# Digital Imaging and Communications in Medicine (DICOM)

*Supplement 61: JPEG 2000 Transfer Syntaxes*

**DICOM Standards Committee, Working Group 4 Compression**

1300 N. 17th Street, Suite 1847

Rosslyn, Virginia 22209 USA

VERSION: Final Text, 14 Jan 2002

## Contents

## Foreword

This Supplement has been prepared by the DICOM Working Group 4 (Compression) according to the procedures of the DICOM Committee.

The DICOM Standard is structured as a multi-part document using the guidelines established in the following document:

- ISO/IEC Directives, 1989 Part 3: Drafting and Presentation of International Standards.

This document is a Supplement to the DICOM Standard. It is an extension to PS 3.3, 3.4 and 3.6 of the published DICOM Standard, which consists of the following parts:

| | | |
|---|---|---|
| PS 3.1 | - | Introduction and Overview |
| PS 3.2 | - | Conformance |
| PS 3.3 | - | Information Object Definitions |
| PS 3.4 | - | Service Class Specifications |
| PS 3.5 | - | Data Structures and Encoding |
| PS 3.6 | - | Data Dictionary |
| PS 3.7 | - | Message Exchange |
| PS 3.8 | - | Network Communication Support for Message Exchange |
| PS 3.9 | - | Point-to-Point Communication Support for Message Exchange |
| PS 3.10 | - | Media Storage and File Format for Data Interchange |
| PS 3.11 | - | Media Storage Application Profiles |
| PS 3.12 | - | Media Formats and Physical Media for Data Interchange |
| PS 3.13 | - | Print Management Point-to-Point Communication Support |
| PS 3.14 | - | Grayscale Standard Display Function |
| PS 3.15 | - | Security Profiles |
| PS 3.16 | - | Content Mapping Resource |

These parts are related but independent documents.

## Scope and Field of Application

### INTRODUCTION.

Additional DICOM Transfer Syntaxes are introduced to add support for the JPEG 2000 Part 1 lossless and lossy compression schemes.

When first introduced, DICOM contained support for the lossless and lossy compression processes defined in the “original” JPEG standard, ISO 10918-1. Though that standard supported various different processes, in practice only those based on sequential block-based DCT Huffman entropy coding for lossy compression and predictive coding with Huffman entropy coding for lossless compression have been widely used.

Given that there are both real and perceived limitations with 10918-1 JPEG, WG 4 began to investigate alternatives, particularly those based on wavelet transformation, multi-resolution analysis and more sophisticated entropy coders than Huffman coding.

Working Group 4 set aside its effort to develop its own (medically specific) image data compression standard when the call for proposals for “JPEG 2000” was announced by ISO/IEC JTC1/SC29/WG1. Since then, efforts have been directed towards developing JPEG 2000 (ISO 15444-1), and ensuring that it provides features which are needed for medical imaging.

The use of ISO/IEC 15444-1 does not necessarily result in improved compression performance for any particular application (in terms of quantitative or qualitative measures of image fidelity, preservation of diagnostically significant information, consumption of resources such as memory or compression and decompression speed). However, JPEG 2000 offers additional features that may be important for some medical applications in which DICOM is used. These features include progressive and embedded spatial and contrast resolution, progression to lossless reconstruction, regions of interest and so on.

At the present time, only the features included in Part 1 of JPEG 2000 (ISO/IEC 15444-1) are included in this proposal. All JPEG 2000 implementations are required to support all features of Part 1 and accordingly this is expected to be a “baseline” for all available codecs. Other proposed parts of JPEG 2000 included additional features that may be of interest for medical imaging, such as alternative quantization methods (such as TCQ) and wavelet transforms in more than two dimensions (potentially useful for hyper-spectral and 3D volume data compression). If these extensions to JPEG 2000 prove viable and receive widespread support by codec implementers then they could be added as additional separate Transfer Syntaxes in DICOM.

The introduction of the JPEG 2000 transfer syntaxes is in no way intended to imply that the compression schemes already incorporated in the standard, some of which are widely used, are in some way “inferior”. Likewise, the introduction of JPEG 2000 does not imply endorsement of the scheme for any particular clinical or diagnostic application. The standard simply makes the scheme available; it is the responsibility of individual users, vendors, regulatory agencies and professional societies to ascertain the safety and efficacy of the use of any tool for a particular clinical application.

At the same time as introducing new Transfer Syntaxes, the opportunity is taken to retire those existing Transfer Syntaxes that are not in use.

### DESIGN DECISIONS

The approach proposed is to encapsulate JPEG 2000 bit streams in exactly the same manner as is currently used for JPEG (10918-1), JPEG-LS and RLE. This implies that:

- Undefined length pixel data contains one or more sequence-item-like fragments preceded by a possibly empty offset table.
- Each frame (or an entire single frame image) will be in one or more fragments.

- The optional JP2 file format header defined in 15444-1 is not included, only the actual compressed JPEG bit stream (this is the same as for JPEG which does not include a JFIF header in the DICOM encapsulation and JPEG-LS which does not include a SPIFF header).

- Information that is not specified in the JPEG 2000 bit stream, such as what color component corresponds to each compressed component, is specified in the DICOM attributes, such as Photometric Interpretation (again, just like JPEG, JPEG-LS and RLE).

- Separate transfer syntaxes are defined for a reversible process and either reversible or irreversible processes (at the sender's discretion), in order to be able to negotiate reversible transfers.

