Ultrasound Ad Hoc Committee

Digital Imaging and Communications in Medicine (DICOM)

Supplement 5

Ultrasound Application Profile, IOD and Transfer Syntax Extensions

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Foreword

ACR (the American College of Radiology) and NEMA (the National Electrical Manufacturers Association) formed a joint committee to develop a Standard for Digital Imaging and Communications in Medicine. This DICOM Standard was developed according to the NEMA Procedures. The ACC (American College of Cardiology) has decided to join this standardization effort with a particular interest in the definition of Digital Media Storage Standards.

This Standard is developed in liaison with other Standard Organizations including CEN TC251 in Europe and JIRA/IS&C in Japan, with review also by other organizations member of the ANSI HISPP in the USA which includes IEEE, HL7, ASTM and X12.

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 an addendum to the DICOM Standard. The first nine Parts of DICOM were approved in October 1993:

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

These Parts are independent but related documents.

Scope and Field of Application

This Supplement to the DICOM Standard is a series of extensions to improve the capabilities needed for the communication of Ultrasound Image Objects. In order to preserve interoperability with existing implementations a new set of Ultrasound SOP Class UIDs have been defined which use the new capabilities described in this supplement. The existing SOP Class UIDs have been retired and should not be used for new implementations.

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 :

1. PS 3.3 Addenda (Extensions to Annex C)
2. PS 3.4 Addenda (Extensions to Annex B)
2. PS 3.5 Addenda (Extensions to the body, Annex A, addition of Annex I)
3. PS 3.6 Addenda (Extensions to the body and Annex A)
4. PS 3.11 Addenda (Addition of Annex B: Ultrasound Application Profile)

Ultrasound Ad Hoc Committee

Digital Imaging and Communications in Medicine (DICOM)

Part 3 Addendum - Ultrasound Image Information Object Definition

Item #1
Change Table A.1-1 to add Palette Color Lookup Table Module. All modifications to the existing table are shown in BOLD font.

Table A.1-1 - Composite Information Object Modules Overview

IODs Modules	CR	CT	MR	NM	US	US-mf	Sec. Capt	St. Over-lay	St. Curv e	Study Descr.	St. Mod LUT	St. VOI LUT
Patient	M	M	M	M	M	M	M	M	M		M	M
Patient Summary										M		
General Study	M	M	M	M	M	M	M	M	M		M	M
Patient study	U	U	U	U	U	U	U	U	U		U	U
Study Content										M		
General Series	M	M	M	M	M	M	M	M	M		M	M
CR Series	M											
NM Series				M								
Frame Of Reference		M	M	U	U	U						
US Frame of Ref.					C	C						
General Equipment	M	M	M	M	M	M	U	M	M		M	M
NM Equipment				U								
SC Equipment							M					
General Image	M	M	M	M*	M*	M	M					
Image Plane		M	M	U*								
Image Pixel	M	M	M	M*	M*	M	M					
Palette Color Lookup Table					**C**	**C**						
Contrast/Bolus	C	C	C		C*	C						
Cine				C		M						
Multi-frame				C		M						
CR Image	M											
CT Image		M										
MR Image			M									
NM Image				M*								
NM SPECT				C								
NM Multi-Gated				C								
US Region Calibration					U*	U						
US Image					M*	M						
SC Image							M					
Overlay Identification								M				
Overlay Plane	U	U	U	U	U*		U	M				
Multi-frame Overlay				U								
Curve Identification					M*	M*			M			
Curve				U	M*	M*			M			
Audio					U	U						
Modality LUT	U						U				M	
VOI LUT	U	U	U	U	U*	U	U					M
LUT Identification											M	M

SOP Common	M	M	M	M	M*	M*	M	M	M	M	M	M

* The notation next to M and U indicates a special condition for these modules. Refer to the corresponding Information Object Definitions in this Annex for details.

Note: **The original US Image IOD & US multi-frame IOD, and the associated US & US multi-frame Storage SOP Class UID have been retired. A new US & US multi-frame Image IOD is defined, as shown in Table A.1-1 which includes the Palette Color Lookup Table module.**

Item #2
Retire Section A.6.3, Table A.6-1 and Section A.6.3.1 (retire existing US IOD).

Item #3
Add Section A.6.4 and Table A.6-2 for the new US IOD with Palette Color Lookup Table Module added.

A.6.4 US Image IOD Module Table

Table A.6-2 — US Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
Frame of Reference	Frame of Reference	C.7.4.1	U
	US Frame of Reference	C.8.5.1	C - Required if images are spatially related
Equipment	General Equipment	C.7.5.1	M
Image (See A.6.3.1)	General Image	C.7.6.1	M
	Image Pixel	C.7.6.3	M
	Contrast/bolus	C.7.6.4	C Required if contrast media was used in this image
	Palette Color Lookup Table	C.7.9	C - Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR
	US Region Calibration	C.8.5.2	U
	US Image	C.8.5.3	M
	Overlay Plane	C.9.2	U
	VOI LUT	C.11.2	U
	SOP Common	C.12.1	M
Curve (See A.6.3.1)	Curve Identification	C.10.1	M
	Curve	C.10.2	M
	Audio	C.10.3	U
	SOP Common	C.12.1	M

A.6.4.1 Mutually Exclusive IEs

The Image and Curve IEs are mutually exclusive. Each SOP Instance using this IOD shall contain exactly one of these IEs.

Item #4
Retire Section A.7.3, Table A.7-1 and Section A.7.3.1 (retire existing US multi-frame IOD).

Item #5
Add Section A.7.4 and Table A.7-2 for the new US multi-frame IOD with Palette Color Lookup Table Module added.

A.7.4 US Multi-frame Image IOD Module Table

Table A.7-2 — US Multi-frame Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
Series	General Series	C.7.3.1	M
Frame of Reference	Frame of Reference	C.7.4.1	U
	US Frame of Reference	C.8.5.1	C - Required if images are spatially related
Equipment	General Equipment	C.7.5.1	M
Image(See A.7.3.1)	General Image	C.7.6.1	M
	Image Pixel	C.7.6.3	M
	Contrast/bolus	C.7.6.4	C Required if contrast media was used in this image
	Cine	C.7.6.5	M
	Multi-frame	C.7.6.6	M
	Palette Color Lookup Table	C.7.9	C - Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR
	US Region Calibration	C.8.5.2	U
	US Image	C.8.5.3	M
	VOI LUT	C.11.2	U
	SOP Common	C.12.1	M
Curve (See A.7.3.1)	Curve Identification	C.10.1	M
	Curve	C.10.2	M
	Audio	C.10.3	U
	SOP Common	C.12.1	M

A.7.4.1 Mutually Exclusive IEs

The Image and Curve IEs are mutually exclusive. Each SOP Instance using this IOD shall contain exactly one of these IEs.

Item # 6
This section shows proposed changes to support Pixel Calibration for RGB images.
Listed below are additions to Table C.8.5.2 Ultrasound Region Calibration Module Attributes.
Changes to existing attribute descriptions are shown in BOLD.

Table C.8.5.2 Ultrasound Region Calibration Module Attributes

Attribute Name	Tag	Type	Attribute Description
>Pixel Component Organization	(0018,6044)	1C	Describes how the components of a pixel can be described. The absence of this Data Element means that pixel component calibration does not exist for this region. See C.8.5.2.1.4 for Enumerated Values and further explanation.
>Number of Table Break Points	(0018,6050)	1C	The number of break point coordinate pairs used to describe a piece wise linear curve. **Required if Pixel Component Organization equals 0 or 1**. Otherwise not used. See C.8.5.2.1.8 for further explanation.
>Table of X Break Points	(0018,6052)	1C	An array of X values used to create the piece wise linear curve. **Required if Pixel Component Organization equals 0 or 1.** Otherwise not used. See C.8.5.2.1.9 for further explanation.
>Table of Y Break Points	(0018,6054)	1C	An array of Y values used to create the piece wise linear curve. **Required if Pixel Component Organization equals 0 or 1**. Otherwise not used. See C.8.5.2.1.9 for further explanation.
>Number of Table Entries	(0018,6056)	1C	The number of entries in the Table of Pixel Values. Required if the Pixel Component Organization equals 2. Otherwise not used. See C.8.5.2.1.11 for further explanation.

