

1	Status	Final Text
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7	Submission Date	2014/09/14

8	Correction Number CP-1447	
9	Log Summary: Clarify 8 bit in Extended JPEG Transfer Syntax	
10	Name of Standard	
11	PS3.5 2015c	
12	Rationale for Correction:	
13	In the description of default Lossy JPEG Compression Transfer Syntaxes (10.3), it is specified that there is one Transfer Syntax for 8 bit images (.50) and another for 12 bit images (.51).	
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15	In the table mapping JPEG processes to Transfer Syntaxes (A.4.1), the .51 Transfer Syntax is listed as supporting both 8 and 12 bits. The difference between the 8 bit JPEG baseline process (used for .50) and 8 bit JPEG extended process 2 (used for .51) is not described in the existing text. The difference (defined in the JPEG standard) involves the use of a different SOF marker segment, and the possibility of more tables being used in the extended process. Some implementors have incorrectly assumed that a baseline JPEG bitstream can be encoded in the .51 Transfer Syntax but the marker segment will then be incorrect (SOF0 rather than the SOF1 required).	
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21	There is further discussion of 8 versus 12 bits, the JPEG processes and the Transfer Syntaxes in the general description of JPEG (8.2.1), which requires that implementations support specific processes as defaults.	
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23	Annex F further describes the JPEG coding processes, and adds more confusion by the presence of a "capable of performing" column, which includes process 1 for .51, in addition to processes 2 and 4, with the rationale that the processes (described in the JPEG standard) build upon one another (even though the encoded bitstreams use different marker segments, which is not considered in Annex F). There is no definition of "capable of performing", whether it applies to encoders or decoders, or what part of the JPEG standard (10918-1 or 10918-2) defines this, if any.	
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28	Informative text is added to emphasize that though 8 bit images can be encoded in either the .50 and .51 Transfer Syntaxes, the bitstreams are different. Further, a recommendation is added that the .50 Transfer Syntax be used for 8 bit images unless the additional features of the extended process are required, particularly since support of the baseline process is required anyway (by 8.2.1). The "capable of performing" column heading is replaced with "capable of decoding" to be consistent with ISO 10918-2's asymmetric encoding and decoding requirements for the processes listed.	
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33	Correction Wording:	

Amend DICOM PS3.5 as follows:

8.2 Native or Encapsulated Format Encoding

8.2.1 JPEG Image Compression

DICOM provides a mechanism for supporting the use of JPEG Image Compression through the Encapsulated Format (see ???). Annex A defines a number of Transfer Syntaxes that reference the JPEG Standard and provide a number of 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 lossy compression is also beyond the scope of this standard.

In order to facilitate interoperability of implementations conforming to the DICOM Standard that elect to use one or more of the Transfer Syntaxes for JPEG Image Compression, the following policy is specified:

- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for lossless JPEG Image Compression, shall support the following lossless compression: The subset (first-order horizontal prediction [Selection Value 1] of JPEG Process 14 (DPCM, non-hierarchical with Huffman coding) (see Annex F).
- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 8-bit lossy JPEG Image Compression, shall support the JPEG Baseline Compression (coding Process 1).
- Any implementation that conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 12-bit lossy JPEG Image Compression, shall support the JPEG Compression Process 4.

...

10 Transfer Syntax

10.3 Transfer Syntaxes for a DICOM Default of Lossy JPEG Compression

DICOM defines defaults for Lossy JPEG Image Compression, one for 8-bit images and the other for 12-bit images. JPEG coding Process 1 (identified by Transfer Syntax UID = "1.2.840.10008.1.2.4.50") is used for 8-bit images. JPEG coding Process 4 (identified by Transfer Syntax UID = "1.2.840.10008.1.2.4.51") is used for 12-bit images. This implies that:

- a. If an Application Entity issues an A-ASSOCIATE request where any offered Abstract Syntaxes is associated in one or more Presentation Context(s) with a JPEG lossy compression Transfer Syntax, at least one of the Presentation Contexts that include this Abstract Syntax, shall include the appropriate DICOM Default Lossy JPEG Compression Transfer Syntax.

