Title: caBIG Algorithm Validation Toolkit DICOM Conformance Statement

Revision Data

Rev	Change Description	Printed Name
10	Initial release	Babu Samuel

History

Document History

Version/ Status	Date of Issue	Author	Description
R0.1	Aug 20, 2010	Babu Samuel	Initial Draft
R1.0	Aug 23, 2010	Babu Samuel	Release Draft

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1. Introduction

This DICOM conformance statement specifies the behavior and functionality of the caBIG Algorithm Validation Toolkit (AVT). This software provides the following capabilities.

- Reads and displays uncompressed monochrome DICOM images.
- Reads and writes DICOM Segmentation Object [2].

1.1 Purpose

This document is written for the people that need to understand how AVT will integrate into their healthcare facility, but especially to understand what kinds of DICOM studies are currently understood by AVT. This includes both those responsible for overall imaging network policy and architecture, as well as integrators who need to have a detailed understanding of the DICOM features of the product. This document contains some basic DICOM definitions so that any reader may understand how this product implements DICOM features. However, integrators are expected to fully understand all the DICOM terminology, how the tables in this document relate to the product's functionality and how that functionality integrates with other devices that support compatible DICOM features.

1.2 Scope and Field

The scope of this DICOM Conformance Statement is to facilitate integration between caBIG Algorithm Validation Toolkit and other DICOM products. The Conformance Statement should be read and understood in conjunction with the DICOM Standard. DICOM by itself does not guarantee interoperability. The Conformance Statement does, however, facilitate a first-level comparison for interoperability between different applications supporting compatible DICOM functionality.

1.3 Terms and Definitions

Informal definitions are provided for the following terms used in this Conformance Statement. The DICOM Standard is the authoritative source for formal definitions of these terms.

Abstract Syntax – generally equivalent to an *Information Object Definition* (IOD), the specification used to define the information to exchange in a message; does not represent a specific instance of the data object, but rather a class of similar data objects that have the same

properties. Examples: CT image object definition, MR image object definition, image query information model.

Application Entity (AE) – an end point of a DICOM information exchange, including the DICOM network or media interface software; i.e., the software that sends or receives DICOM information objects or messages. A single device may have multiple Application Entities.

Application Entity Title – the externally known name of an *Application Entity*, used to identify a DICOM application to other DICOM applications on the network.

Application Context – the specification of the type of communication used between *Application Entities*. Example: DICOM network protocol.

Association – a network communication channel set up between Application Entities.

Attribute – smallest unit of information in an object definition; a data element identified by a tag. Examples: PatientID (0010, 0020), Accession Number (0008, 0050), Photometric Interpretation (0028, 0004)

Information Object Definition (IOD) – the specified set of *Attributes* that comprise a type of data object (see *Abstract Syntax*). The *Attributes* may be specified as Mandatory (Type 1), Required but possibly unknown (Type 2), or Optional (Type 3), and there may be conditions associated with the use of an Attribute (Types 1C and 2C).

1.4   Abbreviations

Abbreviations used in this document are defined within the different parts of the DICOM standard.

Additional Abbreviations and terms are as follows:

ASCII	American Standard Code for Information Interchange
AVT	Algorithm Validation Toolkit
caBIG	cancer Biomedical Informatics Grid
CT	Computed Tomography
DICOM	Digital Imaging and Communication in Medicine
IE	Information Entity
MR	Magnetic Resonance

RIS   Radiology Information System

1.5 References

[1]   [DICOM] Digital Imaging and Communications in Medicine, NEMA PS 3.1-3.15, 2001

[2]   [DICOM] Digital Imaging and Communications in Medicine, Supplement 111:Segmentation Storage SOP Class, VERSION: Final Text-August 22, 2006