>Table of Pixel Values	(0018,6058)	1C	A table of Pixel Values used in conjunction with the Table of Parameter Values to provide a mapping from Pixel Value to Parameter Value. Required if the Pixel Component Organization equals 2. Otherwise not used. See C.8.5.2.1.12 for further explanation.
>Table of Parameter Values	(0018,605A)	1C	A table of Parameter Values used in conjunction with the Table of Pixel Values to provide a mapping from Pixel Value to Parameter Value. Required if the Pixel Component Organization equals 2. Otherwise not used. See C.8.5.2.1.13 for further explanation

Item #7
Add paragraph to part 3 section C.7.6.3.1.1 Samples per Pixel to define "Composite Pixel Code"

The data in each pixel may be represented as a "Composite Pixel Code". If Samples Per Pixel is one, the Composite Pixel Code is just the "n" bit pixel sample, where "n" = Bits Allocated. If Samples Per Pixel is greater than one, the Composite Pixel Code is a "k" bit concatenation of samples, where "k" = Bits Allocated multiplied by Samples Per Pixel, and with the sample representing the vector color designated first in the Photometric Interpretation name comprising the most significant bits of the Composite Pixel Code, followed in order by the samples representing the next vector colors, with the sample representing the vector color designated last in the Photometric Interpretation name comprising the least significant bits of the Composite Pixel Code. For example, for Photometric Interpretation = "RGB", the most significant "Bits Allocated" bits contain the Red sample, the next "Bits Allocated" bits contain the Green sample, and the least significant "Bits Allocated" bits contain the Blue sample.

Item #8
Replace the 1st paragraph of Part 3 section C.8.5.2.1.5 Pixel Component Mask

Pixel Component Mask (0018,6046) is ANDed with the Composite Pixel Code (see section C.7.6.3.1.1) for each pixel within the region, then shifted right by the number of contiguous least significant zeros in the mask to obtain what will be referred to as the "Shifted Masked Composite Pixel Code".

Item #9
This section shows proposed changes to support Pixel Calibration for RGB images
Listed below are changes to section C.8.5.2.1.4 Pixel Component Organization.
Changes are shown in BOLD.

C.8.5.2.1.4 Pixel Component Organization

Pixel Component Organization (0018,6044) provides an Enumerated Value describing how the components of a pixel can be described. The absence of this data element means that pixel component calibration does not exist for this region. Where:

0 = Bit aligned positions
1 = Ranges
2= Table look up

Other values reserved for future use.

Item #10
This section shows proposed changes to support Pixel Calibration for RGB images.
Listed below are the additions of sections C8.5.2.1.11 - C.8.5.2.1.13.

C.8.5.2.1.11 Number of Table Entries

The Number of Table Entries (0018,6056) gives the number of entries in the Table of Pixel Values. The number of entries in the Table of Parameter Values is also equal to this number. Pixel Value and Parameter Value tables are used to assign Parameter values to pixels. A pixel is calibrated by finding an entry in the Pixel Value Table that matches its Composite Pixel Code (see section C.7.6.3.1.1). The offset of this entry is used as an index into the Parameter Value Table. The Parameter value entry at this offset gives the Parameter Value of the Pixel.

Note: If a Composite Pixel Code has no matching value in the Pixel Value Table then there is no unambiguous way to determine the corresponding Parameter Value. A method may exist to determine a valid Parameter Value but the specification of such a method is outside the scope of the DICOM standard. No assumption should be made that linear interpolation will produce a valid result.

C.8.5.2.1.12 Table of Pixel Values

This is a table of unique Pixel Codes (0018,6058). The number of entries in the table is given by Number of Table Entries (0018,6056).

C.8.5.2.1.13 Table of Parameter Values

This is a table of parameter values (0018,605A). The number of table entries is given by Number of Table Entries and the physical units are given by Pixel Component Physical Units (0018,604C). Values may repeat when a parameter value is associated with more than one Composite Pixel Code value.

Item #11
Clarified text for Number of Table Break Points, Table of X Break Points and Table Y Break Points

C.8.5.2.1.8 Number of Table Break Points

The Number of Table Break Points (0018, 6050) gives the number of entries in each of two tables: the Table of X Break Points (0018, 6052) and Table of Y Break Points (0018, 6054). These tables are used to designate a curve mapping the value of a pixel component to its actual physical value, as described in Section C.8.5.2.1.9.

C.8.5.2.1.9 Table of X Break Points and Table of Y Break Points

Table of X Break Points (0018, 6052) and Table of Y Break Points (0018, 6054) are individual arrays of coordinates which interpreted together are used to create a piecewise linear curve. Each X value from the Table of X Break Points is matched with the corresponding Y value from the Table of Y Break Points yielding an (X,Y) coordinate. The set of (X,Y) coordinates describes a piecewise linear curve mapping the value of a pixel component to its actual physical value (in units defined in Pixel Component Physical Units data element (0018, 604C)).

The X direction on the curve has no units, and represents actual pixel component values. If the Pixel Component Organization (0018, 6044) is "Bit aligned positions", and the width of the Pixel Component Mask is "n" bits then the X coordinates are in the range 0 through 2^{n} -1. If the Pixel Component Organization is "Ranges", then the X coordinates are in the range 0 through $2^{\text{number of bits in the composite pixel}}$ - 1.

Note: The X value is NOT relative to the Pixel Component Range Start (0018, 6048). Not all possible X values in the range need be covered by the curve.

For any pixel component value in the range of the curve described by this table, the corresponding Y value is the actual physical value for that pixel, in units specified in the Pixel Component Physical Units data element (0018, 604C). If the pixel component value is NOT within the range of specified X values for the curve, then no pixel calibration is defined by this region. It may be possible for pixel calibration to be defined by other spatial regions underneath this one, if Region Flags (0018, 6016) indicates this region is "Transparent".

Item #12
This section shows proposed changes to support three types of YC_BC_R Photometric Interpretation
Additions to section C.7.6.3.1.2 to add YC_BC_R as a Photometric Interpretation

C.7.6.3.1.2 Photometric Interpretation

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 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 half full scale.

Note: In the case where the Bits Allocated (0028,0100) has a 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.

$$
\begin{aligned}
Y &= + .2990R + .5870G + .1140B \\
C_B &= - .1687R - .3313G + .5000B + 128 \\
C_R &= + .5000R - .4187G - .0813B + 128
\end{aligned}
$$

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 Photometric Interpretation is only allowed with Planar Configuration (0028,0006) equal to 0000. 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 (ie the maximum value is 235)
3. C_B and C_R each have a minimum value of 16
4. C_B and C_R are restricted to 225 levels (ie 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 a value of 8 then the following equations convert between RGB and YBR_PARTIAL_422 Photometric Interpretation.

$$
\begin{aligned}
Y &= + .2568R + .5041G + .0979B + 16 \\
C_B &= - .1482R - .2910G + .4392B + 128 \\
C_R &= + .4392R - .3678G - .0714B + 128
\end{aligned}
$$

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

Item #13
This section shows proposed changes to PS 3.3 to add YC_BC_R photometric interpretation
Change C.8.5.3.1.2 to read as follows (Retired ARGB, added YC_BC_R). Additions shown in BOLD.

C.8.5.3.1.2 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

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

Item #14
This section describes the specialization of the data element, Lossy Image Compression.

Table C.8.5.3 US Image Module

Attribute Name	**Tag**	**Type**	**Attribute Description**
Lossy Image Compression	(0028,2110)	1C	Specifies whether an image has undergone lossy compression. Enumerated Values: 00 = Image has NOT been subjected to lossy compression 01 = Image has been subjected to lossy compression. See C.7.6.1.1.5 This attribute is required when an image has been subjected to lossy compression.

Item #15
This section describes the addition of a new data element, Ultrasound Color Data Present, to table C.8.5.3 US Image Module Attributes, that indicates if an image contains ultrasound color data information.