Note

Offering Abstract Syntax (AS1) in two Presentation Contexts with Transfer Syntaxes JPEG lossy (JL1) and (JL2) is not valid, but offering AS1-JL1, AS1-JL2 and AS1-JLD is valid because the DICOM Default JPEG Lossy Transfer Syntax (JLD) is present in at least one of the Presentation Contexts that are based on Abstract Syntax (AS1).2. The DICOM Default Transfer Syntax (uncompressed) may be offered if the sender has access to the original pixel data in an uncompressed or lossless compressed form.

- b. If an Application Entity that supports one or more Lossy JPEG Transfer Syntaxes receives an A-ASSOCIATE indication corresponding to a request that follows the requirements specified in 10.3 (a), every Presentation Context related to a given Abstract Syntax cannot be rejected in an A-ASSOCIATE response for the reason that the DICOM Default lossy JPEG Transfer Syntax is not supported.

Note

The 12 bit default Transfer Syntax 1.2.840.10008.1.2.4.51 can also be used to encode 8 bit images, but the bit stream required is not identical to that used in the 8 bit default Transfer Syntax 1.2.840.10008.1.2.4.50 (see A.4.1).

1 A Transfer Syntax Specifications (Normative)

2 A.4.1 JPEG Image Compression

3 The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO#S_10918-1 (JPEG Part 1)
4 and an International **Draft** Standard, ISO#S_10918-2 (JPEG Part 2), known as the JPEG Standard, for digital compression and
5 coding of continuous-tone still images (see Annex F for further details).

6 A DICOM Transfer Syntax for JPEG Image Compression shall be identified by a UID value, appropriate to its JPEG coding process,
7 chosen from A.4-3.

8 **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
1.2.840.10008.1.2.4.57	14	lossless, non-hierarchical
1.2.840.10008.1.2.4.70	14 (Selection Value 1)	lossless, non-hierarchical, first-order prediction

15 Note

- 16 1. DICOM identifies, to increase the likelihood of successful association, three Transfer Syntaxes for Default JPEG Com-
17 pression Image processes (see 8.2.1 and Section 10).
- 18 2. Different JPEG processes may use different SOF marker segments. E.g., the baseline JPEG process 1 used
19 with the 1.2.840.10008.1.2.4.50 Transfer Syntax uses the SOF0 marker, whereas the extended process 2 used
20 with the 1.2.840.10008.1.2.4.51 Transfer Syntax uses the SOF1 marker. Accordingly, even though both bit streams
21 encode 8 bit images using DCT and Huffman coding, the bit streams are not identical. Further, the extended
22 process 2 may (but is not required to) use more AC and DC tables (up to 4 of each, rather than 2, per ISO 10918-
23 1 Section F.1.3).
24 It is not compliant to send bit streams with the SOF0 marker using the 1.2.840.10008.1.2.4.51 Transfer Syntax,
25 but it is recommended that receivers of the 1.2.840.10008.1.2.4.51 Transfer Syntax be able to decode bit streams
26 with the SOF0 marker (this asymmetry is consistent with ISO 10918-2 requirements; see A.4.1).
- 27 3. It is recommended that lossy compressed 8 bit images be encoded with the 1.2.840.10008.1.2.4.50 Transfer
28 Syntax rather than the 1.2.840.10008.1.2.4.51 Transfer Syntax, unless the additional features of the extended
29 process are required. Support of the 1.2.840.10008.1.2.4.50 Transfer Syntax is required for 8 bit images anyway
30 (as described in 8.2.1) and to avoid confusion with the use of 12 bit images encoded with Process 4 in the
31 1.2.840.10008.1.2.4.51 Transfer Syntax (defined as a DICOM Default Transfer Syntax for 12 bit images in 10.3).

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

34 Note

35 Though a fragment may not contain encoded data from more than one frame, the encoded data from one frame may span
36 multiple fragments. See note in 8.2.

37 For all images, including all frames of a multi-frame image, the JPEG Interchange Format shall be used (the table specification shall
38 be included).

