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Digital Imaging and Communications in Medicine (DICOM)

Supplement 236: Waveform Presentation State

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Scope and Field of Application

73 This supplement introduces Service Classes for storage and exchange of presentation information for
74 DICOM waveform objects by adding Waveform Presentation State IODs. The Waveform Presentation
75 State object stores the display montages, i.e. calculative combinations of recorded channels, display filter
76 settings, and other display properties as well as arbitrary Annotations.

77 This supplement

- 78 • adds a new Waveform Presentation State IE
- 79 • adds new SOP Classes to store Waveform Presentation States and the related Modules
- 80 • amends the Basic Directory IOD by adding Waveform Presentation as a new Directory Type

81

82 In clinical neurophysiology it is important to be able to recreate the presentation of the recorded data as it
83 was displayed during the recording or during review and reporting. This is important for example when
84 activity is noted by the operator during recording and that view needs to be recreated post-hoc for review
85 by a specialist.

86 In cardiology, technicians annotate previously recorded waveforms (e.g. from home monitoring Holter
87 ECG) and highlight areas of interest. This information is essential input for the cardiologist who reviews
88 the ECG and finally provides the report.

89 Waveform objects support limited display information, which has to be provided within the recorded
90 waveforms. These Attributes only cover color and scaling of waveform channels.

91 A **Waveform Presentation State object** provides textual annotations, segments of interest, montages
92 including filters, colors, gain, and display scale for a given recording (patient related).

93 In neurophysiology a **montage** defines a list of channels for visualization of the data which is created by a
94 list of original channel sources and the method for their mathematical (linear) recombination.

95 **Waveform annotations** are textual or coded markers assigned to a specific timepoint or time range, related
96 to all channels or a selected set of channels. Annotations could be observations as well as measurements.

97

98
99
100

**Changes to NEMA Standards Publications PS3.3
Digital Imaging and Communications in Medicine (DICOM)
Part 3: Information Object Definitions**

101

102 *Add a new Overview Table to PS3.3 Section A.1.4.:*

103

104 **Table A.1-14. Composite Information Object Modules Overview – Waveform Presentation States**