**FORM OF THIS SUPPLEMENT**

This supplement adds new Transfer Syntaxes to support JPEG 2000, adds new Photometric Interpretations compatible with those used in JPEG 2000 encoded bit streams, and retires unused JPEG Transfer Syntaxes.

Since this document proposes changes to existing Parts of DICOM, the reader should have a working understanding of the Standard. This proposed Supplement includes a number of Addenda to existing Parts of DICOM:

- PS 3.3 Addendum: Information Object Definitions

- PS 3.5 Addendum: Data Structures and Encoding

- PS 3.6 Addendum: Data Dictionary

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144 **Changes to**

145 **NEMA Standards Publication PS 3.3-2001**

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147 *Digital Imaging and Communications in Medicine (DICOM)*

148 *Part 3: Information Object Definitions*

*Add JPEG 2000 Photometric Interpretations to Image Pixel Module C.7.6.3:*

*(changes in **bold**, additions **underscored**, deletions ~~struckthrough~~)*

### C.7.6.3Image Pixel Module

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#### C.7.6.3.1.2 Photometric Interpretation

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**YBR_FULL** = Pixel data represent a color image described by one luminance (Y) and two chrominance planes ($C_B$ and $C_R$). This photometric interpretation may be used only when **S**~~s~~amples per **P**~~p~~ixel (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both $C_B$ and $C_R$ values equal to half full scale.

Note: In the case where the Bits Allocated (0028,0100) has value of 8 half full scale is 128.

In the case where Bits allocated (0028,0100) has a value of 8 then the following equations convert between RGB and $YC_BC_R$ Photometric Interpretation.

$$Y = + .2990R + .5870G + .1140B$$

$$C_B = - .1687R - .3313G + .5000B + 128$$

$$C_R = + .5000R - .4187G - .0813B + 128$$

Note: The above is based on CCIR Recommendation 601-2 dated 1990

**YBR_FULL_422** = The same as YBR_FULL except that the $C_B$ and $C_R$ values are sampled horizontally at half the Y rate and as a result there are half as many $C_B$ and $C_R$ values as Y values.

This **P**~~p~~hotometric Interpretation is only allowed with Planar Configuration (0028,0006) equal to ~~000~~0. Two Y values shall be stored followed by one $C_B$ and one $C_R$ value. The $C_B$ and $C_R$ values shall be sampled at the location of the first of the two Y values. For each Row of Pixels, the first $C_B$ and $C_R$ samples shall be at the location of the first Y sample. The next $C_B$ and $C_R$ samples shall be at the location of the third Y sample etc.

Note: This subsampling is often referred to as cosited sampling.

**YBR_PARTIAL_422** = The same as YBR_FULL_422 except that:

1. black corresponds to Y = 16;
2. Y is restricted to 220 levels (i.e. the maximum value is 235);
3. $C_B$ and $C_R$ each has a minimum value of 16;
4. $C_B$ and $C_R$ are restricted to 225 levels (i.e. the maximum value is 240);
5. lack of color is represented by $C_B$ and $C_R$ equal to 128.

In the case where Bits Allocated (0028,0100) has value of 8 then the following equations convert between RGB and YBR_PARTIAL_422 Photometric Interpretation

$$Y = + .2568R + .5041G + .0979B + 16$$

$C_B = - .1482R - .2910G + .4392B + 128$

$C_R = + .4392R - .3678G - .0714B + 128$

Note: The above is based on CCIR Recommendation 601-2 dated 1990.

**YBR_ICT = Irreversible Color Transformation:**

**Pixel data represent a color image described by one luminance (Y) and two chrominance planes ($C_B$ and $C_R$). This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both $C_B$ and $C_R$ values equal to zero.**

**Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and $YC_BC_R$ Photometric Interpretation.**

$$Y = + .29900R + .58700G + .11400B$$

$$C_B = - .16875R - .33126G + .50000B$$

$$C_R = + .50000R - .41869G - .08131B$$

**Notes: 1. The above is based on ISO/IEC 15444-1 (JPEG 2000).**

**2. In a JPEG 2000 bitstream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).**

**3. In JPEG 2000, spatial down-sampling of the chrominance components, if performed, is signalled in the JPEG 2000 bitstream.**

**YBR_RCT = Reversible Color Transformation:**

**Pixel data represent a color image described by one luminance (Y) and two chrominance planes ($C_B$ and $C_R$). This photometric interpretation may be used only when Samples per Pixel (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both $C_B$ and $C_R$ values equal to zero.**

**Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and YBR_RCT Photometric Interpretation.**

$$Y = \lfloor (R + 2G + B) / 4 \rfloor$$ (Note: $\lfloor ... \rfloor$ mean floor)

$$C_B = B - G$$

$$C_R = R - G$$

**The following equations convert between YBR_RCT and RGB Photometric Interpretation.**

$$G = Y - \lfloor (C_R + C_B) / 4 \rfloor$$

$$R = C_R + G$$

$$B = C_B + G$$

**Notes: 1. The above is based on ISO/IEC 15444-1 (JPEG 2000).**

**2. In a JPEG 2000 bitstream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).**

**3. This photometric interpretation is a reversible approximation to the YUV transformation used in PAL and SECAM.**

#### C.7.6.3.1.3 Planar Configuration

Planar Configuration (0028,0006) indicates whether the color pixel data are sent color-by-plane or color-by-pixel. This Attribute shall be present if Samples per Pixel (0028,0002) has a value greater than 1. It shall not be present otherwise.