2. Implementation Model

2.1   Application Data Flow Diagram
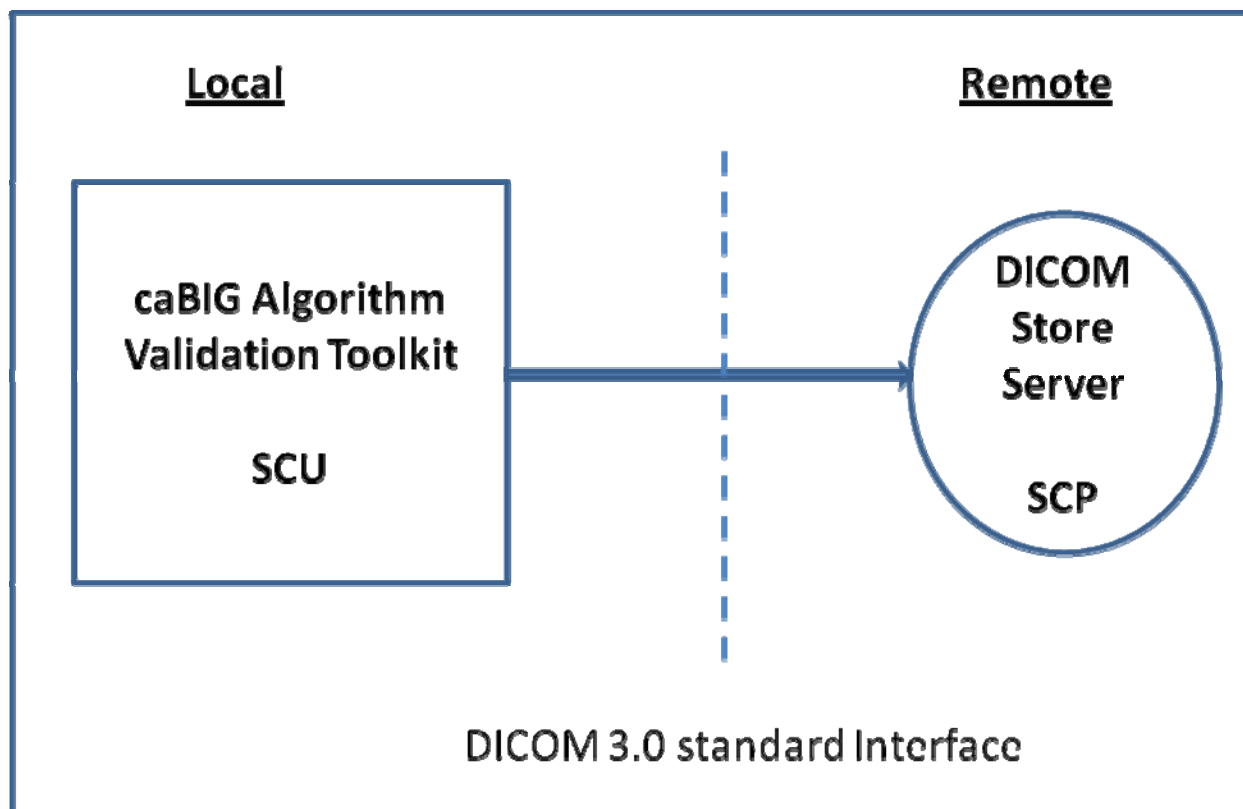
Figure 1: Implementation Model

2.2   Functional Definition

The caBIG Algorithm Validation Toolkit is a DICOM client: the supported service classes consist of SCU implementation. The caBIG Algorithm Validation Toolkit utilizes a single AE for communicating with all remote DICOM servers.

3. AE Specifications

The caBIG Algorithm Validation Toolkit provides standard conformance to the following DICOM V3.0 SOP Classes as a SCU:

Table 1: Supported SOP Classes

SOP Class Name	SOP Class UID
CT Image Storage	1.2.840.10008.5.1.4.1.1.2
MR Image Storage	1.2.840.10008.5.1.4.1.1.4

3.1   Image Storage

3.1.1   Presentation Context

Table 2: Proposed Presentation Context for Image Storage

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
CT Image Storage	1.2.840.10008.5.1.4.1.1.2	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	NONE
		Explicit VR Little Endian	1.2.840.10008.1.2.1		
MR Image Storage	1.2.840.10008.5.1.4.1.1.4	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	NONE
		Explicit VR Little Endian	1.2.840.10008.1.2.1		

4. Information Object Definitions (IOD)

4.1   CT Image IOD Description

The CT Image Information Object Definition (IOD) specifies an image that has been created by a computed tomography imaging device.

