bits Stored | High Bit |
|----------------------------|--------------------------------------|------------------------|-------------------|----------------------|----------------------|----------------|-------------|----------|
| MONOCHROME1<br>MONOCHROME2 | JPEG Lossless, Non-Hierarchical      | 1.2.840.10008.1.2.4.57 | 1                 | absent               | 0 or 1               | 8 or 16        | 1-16        | 0-15     |
|                            | JPEG Lossless, Non-Hierarchical, SV1 | 1.2.840.10008.1.2.4.70 |                   |                      |                      |                |             |          |
| PALETTE COLOR              | JPEG Lossless, Non-Hierarchical      | 1.2.840.10008.1.2.4.57 | 1                 | absent               | 0                    | 8 or 16        | 1-16        | 0-15     |
|                            | JPEG Lossless, Non-Hierarchical, SV1 | 1.2.840.10008.1.2.4.70 |                   |                      |                      |                |             |          |
| YBR_FULL<br>RGB            | JPEG Lossless, Non-Hierarchical      | 1.2.840.10008.1.2.4.57 | 3                 | 0                    | 0                    | 8 or 16        | 1-16        | 0-15     |
|                            | JPEG Lossless, Non-Hierarchical, SV1 | 1.2.840.10008.1.2.4.70 |                   |                      |                      |                |             |          |

The Pixel Data characteristics included in the JPEG Interchange Format shall be used to decode the compressed data stream.

**Note**

1. These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data stream was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.

When decompressing, should the characteristics explicitly specified in the compressed data stream (e.g., spatial sub-sampling or number of components or planar configuration) be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.

2. Those characteristics not explicitly specified in the compressed data stream (e.g., the color space of the compressed components, which is not specified in the JPEG Interchange Format), or implied by the definition of the compression scheme (e.g., always unsigned in JPEG), can therefore be determined from the DICOM Data Element in the enclosing Data Set. For example a Photometric Interpretation of "YBR\_FULL\_422" would describe the color space that is commonly used to lossy compress images using JPEG. It is unusual to use an RGB color space for lossy compression, since no advantage is taken of correlation between the red, green and blue components (e.g., of luminance), and poor compression is achieved; **however, for some applications this is permitted, e.g., Whole Slide Microscopy Images, to allow conversion to DICOM from proprietary formats without loss due to color space transformation.**
3. The JPEG Interchange Format is distinct from the JPEG File Interchange Format (JFIF). The JPEG Interchange Format is defined in [ISO/IEC 10918-1] section 4.9.1, and refers to the inclusion of decoding tables, as distinct from the "abbreviated format" in which these tables are not sent (and the decoder is assumed to already have them). The JPEG Interchange Format does NOT specify the color space. The JPEG File Interchange Format, not part of the original JPEG standard, but defined in [ECMA TR-098] and [ISO/IEC 10918-5], is often used to store JPEG bit streams in consumer format files, and does include the ability to specify the color space of the components. The JFIF APP0 marker segment is NOT required to be present in DICOM encapsulated JPEG bit streams, and should not be relied upon to recognize the color space. Its presence is not forbidden (unlike the JP2 information for JPEG 2000 Transfer Syntaxes), but it is recommended that it be absent.
4. Should the compression process be incapable of encoding a particular form of pixel data representation (e.g., JPEG cannot encode signed integers, only unsigned integers), then ideally only the appropriate form should be "fed" into the compression process. However, for certain characteristics described in DICOM Data Elements but not explicitly described in the compressed data stream (such as Pixel Representation), then the DICOM Data Element should be considered to describe what has been compressed (e.g., the pixel data really is to be interpreted as signed if Pixel Representation so specifies).
5. DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, JPEG lossy processes are limited to 12 bits, hence the value of Bits Stored should be 12 or less. Bits Allocated is irrelevant, and is likely to be constrained by the Information Object Definition in PS3.3 to values of 8 or 16. Also, JPEG compressed data streams are always color-by-pixel and should be specified as such (a decoder can essentially ignore this element however as the value for JPEG compressed data is already known).
6. If JPEG Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from YBR\_FULL\_422 to RGB during decompression and Native re-encoding, the Photometric Interpretation will be changed to RGB in the Data Set with the Native encoding.

## 8.2.4 JPEG 2000 Image Compression

The use of the DICOM Encapsulated Format to support JPEG 2000 Compressed Pixel Data requires that the Data Elements that are related to the Pixel Data encoding (e.g., Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values that are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG 2000 bit stream shall be used to decode the compressed data stream.

The requirements when using a Standard Photometric Interpretation (i.e., a Defined Term from PS.3. C.7.6.3.1.2) are specified in Table 8.2.4-1. No other Standard Photometric Interpretation values shall be used.