Enumerated Values:

~~00~~0 = The sample values for the first pixel are followed by the sample values for the second pixel, etc. For RGB images, this means the order of the pixel values sent shall be R1, G1, B1, R2, G2, B2, ..., etc. For HSV images, this means the order of the pixel values sent shall be H1, S1, V1, H2, S2, V2, ... etc. For ARGB images, this means the order of the pixel values sent shall be A1, R1, G1, B1, A2, R2, G2, B2, ... etc. For CMYK images, this means the order of the pixel values sent shall be C1, M1, Y1, K1, C2, M2, Y2, K2, ... etc.

~~00~~1 = Each color plane shall be sent contiguously. For RGB images, this means the order of the pixel values sent is R1, R2, R3, ..., G1, G2, G3, ..., B1, B2, B3, etc. For HSV images, this means the order of the pixel values sent is H1, H2, H3, ..., S1, S2, S3, ..., V1, V2, V3, etc. For ARGB images, this means the order of the pixel values sent is A1, A2, A3, ..., R1, R2, R3, ..., G1, G2, G3, ... B1, B2, B3... etc. For CMYK images, this means the order of the pixel values sent is C1, C2, C3, ..., M1, M2, M3, ..., Y1, Y2, Y3, ..., K1, K2, K3... etc.

**Note: Planar Configuration (0028,0006) is not meaningful when a compression transfer syntax is used that involves reorganization of sample components in the compressed bit stream. In such cases, since the Attribute is required to be sent, then an appropriate value to use may be specified in the description of the Transfer Syntax in PS 3.5, though in all likelihood the value of the Attribute will be ignored by the receiving implementation.**

*Add JPEG 2000 Photometric Interpretations to US Image Module C.8.5.6:*

### C.8.5.6 US Image Module

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#### C.8.5.6.1.2 Photometric Interpretation

For US Images, Photometric Interpretation (0028,0004) is specified to use the following Defined Terms:

| | | |
|---|---|---|
| MONOCHROME2 | PALETTE COLOR | RGB |
| *ARGB (retired*) | YBR_FULL | YBR_FULL_422 |
| YBR_PARTIAL_422 | **YBR_RCT** | **YBR_ICT** |

Note: It is recommended that future implementations should not use ARGB photometric interpretation.

See PS 3.5 for restrictions imposed by compressed Transfer Syntaxes.

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### C.8.5.6.1.12 Samples Per Pixel

For US Images, Samples Per Pixel (0028,0002) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-19**
**US SAMPLES PER PIXEL**

| Photometric Interpretation | Samples Per Pixel Value |
|---|---|
| MONOCHROME2 | ~~**000**~~1~~**H**~~ |
| RGB | ~~**000**~~3~~**H**~~ |
| YBR_FULL | ~~**000**~~3~~**H**~~ |
| YBR_FULL_422 | ~~**000**~~3~~**H**~~ |
| YBR_PARTIAL_422 | ~~**000**~~3~~**H**~~ |
| **YBR_RCT** | **3** |
| **YBR_ICT** | **3** |
| PALETTE COLOR | ~~**000**~~1~~**H**~~ |

### C.8.5.6.1.13 Bits Allocated

For US Images, Bits Allocated (0028,0100) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-20**
**US BITS ALLOCATED**

| Photometric Interpretation | Bits Allocated Value |
|---|---|
| MONOCHROME2 | ~~**000**~~8~~**H**~~ |
| RGB | ~~**000**~~8~~**H**~~ |
| YBR_FULL | ~~**000**~~8~~**H**~~ |
| YBR_FULL_422 | ~~**000**~~8~~**H**~~ |
| YBR_PARTIAL_422 | ~~**000**~~8~~**H**~~ |
| **YBR_RCT** | **8** |
| **YBR_ICT** | **8** |
| PALETTE COLOR | ~~**000**~~8~~**H**~~ - 8 bit palette, or<br>~~**0010H**~~ **16** - 16 bit palette |

### C.8.5.6.1.14 Bits Stored

For US Images, Bits Stored (0028,0101) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-21**
**US BITS STORED**

| Photometric Interpretation | Bits Stored Value |
|---|---|
| MONOCHROME2 | ~~000~~8~~H~~ |
| RGB | ~~000~~8~~H~~ |
| YBR_FULL | ~~000~~8~~H~~ |
| YBR_FULL_422 | ~~000~~8~~H~~ |
| YBR_PARTIAL_422 | ~~000~~8~~H~~ |
| **YBR_RCT** | **8** |
| **YBR_ICT** | **8** |
| PALETTE COLOR | ~~000~~8~~H~~ - 8 bit palette, or<br>~~0010H~~ **16** - 16 bit palette |

### C.8.5.6.1.15 High Bit

For US Images, High Bit (0028,0102) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-22**
**US HIGH BIT**

| Photometric Interpretation | High Bit Value |
|---|---|
| MONOCHROME2 | ~~000~~7~~H~~ |
| RGB | ~~000~~7~~H~~ |
| YBR_FULL | ~~000~~7~~H~~ |
| YBR_FULL_422 | ~~000~~7~~H~~ |
| YBR_PARTIAL_422 | ~~000~~7~~H~~ |
| **YBR_RCT** | **7** |
| **YBR_ICT** | **7** |
| PALETTE COLOR | ~~000~~7~~H~~ - 8 bit palette, or<br>~~000FH~~ **15** - 16 bit palette |