39 Note

40 This refers to the ISO 10918-1 "interchange format", not the **DISISO** 10918-5 JPEG File Interchange Format (JFIF).

If images with Photometric Interpretation (0028,0004) YBR_FULL_422 or YBR_PARTIAL_422, are encoded with JPEG coding Process 1 (non hierarchical with Huffman coding), identified by DICOM Transfer Syntax UID "1.2.840.10008.1.2.4.50" the minimum compressible unit is YYCBCR, where Y, CB, and CR are 8 by 8 blocks of pixel values. The data stream encodes two Y blocks followed by the corresponding CB and CR blocks.

F Encapsulated Images As Part of A DICOM Message (Informative)

F.1 Encapsulated JPEG Encoded Images

The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an International Standard, ISO/IEC 10918-1 (JPEG Part 1) and International Draft Standard ISO/IEC 10918-2 (JPEG Part 2), for the digital compression and coding of continuous-tone still images. This standard is collectively known as the JPEG Standard.

Part 1 of the JPEG 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. Part 2 of the JPEG Standard defines tests for determining whether implementations comply with the requirements of the various encoding and decoding processes specified in Part 1 of the JPEG Standard.

The JPEG Standard specifies lossy and lossless code processes. The lossy coding is based on the discrete cosine transform (DCT), permitting data compression with an adjustable compression ratio. The lossless coding employs differential pulse code modulation (DPCM).

The JPEG Standard permits a variety of coding processes for the coder and decoder. These processes differ in coding schemes for the quantified data and in sample precision. The coding processes are consecutively numbered as defined in the International Draft Standard ISO/IEC 10918-2 (JPEG Part 2), and are summarized in Table F.1-1. The simplest DCT-based coding process is referred to as Baseline Sequential with Huffman Coding for 8-bit Samples.

Table F.1-1. JPEG Modes of Image Coding

No.	Description	Lossy	Non-Hierarchical	Sequential	Transform	Coding	Accepted Bits
		LY	NH	S			
		Lossless	Hierarchical	Progressive			
		LL	H	P			
1	Baseline	LY	NH	S	DCT	Huffman	8
2	Extended	LY	NH	S	DCT	Huffman	8
4	Extended	LY	NH	S	DCT	Huffman	12
14	Lossless	LL	NH	S	DPCM	Huffman	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 Table F.1-2 for Huffman Coding.

Inclusion of a JPEG-coded image in a DICOM message is facilitated by the use of specific Transfer Syntaxes that are defined in Annex A. Independent of the JPEG coding processes, the same syntax applies. The only distinction for different processes in the syntax (apart from different SOF marker segments in the JPEG bit stream) 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

Process	1	2	4
1	*	*	*
2		*	*

Process	1	2	4
4			*

* Coding process of column can execute coding process of row

Table F.1-5. Identification of JPEG Coding Processes in DICOM

DICOM Transfer Syntax UID	JPEG process	JPEG description	capable of performing decoding
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 <u>(see Note)</u>
1.2.840.10008.1.2.4.57	14	lossless NH	14
1.2.840.10008.1.2.4.70	14 Selection Value 1	lossless NH, first-order prediction	

Note

Though the coding processes (2, 4) described in ISO 10918-1 are capable of decoding the other listed process (1), the bit stream uses different SOF marker segments. I.e., the baseline JPEG process 1 used with the 1.2.840.10008.1.2.4.50 Transfer Syntax uses the SOF0 marker, whereas the extended process 2 used with the 1.2.840.10008.1.2.4.51 Transfer Syntax uses the SOF1 marker. Accordingly, even though both bit streams encode 8 bit images using DCT and Huffman coding, the bit streams are not identical.

ISO 10918-2 describes compliance tests for decoders, and requires that implementations of specific extended processes (such as 2 and 4) be capable of decoding bit streams of related baseline processes (such as 1) (ISO 10918-2 Section 7.4 Compliance tests for DCT-based sequential mode decoding processes). The converse is not true for encoders however, and the presence of SOF marker segments not defined by the specific process is not compliant (ISO 10918-2 Section 5.1.1 Non-hierarchical coding processes syntax compliance test Tables 1 and 2).