Table C.8.5.3 US Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Ultrasound Color Data Present	(0028,0014)	3	This element indicates if any ultrasound color data is present in an image. 00 = Ultrasound color data not present in image 01 = Ultrasound color data is present in image. See C.8.5.3.10

Item #16
This section describes the addition of a new section C.8.5.3.1.10 which describes the newly added data element, Ultrasound Color Data Present.

C.8.5.3.1.10 Ultrasound Color Data Present

Note: This data element can be used to indicate if an image contains any Ultrasound color data. For example: Some Ultrasound images may have a Photometric Interpretation equal to RGB but the image will have no color information if R=G=B for all pixels.

For consistency within a particular implementation Monochrome Ultrasound images may be coded using a color photometric interpretation. In that case inclusion of this data element can significantly speed up processing. Since all components are known to be equal only one need be handled. The enhancements can be significant when compressed Transfer Syntaxes are used.

Item #17
This section shows proposed data element addition to Table C.7.6.5 to support playback sequencing

Table C.7.6.5 Cine Module Attributes

Attribute Name	Tag	Type	Attribute Description
Preferred Playback Sequencing	(0018,1244)	3	Describes the preferred playback sequencing for a multi-frame image. Enumerated value: 0 = Looping (1,2...n,1,2,..n,1,2,...n,...) 1 = Sweeping (1,2,...n,n-1,..2,1,2,...n,...)

Item #18
This section describes an addition to Table C.9.2 to add a new data element to the Overlay Plane Module to describe a specific purpose for a ROI Overlay Type.

Table C.9.2 Overlay Plane Module

Attribute Name	Tag	Type	Attribute Description
Overlay Subtype	(60xx,0045)	3	Defined term which identifies the intended purpose of the ROI Overlay Type.

Item #19
This section describes an addition to Table C.8.5.3, US Image Module Attributes, to specialize the newly added data element(item # 15) to the Overlay Plane Module for Ultrasound.

Table C.8.5.3 US Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Overlay Subtype	(60xx,0045)	3	Defined term which identifies the intended purpose of the ROI Overlay Type. See C.8.5.3.1.11 for specialization.

Item #20
Add section C.8.5.3.1.11 to describe US specialization of Overlay Subtype.

C.8.5.3.1.11 Overlay Subtype

For US Images, Overlay Subtype (60xx,0045) shall use the following Defined Terms:

ACTIVE 2D/BMODE IMAGE AREA = identification of the active area of a 2D/B-mode image.

Item #18
Added specialization to the US Image Module Table C.8.5.3

Table C.8.5.3 US Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Samples Per Pixel	(0028,0002)	1	Number of samples (planes) in this image. See C.8.5.3.1.12 for specialization
Bits Allocated	(0028,0100)	1	Specifies the intended interpretation of the pixel data. See C.8.5.3.1.13 for specialization.
Bits Stored	(0028,0101)	1	Number of bits allocated for each pixel sample. See C.8.5.3.1.14 for specialization.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. See C.8.5.3.1.15 for specialization.
Planar Configuration	(0028,0006)	1	Indicates whether the pixel data are sent color-by-plane or color-by-pixel. See C.8.5.3.1.16 for specialization.

Item #19
Add section C.8.5.3.1.12 for US specialization of Samples per Pixel

C.8.5.3.1.12 Samples Per Pixel

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

Table C.8.5.3.1.12 US Samples Per Pixel

Photometric Interpretation	Samples Per Pixel Value
MONOCHROME2	0001H
RGB	0003H
YBR_FULL	0003H
YBR_FULL_422	0003H
YBR_PARTIAL_422	0003H
PALETTE COLOR	0001H

Item #20
Add section C.8.5.3.1.13 for US specialization of Bits Allocated

C.8.5.3.1.13 Bits Allocated

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

Table C.8.5.3.1.13 US Bits Allocated

Photometric Interpretation	Bits Allocated Value
MONOCHROME2	0008H
RGB	0008H
YBR_FULL	0008H
YBR_FULL_422	0008H
YBR_PARTIAL_422	0008H
PALETTE COLOR	0008H - 8 bit palette or 0010H - 16 bit palette

Item #21
Add section C.8.5.3.1.14 for US specialization of Bits Stored

C.8.5.3.1.14 Bits Stored

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

Table C.8.5.3.1.14 US Bits Stored

Photometric Interpretation	Bits Stored Value
MONOCHROME2	0008H
RGB	0008H
YBR_FULL	0008H
YBR_FULL_422	0008H
YBR_PARTIAL_422	0008H
PALETTE COLOR	0008H - 8 bit palette or 0010H - 16 bit palette

Item #22
Add section C.8.5.3.1.15 for US specialization of High Bit

C.8.5.3.1.15 High Bit

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

Table C.8.5.3.1.15 US High Bit

Photometric Interpretation	High Bit Value
MONOCHROME2	0007H
RGB	0007H
YBR_FULL	0007H
YBR_FULL_422	0007H
YBR_PARTIAL_422	0007H
PALETTE COLOR	0007H - 8 bit palette or 000FH - 16 bit palette

Item #23
Add section C.8.5.3.1.16 for US specialization of Planar Configuration

C.8.5.3.1.16 Planar Configuration

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

Table C.8.5.3.1.16 US Planar Configuration

Photometric Interpretation	Planar Configuration Value
RGB	0000H color-by-pixel or 0001H color-by-plane
YBR_FULL	0001H
YBR_FULL_422	0000H
YBR_PARTIAL_422	0000H

Item #24
Add new anatomic coding sequence, transducer orientation, and transducer position sequences to US Image Module TableC.8.5.3 and retire the following data elements:
Anatomic Structure(0008,2208)
Transducer Position(0008,2200)
Transducer Orientation(0008,2204)

2 **Table C.8.5.3 US Image Module Attributes**

Anatomic Region Sequence	(0008,2218)	3	Sequence of one Item that identifies the anatomic region of interest in this image (i.e. external anatomy, surface anatomy, or general region of the body). See Section C.8.5.3.1.17.
>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the anatomic region. Required if a sequence item is present.
>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>Code Meaning	(0008,0104)	3	The anatomic region that is represented by the Code Value (0008,0100).
>Anatomic Region Modifier Sequence	(0008,2220)	3	Sequence of one or more Items that modifies the anatomic region of interest in this image (i.e. prone, supine, decubitus right). See Section C.8.5.3.1.17.
>>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the anatomic region modifier term. Required if a sequence item is present.
>>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>>Code Meaning	(0008,0104)	3	The anatomic region modifier term that is represented by the Code Value (0008,0100). .
Primary Anatomic Structure Sequence	(0008,2228)	3	Sequence of one or more Items that identifies the primary anatomic structure of interest in this image. See Section C.8.5.3.1.18

>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the primary anatomic structure. Required if a sequence item is present.
>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>Code Meaning	(0008,0104)	3	The anatomic structure that is represented by the Code Value (0008,0100).
>Primary Anatomic Structure Modifier Sequence	(0008,2230)	3	Sequence of one or more Items that modifies the primary anatomic structure of interest in this image.). See Section C.8.5.3.1.18
>>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the anatomic structure modifier term. Required if a sequence item is present.
>>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>>Code Meaning	(0008,0104)	3	The anatomic structure modifier term that is represented by the Code Value (0008,0100).
Transducer Position Sequence	(0008,2240)	3	Sequence of one or more Items that identifies the transducer position used in this image. See section C.8.5.3.1.19.
>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the primary transducer position. Required if a sequence item is present.
>Coding Scheme Designator	(0008,102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>Code Meaning	(0008,0104)	3	The transducer position that is represented by the Code Value (0008,0100).
> Transducer Position Modifier Sequence	(0008,2242)	3	Sequence of one or more Items that modifies the primary transducer position of interest in this image.). See Section C.8.5.3.1.19.