### C.8.5.6.1.16 Planar Configuration

For US Images, Planar Configuration (0028,0006) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-23**
**US PLANAR CONFIGURATION**

| Photometric Interpretation | Planar Configuration Value |
|---|---|
| RGB | ~~000~~0~~H~~ - color-by-pixel, or<br>~~000~~1~~H~~ - color-by-plane |
| YBR_FULL | ~~000~~1~~H~~ |
| YBR_FULL_422 | ~~000~~0~~H~~ |
| YBR_PARTIAL_422 | ~~000~~0~~H~~ |

| | |
|---|---|
| **YBR_RCT** | **0** |
| **YBR_ICT** | **0** |

*Add JPEG 2000 Photometric Interpretations to VL Image Module C.8.12.1:*

### C.8.12.1 VL Image Module

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#### C.8.12.1.1 VL Image Module Attribute Descriptions

##### C.8.12.1.1.1 Photometric Interpretation

The Enumerated Values of Photometric Interpretation (0028,0004) shall **be**:

MONOCHROME2

RGB

YBR_FULL_422

**YBR_RCT**

**YBR_ICT**

##### C.8.12.1.1.2 Bits Allocated, Bits Stored, and High Bit

The Enumerated Value of Bits Allocated (0028,0100) shall be 8; the Enumerated Value of Bits Stored (0028,0101) shall be 8; and the Enumerated Value of High Bit (0028,0102) shall be 7.

##### C.8.12.1.1.3 Pixel Representation

The Enumerated Value of Pixel Representation (0028,0103) shall be 0**~~000H~~**.

**~~Note: A value of 0000H signifies an unsigned integer value.~~**

##### C.8.12.1.1.4 Samples per Pixel

The Enumerated Values of Samples per Pixel (0028,0002) shall be as follows: If the value of Photometric Interpretation (0028,0004) is MONOCHROME2, then the Enumerated Value of Samples per Pixel (0028,0002) shall be one (1). If the value of Photometric Interpretation (0028,0004) is RGB or YBR_FULL_422 **or YBR_RCT or YBR_ICT**, then the Enumerated Value of Samples per Pixel (0028,0002) shall be three (3).

##### C.8.12.1.1.5 Planar Configuration

If present, the Enumerated Value of Planar Configuration (0028,0006) shall be 0**~~000H~~**. This value shall be present if Samples per Pixel (0028,0002) has a value greater than 1.

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330 **Changes to**

331 **NEMA Standards Publication PS 3.5-2001**

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333 *Digital Imaging and Communications in Medicine (DICOM)*

334 *Part 5: Data Structures and Encoding*

*Add JPEG 2000 to Section 2:*

## Section 2 Normative references

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**ISO/IS 15444-1 JPEG 2000 Image Coding System**

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*Add JPEG 2000 to Section 8:*

## Section 8 Encoding of Pixel, Overlay and Waveform Data

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### 8.2.4 JPEG 2000 IMAGE COMPRESSION

**DICOM provides a mechanism for supporting the use of JPEG 2000 Image Compression through the Encapsulated Format (see PS 3.3). Annex A defines a number of Transfer Syntaxes which reference the JPEG 2000 Standard and provide lossless (bit preserving) and lossy compression schemes.**

**Note: The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g. compression ratio) for JPEG 2000 lossy compression are also beyond the scope of this standard.**

**The use of the DICOM Encapsulated Format to support JPEG 2000 Compressed Pixel Data requires that the Data Elements which 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 which 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.**

**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.**

**The JPEG 2000 bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation, 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 reversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_RCT. If the JPEG 2000 irreversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation (0028,0004) shall be YBR_ICT.**

**Notes: 1. For example, single component may be present, and the Photometric Interpretation (0028,0004) may be MONOCHROME2.**

**2. 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-component transformation was specified by the JPEG 2000 bit stream.**

**3. Despite the application of a multi-component color transformation and its reflection in the Photometric Interpretation attribute, the "color space" remains undefined. There is currently no means of conveying "standard color spaces" either by fixed values (such as sRGB) or by ICC profiles. Note in particular that the JP2 file header is not sent in the JPEG 2000 bitstream that is encapsulated in DICOM.**

**The JPEG 2000 bitstream is capable of encoding both signed and unsigned pixel values, hence the value of Pixel Representation (0028,0103) may be either 0 or 1 depending on what has been encoded (as specified in the SIZ marker segment in the precision and sign of component parameter).**

**The value of Planar Configuration (0028,0006) is irrelevant since the manner of encoding components is specified in the JPEG 2000 standard, hence it shall be set to 0.**

*Add JPEG 2000 default requirements to Section 10:*

## Section 10 Transfer Syntax

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### 10.1 DICOM DEFAULT TRANSFER SYNTAX

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Both of these requirements, a) and b), are waived when the Application Entity sending the pixel data has only access to the pixel data in lossy compressed form.