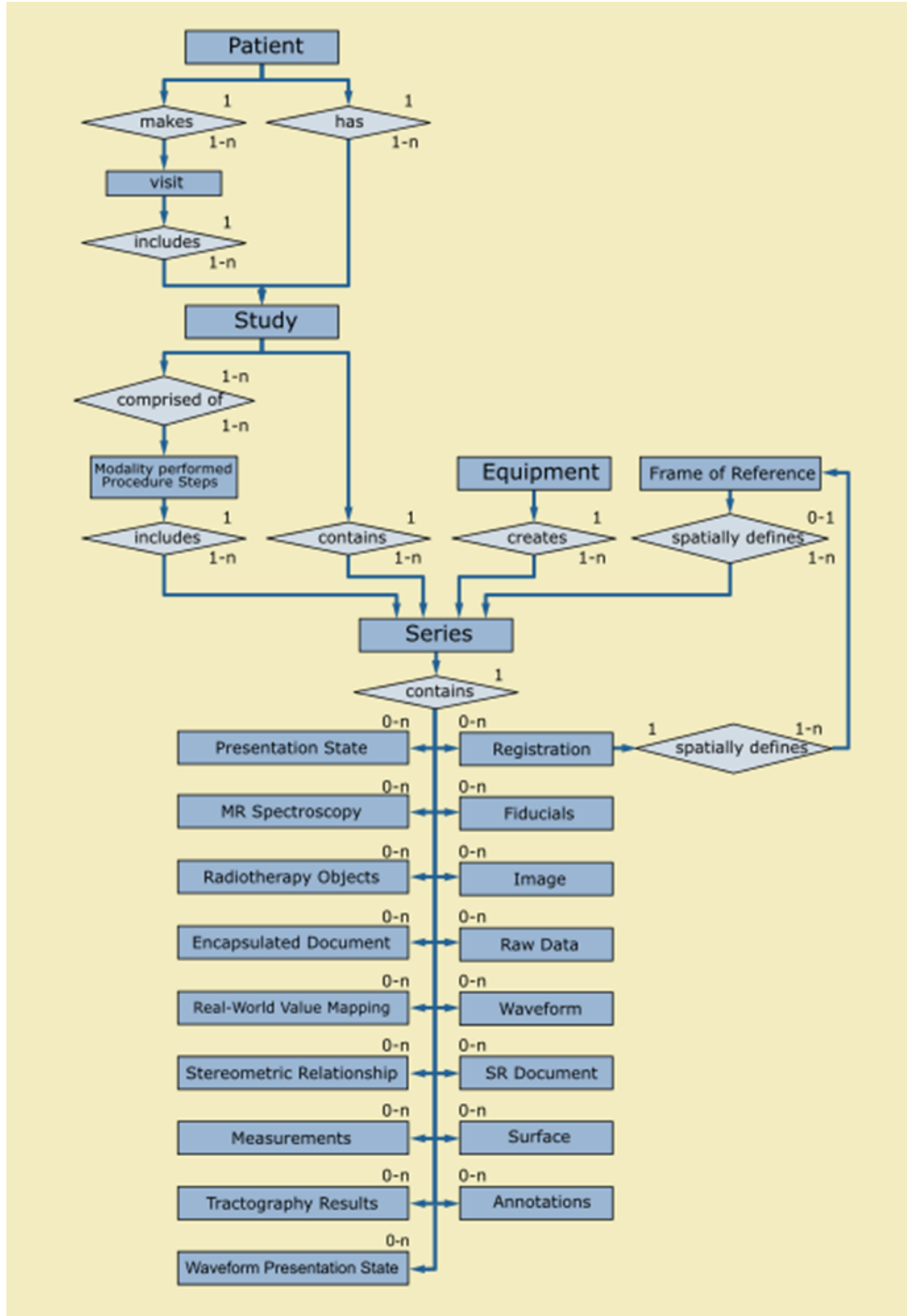
IODs Modules	Waveform Presentation State	Waveform Acquisition Presentation State
Patient	M	M
Clinical Trial Subject	U	U
General Study	M	M
Patient Study	U	U
Clinical Trial Study	U	U
General Series	M	M
Clinical Trial Series	U	U
Presentation Series	M	M
Synchronization	C	C
General Equipment	M	M
Enhanced General Equipment	M	M
Presentation State Identification	M	M
Waveform Presentation State Relationship	M	M
Structured Waveform Annotation	U	U
Textual Waveform Annotation	U	U
Displayed Waveform Segment	U	U
Montage Activation	U	M
Waveform Presentation Montage	C	M
SOP Common	M	M

105

106

107 *Amend PS3.3 Figure 7-1.a DICOM Model of the Real World by adding Waveform Presentation State IE*