Table 3: CT Image IOD Modules

IE	Module	Usage	Reference
Patient	Patient	M	Table 5
Study	General Study	M	Table 6
	Patient Study	U	Table 7
Series	General Series	M	Table 8
Frame of Reference	Frame of Reference	M	
Equipment	General Equipment	M	Table 9
Image	General Image	M	Table 10
	Image Plane	M	Table 11
	Image Pixel	M	Table 12
	Contrast/bolus	C – Required if contrast media was used in this image	Table 13
	CT Image	M	Table 14
	Modality LUT	U	Table 16
	SOP Common	M	Table 17

4.2   MR Image IOD Description

The MR Image Information Object Definition (IOD) specifies an image that has been created by a magnetic resonance imaging device.

Table 4: MR Image IOD Modules

IE	Module	Usage	Reference
Patient	Patient	M	Table 5
Study	General Study	M	Table 6
	Patient Study	U	Table 7
Series	General Series	M	Table 8
Frame of Reference	Frame of Reference	M	
Equipment	General Equipment	M	Table 9
Image	General Image	M	Table 10
	Image Plane	M	Table 11
	Image Pixel	M	Table 12
	Contrast/bolus	C – Required if contrast media was used in this image	Table 13
	MR Image	M	Table 15
	Modality LUT	U	Table 16
	SOP Common	M	Table 17

5. Information Module Definitions

5.1 Patient IE Module

5.1.1 Patient Module

Table 5 specifies the Attributes of the Patient that describe and identify the Patient who is the subject of a diagnostic Study. This Module contains Attributes of the patient that are needed for diagnostic interpretation of the Image and are common for all studies performed on the patient.

Table 5: Patient Module Attributes

Attribute Name	Tag	Type	Attribute Description
Patient's Name	(0010, 0010)	2	Patient's full name.
Patient ID	(0010, 0020)	2	Primary hospital identification number or code for the patient.
Patient's Birth Date	(0010, 0030)	2	Birth date of the patient.
Patient's Sex	(0010, 0040)	2	Sex of the named patient.

5.2 Study IE Module

5.2.1 General Study Module

Table 6 specifies the Attributes that describe and identify the Study performed upon the Patient.

Table 6: General Study Module Attributes

Attribute Name	Tag	Type	Attribute Description
Study Instance UID	(0020, 000D)	1	Unique identifier for the Study.
Study Date	(0008, 0020)	2	Date the Study started.
Study Time	(0008, 0030)	2	Time the Study started.
Referring Physician's Name	(0008, 0090)	2	Name of the patient's referring physician.
Study ID	(0020, 0010)	2	User or equipment generated Study identifier.
Accession Number	(0008, 0050)	2	A RIS generated number, which identifies the order for the study.
Study Description	(0008, 1030)	3	Institution-generated description or classification of the Study

			performed.

5.2.2 Patient Study Module

Table 7 defines Attributes that provide information about the Patient at the time the Study was performed.

Table 7: Patient Study Module Attributes

Attribute Name	Tag	Type	Attribute Description
Additional Patient History	(0010, 21B0)	3	Additional information about the Patient's medical history.

5.3 Series IE Module

5.3.1 General Series Module

Table 8 specifies the Attributes that identify and describe general information about the Series within a Study.

Table 8: General Series Module Attributes

Attribute Name	Tag	Type	Attribute Description
Modality	(0008, 0060)	1	Type of equipment that originally acquired the data used to create the images in this Series.
Series Instance UID	(0020, 000E)	1	Unique identifier of the Series.
Series Number	(0020, 0011)	2	A number that identifies this Series.
Laterality	(0020, 0060)	2C	Whether right or left of body part is to be examined. Necessary when part to be examined is pair-structured. Enumerated values: R = Right L = Left
Series Date	(0008, 0021)	3	Date the Series started.
Series Time	(0008, 0031)	3	Time the series started.
Series Description	(0008, 103E)	3	User provided description of the Series.
Body Part Examined	(0018, 0015)	3	Text description of the part of the body examined

Patient Position	(0018, 5100)	2C	Patient position descriptor relative to the equipment. Required for CT and MR images.