**Note: In other words, every sending AE is required to be able to convert any dataset it is going to transmit into the default Transfer Syntax, regardless of the form in which it originally received or stored the data set, except in the single case of when it received it in a lossy compressed form. In that exceptional case, the sending AE is permitted to propose only the lossy compressed Transfer Syntax appropriate to the lossy form that was received.**

**In particular, this waiver does not apply to data sets received in a lossless compressed form, which means that any AE receiving a data set in a lossless compressed Transfer Syntax that needs to re-send the data set is required to be able to decompress it in order to support (at least) the default Transfer Syntax.**

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## 10.6 TRANSFER SYNTAX FOR JPEG 2000 COMPRESSION

**One Transfer Syntax is specified for JPEG 2000 Image Compression (Lossless Only), and one Transfer Syntax is specified for JPEG 2000 Image Compression. Either of these may be negotiated separately and there is no default or baseline specified (other than described in section 10.1).**

**Notes: 1. All JPEG 2000 codecs are required by ISO/IEC 15444-1 to support both reversible and irreversible wavelet and multi-component transformations. The reason for specifying two separate Transfer Syntaxes in DICOM is to allow an application to request the transfer of images in a lossless manner when possible. The JPEG 2000 Image Compression Transfer Syntax allows for either lossless or lossy compression to be used at the sender's discretion.**

**2. No baseline using other compression schemes is required.**

**3. When the pixel data has been received in the JPEG 2000 Image Compression Transfer Syntax, since it may have been lossy compressed, the waiver of the requirement in Section 10.1 to support the DICOM default Transfer Syntax still applies.**

*Add JPEG 2000 requirements to Annex A:*

# Annex A
# (Normative)
# Transfer Syntax Specifications

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## A.4.1 JPEG IMAGE COMPRESSION

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**Table A.4-3**
**DICOM TRANSFER SYNTAX UIDS FOR JPEG**

| DICOM Transfer Syntax UID | JPEG coding process | JPEG description |
|---|---|---|
| 1.2.840.10008.1.2.4.50 | 1 | baseline |
| 1.2.840.10008.1.2.4.51 | 2(8-bit),4(12-bit) | extended |
| ~~1.2.840.10008.1.2.4.52~~ | ~~3(8-bit),5(12-bit)~~ | ~~extended~~ |
| ~~1.2.840.10008.1.2.4.53~~ | ~~6(8-bit),8(12-bit)~~ | ~~spectral selection, non-hierarchical~~ |
| ~~1.2.840.10008.1.2.4.54~~ | ~~7(8-bit),9(12-bit)~~ | ~~spectral selection, non-hierarchical~~ |
| ~~1.2.840.10008.1.2.4.55~~ | ~~10(8-bit),12(12-bit)~~ | ~~full progression, non-hierarchical~~ |
| ~~1.2.840.10008.1.2.4.56~~ | ~~11(8-bit),13(12-bit)~~ | ~~full progression, non-hierarchical~~ |
| 1.2.840.10008.1.2.4.57 | 14 | lossless, non-hierarchical |
| ~~1.2.840.10008.1.2.4.58~~ | ~~15~~ | ~~lossless, non-hierarchical~~ |
| ~~1.2.840.10008.1.2.4.59~~ | ~~16(8-bit),18(12-bit)~~ | ~~extended, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.60~~ | ~~17(8-bit),19(12-bit)~~ | ~~extended, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.61~~ | ~~20(8-bit),22(12-bit)~~ | ~~spectral selection, hierarchical~~ |

| | | |
|---|---|---|
| ~~1.2.840.10008.1.2.4.62~~ | ~~21(8-bit),23(12-bit)~~ | ~~spectral selection, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.63~~ | ~~24(8-bit),26(12-bit)~~ | ~~full progression, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.64~~ | ~~25(8-bit),27(12-bit)~~ | ~~full progression, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.65~~ | ~~28~~ | ~~lossless, hierarchical~~ |
| ~~1.2.840.10008.1.2.4.66~~ | ~~29~~ | ~~lossless, hierarchical~~ |
| 1.2.840.10008.1.2.4.70 | 14<br>(Selection Value 1) | lossless, non-hierarchical, first-order prediction |

...

### A.4.4 JPEG 2000 IMAGE COMPRESSION

**The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO/IS 15444-1 (JPEG 2000 Part 1), for digital compression and coding of continuous-tone still images. (See Annex F for further details.)**

**A DICOM Transfer Syntax for JPEG 2000 Image Compression shall be identified by a UID value, appropriate to the choice of JPEG 2000 coding process.**

**Two Transfer Syntaxes are specified for JPEG 2000:**

1. **A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.90, which specifies the use of the lossless (reversible) mode of JPEG 2000 Part 1 (ISO/IS 15444-1) (i.e. the use of a reversible wavelet transformation and a reversible color component transformation, if applicable, and no quantization).**
2. **A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.91, which specifies the use of either:**
   a. **the lossless (reversible) mode of JPEG 2000 Part 1 (ISO/IS 15444-1) (i.e. the use of a reversible wavelet transformation and a reversible color component transformation, if applicable, and no quantization), or**
   b. **the lossy (irreversible) mode of JPEG 2000 Part 1 (ISO/IS 15444-1) (i.e. the use of an irreversible wavelet transformation and an irreversible color component transformation, if applicable, and optionally quantization).**

   **The choice is at the discretion of the sender (SCU or FSC/FSU).**

   **Note: When using the lossy (irreversible) mode, even if no quantization is performed, some loss will always occur due to the finite precision of the calculation of the wavelet and multi-component transformations.**

**Only the features defined in JPEG 2000 Part 1 (ISO/IEC 15444-1) are permitted for these two Transfer Syntaxes. Additional features and extensions that may be defined in other parts of JPEG 2000 shall not be included in the compressed bitstream unless they can be decoded or ignored without loss of fidelity by all Part 1 compliant implementations.**