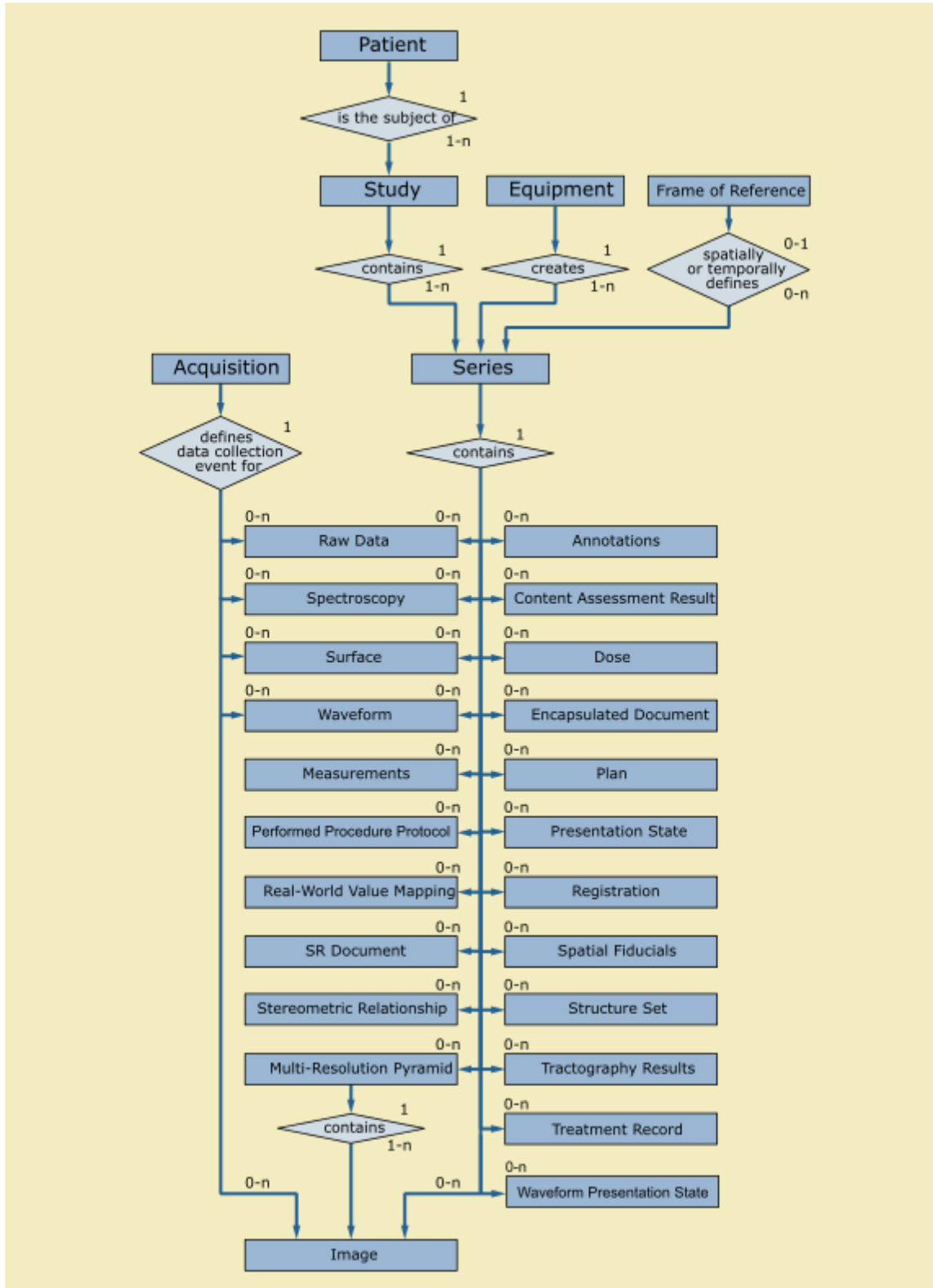
108



109

110

111 Amend PS3.3 Figure A.1-1 DICOM Composite Instance IOD Information Model by adding the Waveform
112 Presentation State IE



113

114

115 Add the following new content to PS3.3 Section A.1.2.

116 **A.1.2.3 Series IE**

117 ...

118 Presentation States shall be grouped into **one or more** Series without Images **or Waveforms** (i.e., in a different
119 Series from the Series containing the Images **or Waveforms** to which they refer).

120 ...

121 Note

122 **1.** The Series containing Grayscale, Color and Pseudo-Color Softcopy Presentation States and the Series
123 containing the Images to which they refer are both contained within the same Study, except for Blended
124 Presentation States, which may refer to images from different Studies.

125 **2. The Series containing the Waveform Presentation State and the Series containing the Waveforms to**
126 **which they refer are both contained within the same Study.**

127 **3. The Series containing the Waveform Presentation State and the Series containing Waveform**
128 **Annotation SRs to which they refer are both contained in the same Study but in different Series.**

129

130 Waveforms shall be grouped into Series without Images. A Frame of Reference IE may apply to both
131 Waveform Series and Image Series.