5.4 Equipment IE Module

5.4.1 General Equipment Module

Table 9 specifies the Attributes that identify and describe the piece of equipment that produced a Series of Composite Instances.

Table 9: General Equipment Module Attributes

Attribute Name	Tag	Type	Attribute Description
Manufacturer	(0008, 0070)	2	Manufacturer of the equipment that produced the composite instances.
Institution Name	(0008, 0080)	3	Institution where the equipment that produced the composite instances is located.
Station Name	(0008, 1010)	3	User defined name identifying the machine that produced the composite instances.
Institutional Department Name	(0008, 1040)	3	Department in the institution where the equipment that produced the composite instances is located.
Manufacturer's Model Name	(0008, 1090)	3	Manufacturer's model name of the equipment that produced the composite instances.
Device Serial Number	(0018, 1000)	3	Manufacturer's serial number of the equipment that produced the composite instances.
Software Versions	(0018, 1020)	3	Manufacturer's designation of software version of the equipment that produced the composite instances.

5.5 Common Image IE Module

5.5.1 General Image Module

Table 10 specifies the Attributes that identify and describe an image within a particular series.

Table 10: General Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Instance Number	(0020, 0013)	2	A number that identifies this image.
Patient Orientation	(0020, 0020)	2C	Patient direction of the rows and columns of the image.
Content Date	(0008, 0023)	2C	The date the image pixel data creation started.
Content Time	(0008, 0033)	2C	The time the image pixel data creation started.
Image Type	(0008, 0008)	3	Image identification characteristics.
Acquisition Number	(0020, 0012)	3	A number identifying the single continuous gathering of data over a period of time that resulted in this image.
Acquisition Date	(0008, 0022)	3	The date the acquisition of data that resulted in this image started.
Acquisition Time	(0008, 0032)	3	The time the acquisition of data that resulted in this image started.
Acquisition Date Time	(0008, 002A)	3	The date and time that the acquisition of data that resulted in this image started.
Derivation Description	(0008, 2111)	3	A text description of how this image was derived.
Image Comments	(0020, 4000)	3	User-defined comments about the image.

5.5.2 Image Plane Module

Table 11 specifies the Attributes that define the transmitted pixel array of a two dimensional image plane.

Table 11: Image Plane Module Attributes

Attribute Name	Tag	Type	Attribute Description
Pixel Spacing	(0028, 0030)	1	Physical distance in the patient between the center of each pixel, specified by a numeric pair – adjacent row spacing (delimiter) adjacent column spacing in mm.
Image Orientation (Patient)	(0020, 0037)	1	The direction cosines of the first row and the first column with respect to the patient.
Image Position (Patient)	(0020, 0032)	1	The x, y and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the image, in mm.
Slice Thickness	(0018, 0050)	2	Nominal slice thickness, in mm.
Slice Location	(0020, 1041)	3	Relative position of the image plane.

5.5.3 Image Pixel Module

Table 12 describes the Image Pixel Module.

Table 12: Image Pixel Module Attributes

Attribute Name	Tag	Type	Attribute Description
Samples per Pixel	(0028, 0002)	1	Number of samples (planes) in this image.
Photometric Interpretation	(0028, 0004)	1	Specifies the intended interpretation of the pixel data.
Rows	(0028, 0010)	1	Number of rows in the image.
Columns	(0028, 0011)	1	Number of columns in the image.
Bits Allocated	(0028, 0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated.
Bits Stored	(0028, 0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored.
High Bit	(0028, 0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit.
Pixel Representation	(0028, 0103)	1	Data representation of the pixel

Attribute Name	Tag	Type	Attribute Description
			samples. Each sample shall have the same pixel representation.
Pixel Data	(7FE0, 0010)	1C	A data stream of the pixel samples that comprise the Image. Required if Pixel Data Provider URL (0028, 7FE0) is not present.
Planar Configuration	(0028, 0006)	1C	Indicates whether the pixel data are sent color-by-plane or color-by-pixel. Required if Samples per Pixel (0028, 0002) has a value greater than 1.
Pixel Aspect Ratio	(0028, 0034)	1C	Ratio of the vertical size and horizontal size of the pixels in the image specified by a pair of integer values where the first value is the vertical pixel size, and the second value is the horizontal pixel size.