**If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each fragment shall contain encoded data from a single frame.**

**Note: That is, the processes defined in ISO/IEC 15444-1 shall be applied on a per-frame basis. The proposal for encapsulation of multiple frames in a non-DICOM manner in so-called "Motion-JPEG" or "M-JPEG" defined in 15444-3 is not used.**

**For all images, including all frames of a multi-frame image, the JPEG 2000 bitstream specified in ISO/IEC 15444-1 shall be used. The optional JP2 file format header shall NOT be included.**

**Note: The role of the JP2 file format header is fulfilled by the non-pixel data attributes in the DICOM data set.**

*Add JPEG 2000 requirements to Annex F:*

## Annex F
## (Informative)
## Encapsulated images as part of a DICOM message

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**Table F.1-1**
**JPEG MODES OF IMAGE CODING**

| No. | Description | Lossy LY Lossless LL | Non-Hierarchical NH Hierarchical H | Sequential S Progressive P | Transform | Coding | Accepted Bits |
|---|---|---|---|---|---|---|---|
| 1 | Baseline | LY | NH | S | DCT | Huffman | 8 |
| 2 | Extended | LY | NH | S | DCT | Huffman | 8 |
| ~~3~~ | ~~Extended~~ | ~~LY~~ | ~~NH~~ | ~~S~~ | ~~DCT~~ | ~~Arithmetic~~ | ~~8~~ |
| 4 | Extended | LY | NH | S | DCT | Arithmetic | 12 |
| ~~5~~ | ~~Extended~~ | ~~LY~~ | ~~NH~~ | ~~S~~ | ~~DCT~~ | Huffman ~~Arithmetic~~ | ~~12~~ |
| ~~6~~ | ~~Spectral selection only~~ | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Huffman~~ | ~~8~~ |
| ~~7~~ | | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Arithmetic~~ | ~~8~~ |
| ~~8~~ | ~~Spectral selection only~~ | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | | ~~12~~ |
| ~~9~~ | | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Huffman~~ | ~~12~~ |
| ~~10~~ | ~~Spectral selection only~~ | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Arithmetic~~ | ~~8~~ |
| ~~11~~ | ~~Spectral selection only~~ | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Huffman~~ | ~~8~~ |
| ~~12~~ | | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Arithmetic~~ | ~~12~~ |
| ~~13~~ | ~~Full progression~~ ~~Full progression~~ ~~Full progression~~ ~~Full progression~~ | ~~LY~~ | ~~NH~~ | ~~P~~ | ~~DCT~~ | ~~Huffman~~ ~~Arithmetic~~ | ~~12~~ |
| 14 | Lossless | LL | NH | S | DPCM | Huffman | 2-16 |
| ~~15~~ | ~~Lossless~~ | ~~LL~~ | ~~NH~~ | ~~S~~ | ~~DPCM~~ | ~~Arithmetic~~ | ~~2-16~~ |
| ~~16~~ | ~~Extended sequential~~ | ~~LY~~ | ~~H~~ | ~~S~~ | ~~DCT~~ | ~~Huffman~~ | ~~8~~ |
| ~~17~~ | ~~Extended sequential~~ | ~~LY~~ | ~~H~~ | ~~S~~ | ~~DCT~~ | ~~Arithmetic~~ | ~~8~~ |
| ~~18~~ | ~~Extended sequential~~ | ~~LY~~ | ~~H~~ | ~~S~~ | ~~DCT~~ | | ~~12~~ |
| ~~19~~ | ~~Extended sequential~~ | ~~LY~~ | ~~H~~ | ~~S~~ | ~~DCT~~ | ~~Huffman~~ ~~Arithmeti~~ | ~~12~~ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | c | |
| 20 | Spectral selection only | LY | H | P | DCT | Huffman | 8 |
| 21 | | LY | H | P | DCT | Arithmetic | 8 |
| 22 | Spectral selection only | LY | H | P | DCT | | 12 |
| 23 | | LY | H | P | DCT | Huffman | 12 |
| 24 | Spectral selection only | LY | H | P | DCT | Arithmetic | 8 |
| 25 | Spectral selection only | LY | H | P | DCT | Huffman | 8 |
| 26 | | LY | H | P | DCT | Arithmetic | 12 |
| 27 | Full progression | LY | H | P | DCT | Huffman | 12 |
| | Full progression | | | | | Arithmetic | |
| | Full progression | | | | | | |
| | Full progression | | | | | | |
| 28 | Lossless | LL | H | S | DPCM | Huffman | 2-16 |
| 29 | Lossless | LL | H | S | DPCM | Arithmetic | 2-16 |

The different coding processes specified in the JPEG Standard are closely related. By extending the capability of an implementation, increasingly more 'lower level' processes can also be executed by the implementation. This is shown in Tables F.1-2 **and F.1-3** for Huffman **and Arithmetic** Coding**, respectively**. **Table F.1-4 presents the capabilities for lossless implementations.**

**It is worth recognizing that implementations using arithmetic coding have the capability of performing Huffman coded operations with two Huffman tables since they must be able to execute the baseline process. Hence, by increasing the capability of operating with two additional Huffman tables, the odd-numbered coding processes with arithmetic coding (Table F.1-1) can also execute all corresponding even-numbered processes with Huffman coding (Table F.1-5).**

Inclusion of a JPEG-coded image in a DICOM message is facilitated by the use of specific Transfer Syntaxes which are defined in Annex A. Independent of the JPEG coding processes, the same syntax applies. The only distinction for different processes in the syntax is the UID value. Table F.1-5 lists the UID values in the Transfer Syntax for the various JPEG coding processes for reference.