**Table 8.2.4-1. Valid Values of Pixel Data Related Attributes for JPEG 2000 Transfer Syntaxes using Standard Photometric Interpretations**

| Photometric Interpretation | Transfer Syntax           | Transfer Syntax UID    | Samples per Pixel | Planar Configuration | Pixel Representation | Bits Allocated      | Bits Stored | High Bit |
|----------------------------|---------------------------|------------------------|-------------------|----------------------|----------------------|---------------------|-------------|----------|
| MONOCHROME1                | JPEG 2000 (Lossless Only) | 1.2.840.10008.1.2.4.90 | 1                 | absent               | 0 or 1               | 8, 16, 24, 32 or 40 | 1-38        | 0-37     |
| MONOCHROME2                | JPEG 2000                 | 1.2.840.10008.1.2.4.91 |                   |                      |                      |                     |             |          |
| PALETTE COLOR              | JPEG 2000 (Lossless Only) | 1.2.840.10008.1.2.4.90 | 1                 | absent               | 0                    | 8 or 16             | 1-16        | 0-15     |
| YBR_RCT                    | JPEG 2000 (Lossless Only) | 1.2.840.10008.1.2.4.90 | 3                 | 0                    | 0                    | 8, 16, 24, 32 or 40 | 1-38        | 0-37     |
|                            | JPEG 2000                 | 1.2.840.10008.1.2.4.91 |                   |                      |                      |                     |             |          |
| YBR_ICT                    | JPEG 2000                 | 1.2.840.10008.1.2.4.91 | 3                 | 0                    | 0                    | 8, 16, 24, 32 or 40 | 1-38        | 0-37     |
| RGB                        | JPEG 2000 (Lossless Only) | 1.2.840.10008.1.2.4.90 | 3                 | 0                    | 0                    | 8, 16, 24, 32 or 40 | 1-38        | 0-37     |
|                            | JPEG 2000                 | 1.2.840.10008.1.2.4.91 |                   |                      |                      |                     |             |          |
| YBR_FULL                   | JPEG 2000 (Lossless Only) | 1.2.840.10008.1.2.4.90 | 3                 | 0                    | 0                    | 8, 16, 24, 32 or 40 | 1-38        | 0-37     |
|                            | JPEG 2000                 | 1.2.840.10008.1.2.4.91 |                   |                      |                      |                     |             |          |

**Note**

These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed Data Set might be encoded, subject to the general and IOD-specific rules for uncompressed Photometric Interpretation and Planar Configuration, which may require that decompressed data be converted to one of the permitted forms.

The JPEG 2000 bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation [ISO 15444-1 Annex G], if any, has been applied. If no multi-component transformation has been applied, then the components shall correspond to those specified by the DICOM Attribute Photometric Interpretation (0028,0004). If the JPEG 2000 Part 1 reversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR\_RCT. If the JPEG 2000 Part 1 irreversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR\_ICT.

**Note**

- For example, single component may be present, and the Photometric Interpretation (0028,0004) may be MONOCHROME2.
- The application of a JPEG 2000 Part 1 reversible multi-component transformation is signaled in the JPEG 2000 bit stream by a value of 1 rather than 0 in the SGcod Multiple component transformation type of the COD marker segment [ISO 15444-1 Table A.17]. No other value of Photometric Interpretation than YBR\_RCT or YBR\_ICT is permitted when SGcod Multiple component transformation type is 1.
- Though it would be unusual, would not take advantage of correlation between the red, green and blue components, and would not achieve effective compression, a Photometric Interpretation of RGB could be specified as long as no multi-

1 component transformation [ISO 15444-1 Annex G] was specified by the JPEG 2000 bit stream. **For some applications**  
2 **the use of RGB is permitted, e.g., Whole Slide Microscopy Images, to allow conversion to DICOM from propri-**  
3 **etary formats without loss due to color space transformation.** Alternative methods of decorrelation of the color  
4 components than those specified in [ISO 15444-1 Annex G] are permitted as defined in PS3.3, such as a Photometric  
5 Interpretation of YBR\_FULL; this may be useful when converting existing YBR\_FULL Pixel Data (e.g., in a different  
6 Transfer Syntax) without further loss.

7 In either case (Photometric Interpretation of RGB or YBR\_FULL), the value of SGcod Multiple component transformation  
8 type would be 0.

9 PS3.3 may constrain the values of Photometric Interpretation for specific IODs.

- 10 4. Despite the application of a multi-component color transformation and its reflection in the Photometric Interpretation at-  
11 tribute, the "color space" remains undefined. There is currently no means of conveying "standard color spaces" either  
12 by fixed values (such as sRGB) or by ICC profiles. Note in particular that the JP2 file header is not sent in the JPEG  
13 2000 bit stream that is encapsulated in DICOM.
- 14 5. If JPEG 2000 Compressed Pixel Data is decompressed and re-encoded in Native (uncompressed) form, then the Data  
15 Elements that are related to the Pixel Data encoding are updated accordingly. If color components are converted from  
16 YBR\_ICT or YBR\_RCT to RGB during decompression and Native re-encoding, the Photometric Interpretation will be  
17 changed to RGB in the Data Set with the Native encoding.
- 18 6. The upper limit of 40 on Bits Allocated (0028,0100) and 38 on Bits Stored (0028,0101) reflects the maximum JPEG  
19 2000 sample precision of 38 and the DICOM requirement to describe Bits Allocated (0028,0100) as multiples of bytes  
20 (octets).