5.5.4   Contrast/Bolus Module

Table 13 specifies the Attributes that describe the contrast/bolus used in the acquisition of the image.

Table 13: Contrast/Bolus Module Attributes

Attribute Name	Tag	Type	Attribute Description
Contrast/Bolus Agent	(0018, 0010)	2	Contrast or bolus agent.

5.5.5   Modality Specific Modules

5.5.5.1   CT Image Module

The Table 14 contains IOD Attributes that describe CT images.

Table 14: CT Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008, 0008)	1	Image identification characteristics.
Samples per Pixel	(0028, 0002)	1	Number of samples (planes) in

				this image.
Photometric Interpretation	(0028, 0004)	1		Specifies the intended interpretation of the pixel data.
Bits Allocated	(0028, 0100)	1		Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated.
Bits Stored	(0028, 0101)	1		Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored.
High Bit	(0028, 0102)	1		Most significant bit for pixel sample data. Each sample shall have the same high bit.
Rescale Intercept	(0028, 1052)	1		The value b in relationship between stored values (SV) and the output units specified in Rescale Type (0028, 1054). Output units = m*SV + b
Rescale Slope	(0028, 1053)	1		m in the equation specified by Rescale Intercept (0028, 1052).
Acquisition Number	(0020, 0012)	2		A number identifying the single continuous gathering of data over a period of time that resulted in this image.
Scan Options	(0018, 0022)	3		Parameters of scanning sequence.
Data Collection Diameter	(0018, 0090)	3		The diameter in mm of the region over which data were collected.
Data Collection Center (Patient)	(0018, 9313)	3		The x, y, and z coordinates (in the patient coordinate system) in mm of the center of the region in which data were collected.
Reconstruction Diameter	(0018, 1100)	3		Diameter in mm of the region form within which data were used in creating the reconstruction of the image. Data may exist outside this region and portions of the patient may exist outside this region.
Reconstruction Target Center (Patient)	(0018, 9318)	3		The x, y and z coordinates (in the patient coordinate system) of the reconstruction center

Attribute Name	Tag	Type	Attribute Description
			target point as used for reconstruction in mm.
Distance Source to Detector	(0018, 1110)	3	Distance in mm from source to detector center.
Distance Source to Patient	(0018, 1111)	3	Distance in mm from source to isocenter (center of field of view)
Gantry/Detector Tilt	(0018, 1120)	3	Nominal angle of tilt in degrees of the scanning gantry. Not intended for mathematical computations.
Table Height	(0018, 1130)	3	The distance in mm of the top of the patient table to the center of rotation; below the center is positive.
Rotation Direction	(0018, 1140)	3	Direction of rotation of the source when relevant, about nearest principal axis of equipment.
Exposure Time	(0018, 1150)	3	Time of x-ray exposure in msec.

5.5.5.2 MR Image Module

The Table 15 contains IOD Attributes that describe MR images.

Table 15: MR Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008, 0008)	1	Image identification characteristics.
Samples per Pixel	(0028, 0002)	1	Number of samples (planes) in this image.
Photometric Interpretation	(0028, 0004)	1	Specifies the intended interpretation of the pixel data.
Bits Allocated	(0028, 0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated.
Scanning Sequence	(0018, 0020)	1	Description of the type of data taken. Enumerated Values: SE = Spin Echo IR = Inversion Recovery GR = Gradient Recalled EP = Echo Planar

				RM = Research Mode Note: Multi-valued, but not all combinations are valid (e.g. SE/GR, etc.).

Sequence Variant	(0018, 0021)		1	Variant of the Scanning Sequence.
				Defined Terms:
				  SK = segmented k-space
				  MTC = magnetization transfer Contrast
				  SS = steady state
				  TRSS = time reversed steady state
				  SP = spoiled
				  MP = MAG prepared
				  OSP = oversampling phase
				  NONE = no sequence variant

Scan Options	(0018, 0022)		2	Parameters of scanning sequence.
				Defined Terms:
				  PER = Phase Encode Reordering
				  RG = Respiratory Gating
				  CG = Cardiac Gating
				  PPG = Peripheral Pulse Gating
				  FC = Flow Compensation
				  PFF = Partial Fourier-Frequency
				  PFP = Partial Fourier-Phase
				  SP = Spatial Presaturation
				  FS = Fat Saturation