>>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the transducer position modifier term. Required if a sequence item is present.
>>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>>Code Meaning	(0008,0104)	3	The transducer position modifier term that is represented by the Code Value (0008,0100).
Transducer Orientation Sequence	(0008,2244)	3	Sequence of one or more Items that identifies the Transducer Orientation used in this image. See section C.8.5.3.1.20.
>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the primary Transducer Orientation. Required if a sequence item is present.
>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>Code Meaning	(0008,0104)	3	The transducer orientation that is represented by the Code Value (0008,0100).
> Transducer Orientation Modifier Sequence	(0008,2246)	3	Sequence of one or more Items that modifies the primary Transducer Orientation of interest in this image.). See Section C.8.5.3.1.20
>>Code Value	(0008,0100)	1C	The code value (defined by the coding scheme) that represents the transducer orientation modifier term. Required if a sequence item is present.
>>Coding Scheme Designator	(0008,0102)	1C	The code from Annex D designating the coding scheme which maps the Code Value (0008,0100) onto the Code Meaning (0008,0104). Required if a sequence item is present. Defined Terms: 99SDM
>>Code Meaning	(0008,0104)	3	The transducer orientation structure modifier term that is represented by the Code Value (0008,0100).

2

Item #25
Add descriptions of Anatomic Region, Primary Anatomic Sequence, Transducer Position Sequence, and Transducer Orientation Sequence for SNOMED DICOM coding schemes.

C.8.5.3.1.17 Anatomic Region Sequence

The general region of the body (e.g. the anatomic region, organ, or body cavity being examined) may be identified by the Anatomic Region Sequence (0008,2218). Characteristics of the anatomic region being examined, such as its orientation relative to gravity (e.g. prone, supine, semi-erect), sub-region (e.g. medial, lateral, superior, inferior, lobe, quadrant), and laterality (e.g. right, left, both), and so on, may be refined by the Anatomic Region Modifier Sequence (0008,2220).

If the Coding Scheme Designator (0008,0102) for the Anatomic Region Sequence (0008,2218) is 99SDM, then the Code Value (0008,0100) for the Anatomic Region Sequence (0008,2218) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of “SNMI”, any Context value, and a Semantic Type value of “anatomic region or structure”.

If the Coding Scheme Designator (0008,0102) for the Anatomic Region Modifier Sequence (0008,2220) is 99SDM, then the Code Value (0008,0100) for the Anatomic Region Modifier Sequence (0008,2220) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of “SNMI”, any Context value, and a Semantic Type value of “anatomic region modifier”.

Note: 1) These Data Elements allow the specification of the information encoded by the Body Part Examined (0018,0015) and Patient Position (0018,5100) Data Attributes (in the General Series Module) in a more robust, consistent way.

2) Anatomic Region Sequence (0008,2218) and Anatomic Region Modifier Sequence (0008,2220) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

C.8.5.3.1.18 Primary Anatomic Structure Sequence

The specific anatomic structures of interest within the image (e.g. a particular artery within the anatomic region) is identified by the Primary Anatomic Structure Sequence (0008,2228). Characteristics of the anatomic structure, such as its location (e.g. subcapsular, peripheral, central), configuration (e.g. distended, contracted), and laterality (e.g. right, left, both), and so on, may be refined by the Primary Anatomic Structure Modifier Sequence (0008,2230).

If the Coding Scheme Designator (0008,0102) for the Primary Anatomic Structure Sequence (0008,2228) is 99SDM, then the Code Value (0008,0100) for the Primary Anatomic Structure Sequence (0008,2228) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of “SNMI”, any Context value, and a Semantic Type value of “anatomic region or structure”.

If the Coding Scheme Designator (0008,0102) for the Primary Anatomic Structure Modifier Sequence (0008,2230) is 99SDM, then the Code Value (0008,0100) for the Primary Anatomic Structure Modifier Sequence (0008,2230) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of “SNMI”, any Context value, and a Semantic Type value of “anatomic structure modifier”.

Note: 1) These Data Elements are intended to replace the Anatomic Structure (0008,2208) Data Element.

2) Primary Anatomic Structure Sequence (0008,2228) and Primary Anatomic Structure Modifier Sequence (0008,2230) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

C.8.5.3.1.19 Transducer Position Sequence

If the Coding Scheme Designator (0008,0102) for the Transducer Position Sequence (0008,2240) is 99SDM, then the Code Value (0008,0100) for the Transducer Position Sequence (0008,2240) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of "SNMI", any Context value, and a Semantic Type value of "transducer position".

If the Coding Scheme Designator (0008,0102) for the Transducer Position Modifier Sequence (0008,2242) is 99SDM, then the Code Value (0008,0100) for the Transducer Position Modifier Sequence (0008,2242) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of "SNMI", any Context value, and a Semantic Type value of "transducer position modifier".

Note: 1) These Data Elements are intended to replace the Transducer Position (0008,2200) Data Element.

2) Transducer Position Sequence (0008,2240), Transducer Position Modifier Code Sequence (0008,2242) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

C.8.5.3.1.20 Transducer Orientation Sequence

If the Coding Scheme Designator (0008,0102) for the Transducer Orientation Sequence (0008,2244) is 99SDM, then the Code Value (0008,0100) for the Transducer Orientation Sequence (0008,2244) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of "SNMI", any Context value, and a Semantic Type value of "transducer orientation".

If the Coding Scheme Designator (0008,0102) for the Transducer Orientation Modifier Sequence (0008,2246) is 99SDM, then the Code Value (0008,0100) for the Transducer Orientation Modifier Sequence (0008,2246) shall be the Source UID value from a SNOMED DICOM Microglossary record. This record shall have Source value of "SNMI", any Context value, and a Semantic Type value of "transducer orientation modifier".

Note: 1) These Data Elements are intended to replace the Transducer Orientation(0008,2204) Data Element.

2) Transducer Orientation Sequence (0008,2244), Transducer Orientation Modifier Code Sequence (0008,2246) specify value 99SDM from Annex D for Coding Scheme Designator. It is expected that this value will evolve when Coding Scheme Designator UIDs are available from a registration authority.

Item #26
This section shows the addition of Palette Color Lookup Table Module Section C.7.9

C.7.9 Palette Color Lookup Table Module

Table C.7.9 specifies the Attributes that describe the Lookup table data for images with Palette Color photometric interpretation.

When the Palette Color Lookup Table Module is present, the conditional requirements for the use of Palette Color Lookup Table Data (0028,1201-1203) and Segmented Palette Color Lookup Table Data (0028,1221-1223), described in Table C.7.9, shall take precedence over the conditional requirements described in the Image Pixel Module (See Section C.7.6.3).

Table C.7.9 Palette Color Lookup Table Module

Attribute Name	Tag	Type	Attribute Description
Red Palette Color Lookup Table Descriptor	(0028,1101)	1C	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201) Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB. See C.7.6.3.1.5 for further explanation.
Green Palette Color Lookup Table Descriptor	(0028,1102)	1C	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202) Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB. See C.7.6.3.1.5 for further explanation.
Blue Palette Color Lookup Table Descriptor	(0028,1103)	1C	Specifies the format of the Blue Palette Color Lookup Table Data (0028,1203) Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB. See C.7.6.3.1.5 for further explanation.
Palette Color Lookup Table UID	(0028,1199)	3	Palette Color Lookup Table UID. See C.7.9.1 for further explanation.
Red Palette Color Lookup Table Data	(0028,1201)	1C	Red Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB and segmented data is NOT used. See C.7.6.3.1.6 for further explanation.

Green Palette Color Lookup Table Data	(0028,1202)	1C	Green Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB and segmented data is NOT used. See C.7.6.3.1.6 for further explanation.
Blue Palette Color Lookup Table Data	(0028,1203)	1C	Blue Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR or ARGB and segmented data is NOT used. See C.7.6.3.1.6 for further explanation.
Segmented Red Palette Color Lookup Table Data	(0028,1221)	1C	Segmented Red Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR and segmented data is used. See C.7.9.2 for further explanation.
Segmented Green Palette Color Lookup Table Data	(0028,1222)	1C	Segmented Green Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR and segmented data is used. See C.7.9.2 for further explanation.
Segmented Blue Palette Color Lookup Table Data	(0028,1223)	1C	Segmented Blue Palette Color Lookup Table Data. Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR and segmented data is used. See C.7.9.2 for further explanation.