**Table F.1-2**
**RELATIONSHIP BETWEEN THE LOSSY JPEG HUFFMAN CODING PROCESSES**
* Coding process of column can execute coding process of row

| Process | 1 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 18 | 20 | 22 | 24 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 2 | | * | * | * | * | * | * | * | * | * | * | * | * |
| 4 | | | * | | * | | * | | * | | * | | * |
| 6 | | | | * | * | * | * | | | * | * | * | * |
| 8 | | | | | * | | * | | | | * | | * |
| 10 | | | | | | * | * | | | | | * | * |
| 12 | | | | | | | * | | | | | | * |
| 16 | | | | | | | | * | * | * | * | * | * |
| 18 | | | | | | | | | * | | * | | * |
| 20 | | | | | | | | | | * | * | * | * |
| 22 | | | | | | | | | | | * | | * |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~24~~ | | | | | | | | | | | | ± | ± |
| ~~26~~ | | | | | | | | | | | | | ± |

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**Table F.1-3**
**RELATIONSHIP BETWEEN THE LOSSY JPEG ARITHMETIC CODING PROCESSES**
*** Coding process of column can execute coding process of row**

| Process | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 17 | 19 | 21 | 23 | 25 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1[+] | * | * | * | * | * | * | * | * | * | * | * | * | * |
| 3 | | * | * | * | * | * | * | * | * | * | * | * | * |
| 5 | | | * | | * | | * | | * | | * | | * |
| 7 | | | | * | * | * | * | | | * | * | * | * |
| 9 | | | | | * | | * | | | | * | | * |
| 11 | | | | | | * | * | | | | | * | * |
| 13 | | | | | | | * | | | | | | * |
| 17 | | | | | | | | * | * | * | * | * | * |
| 19 | | | | | | | | | * | | * | | * |
| 21 | | | | | | | | | | * | * | * | * |
| 23 | | | | | | | | | | | * | | * |
| 25 | | | | | | | | | | | | * | * |
| 27 | | | | | | | | | | | | | * |

**+ The Baseline Coding Process, which uses Huffman encoding, is required by all lossy coding processes.**

**Table F.1-4**
**RELATIONSHIP BETWEEN THE LOSSLESS JPEG PROCESSES**
*** Coding process of column can execute coding process of row**

| Process | 14 | 15 | 28 | 29 |
|---|---|---|---|---|
| 14 | * | | * | |
| 15 | | * | | * |
| 28 | | | * | |
| 29 | | | | * |

**Table F.1-5**
**IDENTIFICATION OF JPEG CODING PROCESSES IN DICOM**

| DICOM Transfer Syntax UID | JPEG process | JPEG description | capable of performing | |
|---|---|---|---|---|
| | | | | ~~lossy arithmetic coding w/opt. 4 Huffman tables~~ |
| 1.2.840.10008.1.2.4.50 | 1 | baseline | 1 | |
| 1.2.840.10008.1.2.4.51 | 2,4 | extended | 1,2,4 | |
| ~~1.2.840.10008.1.2.4.52~~ | ~~3,5~~ | ~~extended~~ | ~~1,3,5~~ | ~~ALL ≤ 5~~ |
| ~~1.2.840.10008.1.2.4.53~~ | ~~6,8~~ | ~~spect. select. NH~~ | ~~1,2,4,6,8~~ | |
| ~~1.2.840.10008.1.2.4.54~~ | ~~7,9~~ | ~~spect. select. NH~~ | ~~1,3,5,7,9~~ | ~~ALL ≤ 9~~ |
| ~~1.2.840.10008.1.2.4.55~~ | ~~10,12~~ | ~~full progression NH~~ | ~~1,2,4,6,8,10,12~~ | |
| ~~1.2.840.10008.1.2.4.56~~ | ~~11,13~~ | ~~full progression NH~~ | ~~1,3,5,7,9,11,13~~ | ~~ALL ≤ 13~~ |
| 1.2.840.10008.1.2.4.57 | 14 | lossless NH | 14 | |
| ~~1.2.840.10008.1.2.4.58~~ | ~~15~~ | ~~lossless NH~~ | ~~15~~ | |
| ~~1.2.840.10008.1.2.4.59~~ | ~~16,18~~ | ~~extended H~~ | ~~1,2,4,16,18~~ | |
| ~~1.2.840.10008.1.2.4.60~~ | ~~17,19~~ | ~~extended H~~ | ~~1,3,5,17,19~~ | ~~1,2,3,4,5,16,17,18,19~~ |
| ~~1.2.840.10008.1.2.4.61~~ | ~~20,22~~ | ~~spect. select.H~~ | ~~1,2,4,6,8,16,18,20,22~~ | |
| ~~1.2.840.10008.1.2.4.62~~ | ~~21,23~~ | ~~spect. select. H~~ | ~~1,3,5,7,9,17,19,21,23~~ | ~~1,2,3,4,5,6,7,8,9,16,17,18,19,20,21,22,23~~ |
| ~~1.2.840.10008.1.2.4.63~~ | ~~24,26~~ | ~~full progression H~~ | ~~1,2,4,6,8,10,12,16,18, 20,22,24,26~~ | |
| ~~1.2.840.10008.1.2.4.64~~ | ~~25,27~~ | ~~full progression H~~ | ~~1,3,5,7,9,11,13,17,19, 21,23,25,27~~ | ~~ALL ≤ 27, EXCEPT 14,15~~ |
| ~~1.2.840.10008.1.2.4.65~~ | ~~28~~ | ~~lossless H~~ | ~~14,28~~ | |
| ~~1.2.840.10008.1.2.4.66~~ | ~~29~~ | ~~lossless H~~ | ~~15,29~~ | |
| 1.2.840.10008.1.2.4.70 | 14 Selection Value 1 | lossless NH, first-order prediction | | |