132 SR Documents shall be grouped into Series without Images.

133

134 **A.1.2.31 Waveform Presentation State IE**

135 The Waveform Presentation State IE defines how referenced waveforms will be presented.

136 The Waveform Presentation State IE comprises text annotations, segments of interest, and montages
137 including filters, colors, gain, and vertical sizes of waveform channels if this information is to be applied to
138 the referenced waveform(s). It might also contain display information for structured annotations related to
139 the referenced waveform(s).

140

141 *Add the following new content to PS3.3 Annex A*

142 **A.92 Waveform Presentation State Information Object Definitions**

143 **A.92.1 Waveform Presentation State IOD**

144 **A.92.1.1 Waveform Presentation State IOD Description**

145 The Waveform Presentation State Information Object Definition (IOD) specifies information that may be
146 used to present (display) waveforms that are referenced from within the IOD.

147 Note

148 The Waveform Presentation State object allows to store textual annotations, as well as to provide display
149 information for annotations stored in a separate SR document. The policies related to the criteria for
150 where specific annotations should be stored – in the Waveform Presentation State object or in the SR
151 document – are outside the scope of the Standard.

152 **A.92.1.2 Waveform Presentation State IOD Entity-Relationship Model**

153 This IOD uses the E-R Model in Section A.1.2, with only the Waveform Presentation State IE below the
154 Series IE.

155 **A.92.1.3 Waveform Presentation State IOD Module Table**

156 Table A.92.1-1 specifies the Modules of the Waveform Presentation State IOD.

157

Table A.92.1-1. Waveform Presentation State IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Frame of Reference	Synchronization	C.7.4.2	C – Required if time synchronization was applied.
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Waveform Presentation State	Presentation State Identification	C.11.10	M
	Waveform Presentation State Relationship	C.39.1	M
	Structured Waveform Annotation	C.39.2	U
	Textual Waveform Annotation	C.39.3	U
	Displayed Waveform Segment	C.39.4	U
	Montage Activation	C.39.5	U
	Waveform Presentation Montage	C.39.6	C – Required if Montage Activation Module is present.
	SOP Common	C.12.1	M

158

159

Note

160

All Attributes containing color information are defined to contain PCS values, so the ICC Profile Module is not used.

161

162

163 **A.92.2 Waveform Acquisition Presentation State IOD**

164 **A.92.2.1 Waveform Acquisition Presentation State IOD Description**

165 The Waveform Acquisition Presentation State Information Object Definition (IOD) provides information
 166 about the display settings such as filters and montages used during acquisition of the waveform. This
 167 allows presentation of the “recording view” later during review of the waveform.

168

Note

169

The Waveform Acquisition Presentation State object allows to store textual annotations, as well as to provide display information for annotations stored in a separate SR document. The policies related to the criteria for where specific annotations should be stored – in the Waveform Acquisition Presentation State object or in the SR document – are outside the scope of the Standard.

170

171

172

173

174 **A.92.2.2 Waveform Acquisition Presentation State IOD Entity-Relationship Model**175 This IOD uses the E-R Model in Section A.1.2, with only the Waveform Presentation State IE below the
176 Series IE.177 **A.92.2.3 Waveform Acquisition Presentation State IOD Module Table**

178 Table A.92.2-1 specifies the Modules of the Waveform Acquisition Presentation State IOD.

179 **Table A.92.2-1. Waveform Acquisition Presentation State IOD Modules**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Frame of Reference	Synchronization	C.7.4.2	C – Required if time synchronization was applied.
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Waveform Presentation State	Presentation State Identification	C.11.10	M
	Waveform Presentation State Relationship	C.39.1	M
	Structured Waveform Annotation	C.39.2	U
	Textual Waveform Annotation	C.39.3	U
	Displayed Waveform Segment	C.39.4	U
	Montage Activation	C.39.5	M
	Waveform Presentation Montage	C.39.6	M
	SOP Common	C.12.1	M

180

181 Note

182 All Attributes in this IOD containing color information are defined to contain PCS values, so the ICC Profile
183 Module is not used.