C.7.9.1 Palette Color Lookup Table UID

This data element uniquely identifies a palette color lookup table set (red, green, blue).

Note: This can be used to avoid reloading a palette if a system already has that palette loaded without examining all the data entries in the palette.

C.7.9.2 Segmented Palette Color Lookup Table Data

The Segmented Palette Color Lookup Table Data (0028,1221-1223) is stored as a series of segments, see Table C.7.9.2.1. When the segments are expanded into the actual lookup table data, it shall have the number of table entries specified by the first value of the Palette Color Lookup Table Descriptors (0028,1101-1103), Number of Table Entries.

These lookup tables shall be used only when segmented lookup table data use is desirable and there is a single sample per pixel (single image plane) in the image.

Table C.7.9.2.1 Compressed Palette Color Lookup Table Data

Segment 0
Segment 1
.
Segment n

There are currently three types of segments: discrete, linear, and indirect. The segment type is identified by the opcodes defined in Table C.7.9.2.2:

Table C.7.9.2.2 Segment Types

Opcode	Segment type
0	Discrete
1	Linear
2	Indirect
3 & above	reserved

C.7.9.2.1 Discrete segment type

The discrete segment is used to represent a series of palette components which are not monotonic with respect to their predecessors or successors. The SegmentLength indicates the number of lookup table entries.

The format of the Discrete Segment Type shall be as follows:

Table C.7.9.2.1.1 Discrete Segment Type

Segment Opcode = 0
SegmentLength
SegmentLength number of lookup table entries

C.7.9.2.2 Linear segment type

The linear segment represents a series of palette components whose values may be represented by a straight line.

X = palette address, Y = Value contained in the palette

(X_0,Y_0) = end of the previous segment
$(X_0$ + SegmentLength, $Y_1)$ = end of this linear segment
Where: Y_1 is contained in the data portion of this segment.

During expansion, the application should "connect" the previous segment's endpoint, (X_0,Y_0), with this segment's endpoint, $(X_0$ +SegmentLength, $Y_1)$, using a straight line, by computing the values for each point between the endpoints.

Note: Because the linear segment uses the end point from the previous segment, a linear segment can not be the first segment.

The linear segment's format shall be as follows:

Table C.7.9.2.2.1 Linear Segment Type

Segment Opcode = 1
SegmentLength
Y1

C.7.9.2.3 Indirect Segment Type

The indirect segment allows the re-use of repetitive regions within lookup table without respecifying the segments. The opcode is followed by the number of segments to copy and one offset pointer to the first segment to copy. The byte offset is relative to the beginning of the lookup table. For example, if an indirect segment wants to point to the first segment then the offset will be zero. The offset is a 32 bit value but is stored in the segment as a least significant 16 bit value followed by a most significant 16 bit value. A indirect segment shall not point to or copy another indirect segment. This avoids the need for recursion and also avoids the possibility of infinite loops.

The indirect segment's format shall be as follows:

Table C.7.9.2.3.1 Indirect Segment Type

Segment Opcode = 2
Number of segments to copy
Least significant 16 bits of byte offset to first segment to copy
Most significant 16 bits of byte offset to first segment to copy

Item #27
This section shows the changes to section C.7.6.3.1.5 change shown in BOLD

C.7.6.3.1.5 Palette Color Lookup Table Descriptor

The three values of Palette Color Lookup Table Descriptors (0028,1101-1103) describe the format of the Lookup Table Data in the corresponding Data Elements (0028,1201-1203) **or (0028,1221-1223).**

The first value is the number of entries in the lookup table. **When the number of table entries is equal to 2^{16} then this value shall be 0.**

The second value is the first stored pixel value mapped. This pixel value is mapped to the first entry in the Lookup Table Data. All image pixel values less than the first entry are also mapped to the first entry in the Lookup Table Data. An image pixel value one greater than the first entry is mapped to the second entry in the Lookup Table Data. Subsequent image pixel values are mapped to the subsequent entries in the Lookup Table Data up to an image pixel value equal to number of entries + first entry - 1 which is mapped to the last entry in the Lookup Table Data. Image pixel values greater than number of entries + first entry are also mapped to the last entry in the Lookup Table Data.

The third value specifies the number of bits for each entry in the Lookup Table Data.

When the Palette Color Lookup Table Descriptor (0028,1101-1103) are used as part of the Palette Color Lookup Table Module the third value shall be equal to 16.

Note: A value of 16 indicates the Lookup Table Data will range from (0,0,0) minimum intensity to (65535,65535,65535) maximum intensity.

Item # 28
Add CCIR 601-2 normative reference

CCIR Recommendation 601-2, 1990, Section 11F Digital Methods of Transmitting Television Information -- Encoding Parameters of Digital Television for Studios

Item #29
Add CCIR & LUT to abbreviation list in Section 4

CCIR	Consultative Committee, International Radio
LUT	Lookup Table

Ultrasound Ad Hoc Committee

Digital Imaging and Communications in Medicine (DICOM)

Part 4 Addendum - Ultrasound Image Storage SOP Class

Item #1
Retire the following SOP Class UIDs in section B.5

SOP Class Name	SOP Class UID
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3
Ultrasound Image Storage	1.2.840.10008.5.1.4.1.1.6

Item #2
Add the following SOP Class UIDs in section B.5

SOP Class Name	SOP Class UID
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3.1
Ultrasound Image Storage	1.2.840.10008.5.1.4.1.1.6.1

Item #3
Retire the following SOP Class UIDs in Table X.4-1 Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3	IOD defined in PS3.3
Ultrasound Image Storage	1.2.840.10008.5.1.4.1.1.6	IOD defined in PS3.3

Item #4
Add the following SOP Class UIDs in Table X.4-1 Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3.1	IOD defined in PS3.3
Ultrasound Image Storage	1.2.840.10008.5.1.4.1.1.6.1	IOD defined in PS3.3

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Part 5 Addendum - Data Structures and Encoding Extensions

Item #1
***Add new section to describe Run Length Encoding Compression*.**

8.2.2 Run Length Encoding Compression

DICOM provides a mechanism for supporting the use of Run Length Encoding (RLE) Compression which is a byte oriented lossless compression scheme through the Encapsulated Format (see PS 3.3 of this Standard). Annex I defines RLE Compression and its Transfer Syntax.

Note: The RLE Compression algorithm described in Annex I is the compression used in the TIFF 6.0 specification known as the “PackBits” scheme.

The use of the DICOM Encapsulated Format to support RLE Compressed Pixel Data implies that the Data Elements which are related to the Native Format Pixel Data encoding (e.g. Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the characteristics of the uncompressed pixel data from which the compressed data was derived.

Item #2
***Add new section to describe RLE Compression Transfer Syntax*.**

10.4 Transfer Syntax for DICOM RLE Compression

DICOM defines the RLE Compression (see Annex I). 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 RLE compression Transfer Syntax, at least one of the Presentation Contexts which include this Abstract Syntax, shall include the DICOM Default Transfer Syntax (uncompressed).

Item #3
Add new section after A.4.1 to describe RLE Compression.

A.4.2 RLE Compression

Annex I defines a RLE Compression Transfer Syntax. This Transfer Syntax is identified by the UID value 1.2.840.10008.1.2.5. If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each frame shall be encoded in one and only one Fragment (see PS3.5.8.2).

Item #4
Add new Annex I to describe RLE Compression.

Annex I (Normative) Encapsulated RLE Compressed Images

I.1 Summary

This annex describes how to apply RLE Compression to an image or an individual frame of a multi-frame image. This method can be used for any image, independent of the values of the data elements that describe the image (ie: Photometric Interpretation (0028,0004) and Bits Stored (0028,0101)).

RLE Compression consists of the following steps:

1. The image is converted to a sequence of Composite Pixel Codes (see PS3.3 C.7.6.3.1.1).
2. The Composite Pixel Codes are used to generate a set of Byte Segments (see section I.2)
3. Each Byte Segment is RLE compressed to produce a RLE Segment (see section I.4)
4. The RLE Header is appended in front of the concatenated RLE Segments (see section I.5)

I.2 Byte Segments

A Byte Segment is a series of bytes generated by decomposing the Composite Pixel Code (see PS 3.3 section C.7.6.3.1.1).