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## F.3 ENCAPSULATED JPEG 2000 ENCODED IMAGES

**The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an International Standard, ISO/IS-15444-1 (JPEG 2000 Part 1), for the digital compression and coding of continuous-tone still images. This standard is known as the JPEG 2000 Standard.**

**Part 1 of the JPEG 2000 Standard sets out requirements and implementation guidelines for the coded representation of compressed image data to be interchanged between applications. The processes and representations are intended to be generic in order to support the broad range of applications for color and grayscale still images for the purpose of communications and storage within computer systems.**

**Though a different coding process from those specified in ISO 10918-1 is used, the syntax of the encoded bit stream is closely related.**

**A single JPEG 2000 process is used for bit depths up to 16 bits.**

**Inclusion of a JPEG 2000 coded image in a DICOM message is facilitated by the use of specific Transfer Syntaxes that are defined in Annex A.**

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544 **Changes to**

545 **NEMA Standards Publication PS 3.6-2001**

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547 *Digital Imaging and Communications in Medicine (DICOM)*

548 *Part 6: Data Dictionary*

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*Add new UIDs to Annex A:*

## Annex A Registry of DICOM unique identifiers (UID) (Normative)

Table A-1 lists the UID values which are registered and used throughout the Parts of the DICOM Standard. This central registry ensures that when additional UIDs are assigned, non duplicate values are assigned.

**Table A-1**
**UID VALUES**

| UID Value | UID NAME | UID TYPE | Part |
|---|---|---|---|
| 1.2.840.10008.1.1 | Verification SOP Class | SOP Class | PS 3.4 |
| 1.2.840.10008.1.2 | Implicit VR Little Endian: Default Transfer Syntax for DICOM | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.1 | Explicit VR Little Endian | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.2 | Explicit VR Big Endian | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.4.50 | JPEG Baseline (Process 1): Default Transfer Syntax for Lossy JPEG 8 Bit Image Compression | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.4.51 | JPEG Extended (Process 2 & 4): Default Transfer Syntax for Lossy JPEG 12 Bit Image Compression (Process 4 only) | Transfer Syntax | PS 3.5 |
| ***1.2.840.10008.1.2.4.52*** | ***JPEG Extended (Process 3 & 5) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.53*** | ***JPEG Spectral Selection, Non-Hierarchical (Process 6 & 8) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.54*** | ***JPEG Spectral Selection, Non-Hierarchical (Process 7 & 9) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.55*** | ***JPEG Full Progression, Non-Hierarchical (Process 10 & 12) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.56*** | ***JPEG Full Progression, Non-Hierarchical (Process 11 & 13) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |

| | | | |
|---|---|---|---|
| 1.2.840.10008.1.2.4.57 | JPEG Lossless, Non-Hierarchical (Process 14) | Transfer Syntax | PS 3.5 |
| ***1.2.840.10008.1.2.4.58*** | ***JPEG Lossless, Non-Hierarchical (Process 15) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.59*** | ***JPEG Extended, Hierarchical (Process 16 & 18) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.60*** | ***JPEG Extended, Hierarchical (Process 17 & 19) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.61*** | ***JPEG Spectral Selection, Hierarchical (Process 20 & 22) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.62*** | ***JPEG Spectral Selection, Hierarchical (Process 21 & 23) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.63*** | ***JPEG Full Progression, Hierarchical (Process 24 & 26) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.64*** | ***JPEG Full Progression, Hierarchical (Process 25 & 27) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.65*** | ***JPEG Lossless, Hierarchical (Process 28) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| ***1.2.840.10008.1.2.4.66*** | ***JPEG Lossless, Hierarchical (Process 29) (Retired)*** | ***Transfer Syntax*** | ***PS 3.5*** |
| 1.2.840.10008.1.2.4.70 | JPEG Lossless, Non-Hierarchical, First-Order Prediction (Process 14 [Selection Value 1]): Default Transfer Syntax for Lossless JPEG Image Compression | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.4.80 | JPEG-LS Lossless Image Compression | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.2.4.81 | JPEG-LS Lossy (Near-Lossless) Image Compression | Transfer Syntax | PS 3.5 |
| **1.2.840.10008.1.2.4.90** | **JPEG 2000 Image Compression (Lossless Only)** | **Transfer Syntax** | **PS 3.5** |
| **1.2.840.10008.1.2.4.91** | **JPEG 2000 Image Compression** | **Transfer Syntax** | **PS 3.5** |
| 1.2.840.10008.1.2.5 | RLE Lossless | Transfer Syntax | PS 3.5 |
| 1.2.840.10008.1.3.10 | Media Storage Directory Storage | SOP Class | PS 3.4 |