MR Acquisition Type	(0018, 0023)		2	Identification of data encoding scheme. Enumerated Values: 2D = frequency x phase 3D = frequency x phase x phase
Repetition Time	(0018, 0080)		2	The period of time in msec between the beginning of a pulse sequence and the beginning of the succeeding (essentially identical) pulse sequence. Required except when Scanning Sequence (0018,0020) is EP and Sequence Variant (0018,0021) is not SK.
Eco Time	(0018, 0081)		2	Time in ms between the middle of the excitation pulse and the

				peak of the echo produced (kx=0). In the case of segmented k-space, the TE(eff) is the time between the middle of the excitation pulse to the peak of the echo that is used to cover the center of k-space (i.e.-kx=0, ky=0).
Eco Train Length	(0018, 0091)	2		Number of lines in k-space acquired per excitation per image.
Inversion Time	(0018, 0082)	2C		Time in msec after the middle of inverting RF pulse to middle of excitation pulse to detect the amount of longitudinal magnetization. Required if Scanning Sequence (0018,0020) has values of IR.
Trigger Time	(0018, 1060)	2C		Time, in msec, between peak of the R wave and the peak of the echo produced. In the case of segmented k-space, the TE(eff) is the time between the peak of the echo that is used to cover the center of kspace. Required for Scan Options (0018,0022) which include heart gating (e.g. CG, PPG, etc.)
Sequence Name	(0018, 0024)	3		User defined name for the Scanning Sequence (0018, 0020) and Sequence Variant (0018, 0021) combination.
Angio Flag	(0018, 0025)	3		Angio Image Indicator. Primary image for Angio processing. Enumerated Values: Y = Image is Angio N = Image is not Angio
Number of Averages	(0018, 0083)	3		Number of times a given pulse sequence is repeated before any parameter is changed.
Imaging Frequency	(0018, 0084)	3		Precession frequency in MHz of the nucleus being addressed.
Imaged Nucleus	(0018, 0085)	3		Nucleus that is resonant at the imaging frequency.
Eco Number	(0018, 0086)	3		The echo number used in

			generating this image. In the case of segmented k-space, it is the effective Echo Number.
Magnetic Field Strength	(0018, 0087)	3	Nominal field strength of MR magnet, in Tesla
Spacing Between Slices	(0018, 0088)	3	Spacing between slices, in mm. The spacing is measured from the center-to-center of each slice.

5.5.6   Modality LUT Module

Table 16 specifies the Attributes that describe the Modality LUT.

Table 16: Modality LUT Module Attributes

Attribute Name	Tag	Type	Attribute Description
Rescale Intercept	(0028, 1052)	1C	The value b in relationship between stored values (SV) and the output units specified in Rescale Type (0028, 1054). Output units = m*SV + b
Rescale Slope	(0028, 1053)	1C	m in the equation specified by Rescale Intercept (0028, 1052).
Rescale Type	(0028, 1054)	1C	Specifies the output units of Rescale Slope (0028, 1053) and Rescale Intercept (0028, 1052).

5.5.7   General Module

5.5.7.1   SOP Common Module

Table 17 defines the Attributes which are required for proper functioning and identification of the associated SOP Instances. They do not specify any semantics about the Real-World Object represented by the IOD.

Table 17: SOP Common Module Attributes

Attribute Name	Tag	Type	Attribute Description
SOP Class UID	(0008, 0016)	1	Uniquely identifies the SOP Class.
SOP Instance UID	(0008, 0018)	1	Uniquely identifies the SOP Instance.

Specific Character Set	(0008, 0005)	1C	Character Set that expands or replaces the Basic Graphic Set. Required if an expanded or replacement character set is used.
Instance Creation Date	(0008, 0012)	3	Date the SOP Instance was created.
Instance Creation Time	(0008, 0013)	3	Time the SOP Instance was created.
Instance Creator UID	(0008, 0014)	3	Uniquely identifies device which created the SOP Instance.

6. Extensions/Specialization/Privatizations

N/A.