If the Composite Pixel Code is not an integral number of bytes in size, sufficient Most Significant zero bits are added to make it an integral byte size. This is known as the Padded Composite Pixel Code.

The first Segment is generated by stripping off the most significant byte of each Padded Composite Pixel Code and ordering these bytes sequentially. The second Segment is generated by repeating this process on the stripped Padded Composite Pixel Code continuing until the last Pixel Segment is generated by ordering the least significant byte of each Padded Component Pixel Code sequentially.

Note: If Photometric Interpretation (0028, 0004) equals RGB and Bits Stored equals 8 then three Segments are generated. The first one holds all the Red values, the second all the Green values and the third all the Blue values.

I.3 The RLE algorithm

The RLE algorithm described in this section is used to compress Byte Segments into RLE Segments. There is a one-to-one correspondence between Byte Segments and RLE Segments. Each RLE segment must be an even number of bytes or padded at its end with zero to make it even.

I.3.1 The RLE encoder

A sequence of identical bytes (Replicate Run) is encoded as a two-byte code

<-count+1> <byte value>, where count=the number of bytes in the run, and 2<=count<=128

and a non-repetitive sequence of bytes (Literal Run) is encoded as

<count-1> <literal sequence of bytes>, where count=number of bytes in the sequence, and 1<=count<=128

The value of -128 may not be used to prefix a byte value.

> Note: It is common to encode a 2-byte repeat run as a Replicate Run except when preceded and followed by a Literal Run, in which case it's best to merge the three runs into a Literal Run.

Three-byte repeats shall be encoded as Replicate Runs. Each row of the image shall be encoded separately and not cross a row boundary.

I.3.2 The RLE decoder

Pseudo code for the RLE decoder is shown below:

```
Loop until the number of output bytes equals the uncompressed segment size

        Read the next source byte into n

        If n>=0 and n<=127 then
                output  the next n+1 bytes literally
        Elseif n<=-1 and n>=-127 then
                output the next byte -n+1 times
        Elseif n = -128 then
                output nothing
        Endif

Endloop
```

I.4 Organization of RLE Compressed Frame

The RLE Segments are ordered as described in section I.2. They are preceded by the RLE Header which contains offsets to the start of each RLE Segment. The RLE Header is described in I.5.

The first RLE Segment immediately follows the RLE Header and the remaining RLE Segments immediately follow each other. This is illustrated in the diagram below.

Header
RLE Segment 1
RLE Segment 2
...
...
RLE Segment n

I.5 RLE Header format

The RLE Header contains the number of RLE Segments for the image, and the starting offset of each of the RLE Segments. Each of these numbers is represented by a UL (unsigned long) value stored in little-endian format. The RLE Header is 16 long words in length. This allows it to describe a compressed image with up to 15 RLE Segments. All unused segments offsets shall be set to zero.

Each of the starting locations for the RLE Segments are byte offsets relative to the beginning of the RLE Header. Since the RLE Header is 16 unsigned longs or 64 bytes, the offset of RLE Segment One is 64.

The following diagram illustrates the ordering of the offsets within the RLE Header.

number of RLE Segments
offset of RLE Segment 1 = 64
offset of RLE Segment 2
...
...
offset of RLE Segment n
0
0
0

I.6 Example of elements for an encoded YC_BC_R RLE three-frame image with Basic Offset Table

Figure I.6.1 is an example of encoding of RLE Compressed Frames (described in Section I.4) with the basic offset table. Figure I.6.2 is an example of Item Value data for one frame.

Figure I.6.1 Example of elements for an encoded YC_BC_R RLE three-frame image with Basic Offset Table.

Pixel Data Element Tag	VR		Data Element Length	Data Element					
				Basic Offset Table with Item Value			First Fragment (Frame 1) of Pixel Data		
(7FE0, 0010) with VR of OB	“OB”	0000H	FFFF FFFFH undefined length	Item Tag (FFFE, E000)	Item Length 0000 000CH	Item Value 0000 0000H 0000 02D0H 0000 0642H	Item Tag (FFFE, E000)	Item Length 0000 02C8H	Item Value RLE Compressed Frame
4 bytes	2 bytes	2 bytes	4 bytes	4 bytes	4 bytes	000CH bytes	4 bytes	4 bytes	02C8H bytes

Data Element continued							
Second Fragment (Frame 2) of Pixel Data			Third Fragment (Frame 3) of Pixel Data			Sequence Delimiter Item	
Item Tag (FFFE, E000)	Item Length 0000 036AH	Item Value RLE Compressed Frame	Item Tag (FFFE, E000)	Item Length 0000 0BC8H	Item Value RLE Compressed Frame	Sequence Delim. Tag (FFFE, E0DD)	Item Length 0000 0000H
4 bytes	4 bytes	036AH bytes	4 bytes	4 bytes	0BC8H bytes	4 bytes	4 bytes

Figure I.6.2: Example of encoded YC_BC_R RLE Compressed Frame Item Value

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Offset	Data	Description of data	
0000 0000H	0000 0003H	number of RLE Segments	
	0000 0040H	location of RLE Segment 1 (Y component)	Header
	0000 0140H	location of RLE Segment 2 (C_B component)	
	0000 01C0H	location of RLE Segment 3 (C_R component)	
	0000 0000H		
	......		
	......		
	0000 0000H		
0000 0040H	Y - RLE Segment Data		DATA
0000 0140H	C_B - RLE Segment Data		DATA
0000 01C0H	C_R - RLE Segment Data		DATA

Item #5
Add paragraph to the end of section A.4.1 to clarify how to apply baseline JPEG compression to YBR_ FULL_422 and YBR_PARTIAL_422 images.

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 YYC_BC_R, where Y, C_B and C_R are 8 by 8 blocks of pixel values. The data stream encodes two Y blocks followed by the corresponding C_B and C_R blocks.

Item #6
Added descriptions of how the OW VR is to be represented for Palette Color Lookup Table Data and Segmented Palette Color Lookup Table Data.

A.1 DICOM Implicit VR Little Endian Transfer Syntax

C) ......

- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element.
  - ....
  - .....
  - Data Elements (0028,1201), (0028,1202), (0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.
  - Data Elements (0028,1221), (0028,1222), (0028,1223) Segmented Red, Green, Blue Palette Color Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.

A.2 DICOM Little Endian Transfer Syntax (explicit VR)

C) ......

- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element.
  - ....
  - .....
  - Data Elements (0028,1201), (0028,1202), (0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.
  - Data Elements (0028,1221), (0028,1222), (0028,1223) Segmented Red, Green, Blue Palette Color Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian

A.3 DICOM Big Endian Transfer Syntax (explicit VR)

C) ......

- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element.
  - ....
  - .....
  - Data Elements (0028,1201), (0028,1202), (0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Big Endian.
  - Data Elements (0028,1221), (0028,1222), (0028,1223) Segmented Red, Green, Blue Color Lookup Table Data have the Value Representation OW and shall be encoded in Big Endian

A.4 Transfer Syntaxes for Encapsulation of Encoded Pixel Data

C) ......

- For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element.
  - ....
  - .....
  - Data Elements (0028,1201), (0028,1202), (0028,1203) Red, Green, Blue Palette Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian.
  - Data Elements (0028,1221), (0028,1222), (0028,1223) Segmented Red, Green, Blue Color Lookup Table Data have the Value Representation OW and shall be encoded in Little Endian

Item #7
Add RLE to abbreviation list in Section 4

RLE Run Length Encoding

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Part 6 Addendum - Ultrasound Data Dictionary

Item #1
Add the following Data Elements to Part 6 to support Pixel Calibration for RGB images:

Tag	Name	VR	VM
(0018,6056)	**Number of Table Entries**	**UL**	**1**
(0018,6058)	**Table of Pixel values**	**UL**	**1-n**
(0018,605A)	**Table of Parameter Values**	**FL**	**1-n**

Item #2
This section describes an addition of a new data element that indicates if an image contains color or information

Tag	Name	VR	VM
(0028,0014)	Ultrasound Color Data Present	US	1

Item #3
This section shows an addition of the data element to support playback sequencing

Tag	Name	VR	VM
(0018,1244)	Preferred Playback Sequencing	US	1

Item #4
This section shows an addition of the data element to support segmented color maps, add Palette Color Lookup Table UID and correct existing Lookup Table Data .

Tag	Name	VR	VM
(0028,1199)	Palette Color Lookup Table UID	UI	1
(0028,1201)	Red Palette Color Lookup Table Data	US or SS or OW	1-n 1
(0028,1202)	Green Palette Color Lookup Table Data	US or SS or OW	1-n 1
(0028,1203)	Blue Palette Color Lookup Table Data	US or SS or OW	1-n 1
(0028,1221)	Segmented Red Palette Color Lookup Table Data	OW	1
(0028,1222)	Segmented Green Palette Color Lookup Table Data	OW	1
(0028,1223)	Segmented Blue Palette Color Lookup Table Data	OW	1

Item #5
This section shows an addition of the data element which indicates Overlay Subtype

Tag	Name	VR	VM
(60xx,0045)	Overlay Subtype	LO	1

Item #6
This section shows an addition to Annex A of UID value to support RLE compression

UID Value	UID NAME	UID TYPE	Part
1.2.840.10008.1.2.5	RLE Lossless	Transfer Syntax	PS 3.5

Item #7
This section shows an addition of the data elements for anatomic structure, transducer position, and transducer orientation , sequences. Also retiring their previous counterparts

Tag	Name	VR	VM
(0008,2218)	Anatomic Region Sequence	SQ	1
(0008,2220)	Anatomic Region Modifier Sequence	SQ	1
(0008,2228)	Primary Anatomic Structure Sequence	SQ	1
(0008,2230)	Primary Anatomic Structure Modifier Sequence	SQ	1
(0008,2240)	Transducer Position Sequence	SQ	1
(0008,2242)	Transducer Position Modifier Sequence	SQ	1
(0008,2244)	Transducer Orientation Sequence	SQ	1
(0008,2246)	Transducer Orientation Modifier Sequence	SQ	1
(0008,2204)	***Transducer Orientation***	***RET***	
(0008,2200)	***Transducer Position***	***RET***	
(0008,2208)	***Anatomic Structure***	***RET***	

Item #8
Retire the following UIDs to Annex A, Table A-1:

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.3	Ultrasound Multi-frame Image Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.6	Ultrasound Image Storage	SOP Class	PS 3.4

Item #9
Add the following UIDs to Annex A, Table A-1:

UID Value	UID Name	UID Type	Part

1.2.840.10008.5.1.4.1.1.3.1	Ultrasound Multi-frame Image Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.1.1.6.1	Ultrasound Image Storage	SOP Class	PS 3.4

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Digital Imaging and Communications in Medicine (DICOM)

Part 11 Addendum - Annex B, Ultrasound Application Profile

Annex B - Ultrasound Application Profile

B.1 Class and Profile Identification

This Annex defines Application Profiles for Ultrasound Media Storage applications. Each Application Profile has a unique identifier used for conformance claims. Due to the variety of clinical applications of storage media in Ultrasound, a family of application profiles are described in this section to best tailor an application choice to the specific needs of the user. The identifier used to describe each profile is broken down into three parts: a prefix, mid-section, and suffix. The prefix describes the overall Application Profile Class and is common for all ultrasound application profiles. The mid section describes the specific clinical application of the profile. The suffix is used to describe the actual media choice the profile will use.

The prefix for this class of application profiles is identified with the APL-US identifier.

The midsection is broken down into three subclasses which describes the clinical use of the data. These classes are: Image Display (ID identifier), Spatial Calibration (SC identifier), and Combined Calibration (CC identifier). All three subclasses can be applied to either single frames (SF) images or single and multi-frames (MF) images. The SC subclass enhances the ID class by adding the requirement for region specific spatial calibration data with each IOD. The CC subclass enhances the SC subclass by requiring region specific pixel component calibration.

The suffix, xxxx, is used to describe the actual media choice used for the conformance claim. Any of the above mentioned classes can be stored onto one of five pieces of media described in the Table B.3.2.

The specific Application Profiles are shown in the following table.

Table B.1 Application Profile Identifiers

Application Profile	Single Frame	Single & Multi-Frame
Image Display	APL-US-ID-SF-xxxx	APL-US-ID-MF-xxxx
Spatial Calibration	APL-US-SC-SF-xxxx	APL-US-SC-MF-xxxx
Combined Calibration	APL-US-CC-SF-xxxx	APL-US-CC-MF-xxxx

The ID Application Profile Classes are intended to be used for the transfer of ultrasound images for display purposes

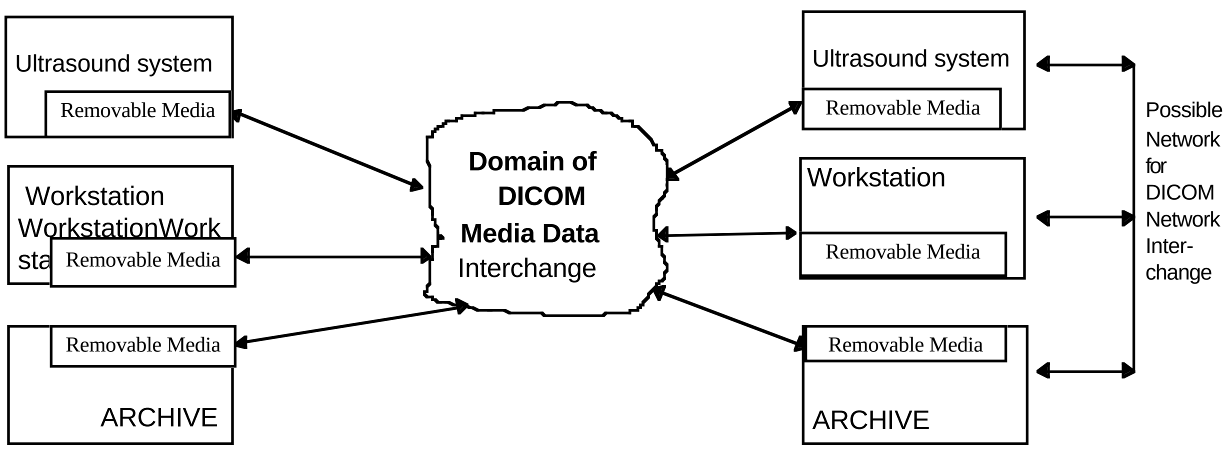
The SC Application Profile Classes are intended to be used for the transfer of ultrasound images with spatial calibration data for quantitative purposes (see section B.4).

The CC Application Profile Classes are intended to be used for the transfer of ultrasound images with spatial and pixel component calibration data for more advanced quantitative purposes (see section B.5).

B.2 Clinical Context

These classes of Application Profiles facilitate the interchange of ultrasound data on media. Typical interchanges would be between ultrasound systems, between an ultrasound system and a display workstation, between display workstations, or between an ultrasound system and a data archive. This context is shown in Figure B.2.

Figure B.2 Clinical Context



The operational use of the media transfer is potentially both intra-institutional and inter-institutional.

B.2.1 Roles

B.2.1.1 FSC

The role of File Set Creator shall be used by Application Entities which generate a File Set under the APL-US class of Application Profiles. Typical entities using this role would include ultrasound imaging equipment, workstations, and archive systems which generate a patient record for transfer. File Set Creators shall be able to generate the DICOMDIR directory file, single and/or multi frame Ultrasound Information Object files, and depending on the subclass, region specific calibration in the defined Transfer Syntaxes.

B.2.1.2 FSR

The role of File Set Reader shall be used by Application Entities which receive a transferred File Set. Typical entities using this role would include ultrasound systems, display workstations, and archive systems which receive a patient record from a piece of media. File Set Readers shall be able to read the DICOMDIR directory file and all Information Objects defined for the specific Application Profiles, using the defined Transfer Syntaxes.

B.2.1.3 FSU

The role of File Set Updater shall be used by Application Entities which receive a transferred File Set and updates it by the addition or deletion of objects to the media. Typical entities using this role would include ultrasound systems adding new patient records to the media and workstations which may add an information object containing a processed or modified image.

B.3 General Class Profile

B.3.1 Abstract and Transfer Syntaxes

Application Profiles in this class, APL-US, shall support the appropriate Information Object Definitions(IOD) and Transfer Syntaxes for the Media Storage SOP Class in the following table. In the role of FS-Updater or FS-Creator the application can choose one of the three possible transfer syntaxes to create an IOD. In the role of FS-Reader an application shall support all transfer syntaxes defined for the APL-US application profile.

Table B.3.1 Abstract and Transfer Syntaxes

Information Object Definition	**SOP Class UID**	**Transfer Syntax**	**Transfer Syntax UID**
DICOM Media Storage Directory	1.2.840.10008.1.3.10	Explicit VR Little Endian Uncompressed	1.2.840.10008.1.2.1 (see PS 3.10 section 8.6)
Ultrasound Image Storage	1.2.840.10008.5.1.4.1.1.6.1	Explicit VR Little Endian Uncompressed	1.2.840.10008.1.2.1
		RLE Lossless Image Compression	1.2.840.10008.1.2.5
		JPEG Lossy, Baseline Sequential with Huffman Coding (Process 1)	1.2.840.10008.1.2.4.50
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3.1	Explicit VR Little Endian Uncompressed	1.2.840.10008.1.2.1
		RLE Lossless Image Compression	1.2.840.10008.1.2.5
		JPEG Lossy, Baseline Sequential with Huffman Coding (Process 1)	1.2.840.10008.1.2.4.50

B.3.1.1 Ultrasound Single and Multi-Frame Pixel Formats Supported

The APL-US application profile requires that all ultrasound image objects only be stored using the values described in PS 3.3 US Image Module Section C.8.5.3.1.2 and Tables C.8.5.3.1.12 to Table C.8.5.3.1.16 which describe the specializations used for the Ultrasound Single and Multi-Frame IODs.

In the role of FS-Updater or FS-Creator the application can choose any of the supported Photometric Interpretations described in PS 3.3 US Image Module Section C.8.5.3.1.2, to create an IOD. In the role of FS-Reader an application shall support all Photometric Interpretations described in PS 3.3 US Image Module Section C.8.5.3.1.2.

Table B.3.1.1 describes restrictions on the use of various Transfer Syntaxes with the supported Photometric Interpretations for both single and multi-frame images.

Table B.3.1.1 Defined Photometric Interpretation and Transfer Syntax Pairs

Photometric Interpretation Value	Transfer Syntax	Transfer Syntax UID
MONOCHROME2	Uncompressed RLE Lossless Image Compression	1.2.840.10008.1.2.1 1.2.840.10008.1.2.5
RGB	Uncompressed RLE Lossless Image Compression	1.2.840.10008.1.2.1 1.2.840.10008.1.2.5
PALETTE COLOR	Uncompressed RLE Lossless Image Compression	1.2.840.10008.1.2.1 1.2.840.10008.1.2.5
YBR_FULL	RLE Lossless Image Compression	1.2.840.10008.1.2.5
YBR_FULL_422	Uncompressed JPEG Lossy	1.2.840.10008.1.2.1 1.2.840.10008.1.2.4.50
YBR_PARTIAL_422	Uncompressed JPEG Lossy	1.2.840.10008.1.2.1 1.2.840.10008.1.2.4.50

B.3.2 Physical Media And Media Formats

An ultrasound application profile class may be supported by any one of the media described in Table B.3.2.

Table B.3.2 Media Classes

Media	Media Class	Media Format	PS 3.12
1.44MB 3.5" Floppy Disc	FLOP	DOS	Annex B
128MB 3.5" MOD	MOD128	DOS, unpartitioned (removable media)	Annex C
650MB 5.25" MOD	MOD650	DOS, unpartitioned (removable media)	Annex D
1.2GB 5.25" MOD	MOD12	DOS, unpartitioned (removable media)	Annex E
CD-R	CDR	ISO/IEC 9660	Annex F

B.3.3 DICOMDIR

The Directory shall include Directory Records of PATIENT, STUDY, SERIES, IMAGE corresponding to the information object files in the File Set. All DICOM files in the File Set incorporating SOP Instances (Information Objects) defined for the specific Application Profile shall be referenced by Directory Records. At the image level each file contains a single ultrasound image object or a single ultrasound multi-frame image object as defined in PS 3.3 of the standard.

Note: For all media selected in this Application Profile Class, APL-US, the following applies as defined in PS 3.12.

All implementations should include the DICOM Media Storage Directory in the DICOMDIR file. There should only be one DICOMDIR file on a single media. The DICOMDIR file should be found in the root directory of the media. For the case of double-sided MOD media, there shall be a DICOMDIR on each side of the media.

On a single media the patient ID key at the patient level shall be unique for each patient directory record.

B.3.3.1 Additional Keys

File Set Creators and Updaters are only required to generate mandatory elements specified in PS 3.10, Annex B of the standard. At each directory record level any additional data elements can be added as keys, but is not required by File Set Readers to be able to use them as keys.

B.3.3.2 File Component IDs

Note: File Component IDs should be created using a random number filename to minimize File Component ID collisions as described in section 6.2 of PS 3.12. The FS-Updater should check the existence of a Component ID prior to creating that ID. Should a ID collision occur the FS-Updater should try another ID.

B.4 Spatial Calibration (SC) Class Requirements

All implementations conforming to the Application Profile Class SC shall include the US Region Calibration Module with the exception of pixel component organization data element (0018,6044) and other data elements which are conditional on that data element.

B.5 Combined Calibration (CC) Class Requirements

All implementations conforming to the Application Profile Class CC shall include the US Region Calibration Module including the pixel component organization data element (0018,6044) and other data elements which are conditional on that data element.

Index of Attribute Tags

(0008,0100), 21, 22, 23, 24, 25, 26
(0008,0102), 21, 22, 23, 24, 25, 26
(0008,0104), 21, 22, 23, 24
(0008,2200), 26, 46
(0008,2204), 26, 46
(0008,2208), 25, 46
(0008,2218), 21, 24, 25, 46
(0008,2220), 21, 24, 25, 46
(0008,2228), 22, 25, 46
(0008,2230), 22, 25, 46
(0008,2240), 22, 26, 46
(0008,2242), 23, 26, 46
(0008,2244), 23, 26, 46
(0008,2246), 23, 26, 46
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(0018, 6044), 11
(0018, 6048), 11
(0018, 604C), 10, 11
(0018, 6050), 10
(0018, 6052), 10
(0018, 6054), 10
(0018,0015), 25
(0018,1244), 16, 45
(0018,5100), 25
(0018,6044), 7, 9, 55
(0018,604C), 10
(0018,6050), 7
(0018,6052), 7
(0018,6054), 7
(0018,6056), 8, 9, 10, 45
(0018,6058), 8, 10, 45
(0018,605A), 8, 10, 45
(0028,00014), 15
(0028,0002), 18, 19, 20
(0028,0004), 4, 6, 13, 28, 37, 42
(0028,0006), 18, 20
(0028,0014), 45
(0028,0100), 18, 19
(0028,0101), 18, 19, 37
(0028,0102), 18, 20
(0028,1101), 27
(0028,1101-1103), 28, 31
(0028,1102), 27
(0028,1103), 27
(0028,1199), 27, 45
(0028,1201), 27, 42, 43, 45
(0028,1201-1203), 31
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(0028,1203), 28, 42, 43, 45
(0028,1221), 28, 42, 43, 45
(0028,1221-1223), 28, 31
(0028,1222), 28, 42, 43, 45
(0028,1223), 28, 42, 43, 45
(0028,2110), 14
(60xx,0045), 17, 46
(7FE0,0010), 40
(FFFE,E000), 40

(FFFE,E0DD), 40