184

185 *Adapt Section PS3.3 Section C.10.10.1.1 by adding an additional note to indicate, that this Attribute is*
186 *also used in context of Waveform Presentation States.*

187 **C.10.10.1.1 Referenced Channels**

188

189

190 Note

191 **1.** As an example, an annotation that applies to the entire first multiplex group and channels 2 and 3 of the third
192 multiplex group would have Referenced Channels value 0001 0000 0003 0002 0003 0003.193 **2. This Attribute is also used in the context of Waveform Presentation States to express the relationship**
194 **of a presentation property to selected waveform channels.**

195

196 *Adapt Section PS3.3 Section C.11.9 by changing the note to reflect, that a PR could not only apply to*
197 *images.*

198 Note

199 This implies that presentation states will be in different Series from the **images instances** to which they apply,
200 which will have different values for Modality.

201

202 *Add the following new content to PS3.3 Section C.39*203 **C.39 Waveform Presentation State Modules**204 **C.39.1 Waveform Presentation State Relationship Module**205 Table C.39.1-1 specifies the Attributes of the Waveform Presentation State Relationship Module, which
206 describe the waveforms to which a Waveform Presentation State applies.

207

208 Note

209 This module only allows for referencing waveforms and SR documents from a single study. The Presentation
210 State itself will belong to the same study. Creating annotations that reference waveforms and SR
211 documents in a different study can be done by creating another Waveform Presentation State in that
212 other study.

213

214

Table C.39.1-1. Waveform Presentation State Relationship Module

Attribute Name	Tag	Type	Attribute Description
Referenced Series Sequence	(0008,1115)	1	Sequence of Items where each Item includes the Attributes of one Series to which the Waveform Presentation State applies. One or more Items shall be included in this Sequence.
>Series Instance UID	(0020,000E)	1	Unique identifier of a Series that is part of the Study defined by the Study Instance UID (0020,000D) in the enclosing data set. Note The Study Instance UID (0020,000D) value will be that of the Waveform Presentation State.
>Referenced Instance Sequence	(0008,114A)	1C	The set of SR documents containing waveform Annotations to which the Presentation State applies. These SR documents shall be of the Study defined by Study Instance UID (0020,000D) and

Attribute Name	Tag	Type	Attribute Description
			<p>the Series defined by Series Instance UID (0020,000E) in the enclosing Item.</p> <p>The referenced Instances shall be of SOP Class 1.2.840.10008.5.1.4.1.1.88.77 Waveform Annotation SR Storage.</p> <p>One or more Items shall be included in this Sequence.</p> <p>Required if Structured Waveform Annotation Sequence (0040,B030) is present.</p>
>> Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>>Referenced Waveform Sequence	(0008,113A)	1C	<p>The set of waveforms to which the Presentation State applies. These shall be of the Study defined by Study Instance UID (0020,000D) and the Series defined by Series Instance UID (0020,000E) in the enclosing Item.</p> <p>One or more Items shall be included in this Sequence.</p> <p>The referenced SOP Class shall be the same for all SOP Instances in a single Item of this Referenced Series Sequence (0008,1115) but may be different for different Items.</p> <p>Notes:</p> <ol style="list-style-type: none"> 1. For example, some Series might represent EEG and some Series might represent ECG. 2. The Waveform Presentation State applies to waveforms that are referenced in annotations in Structured Waveform Annotation Sequence (0040,B030), thus those waveforms also need to be included here. <p>Required if Referenced Instance Sequence (0008,114A) is not present.</p>
>>Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>>Referenced Waveform Channels	(0040,A0B0)	1C	<p>Identifies the waveform multiplex group (M) and channel (C) within the referenced waveform SOP Instance using pairs of values (M,C). See Section C.10.10.1.1.</p> <p>Required if the Referenced Waveform SOP Instance contains multiple channels and the reference does not apply to all channels of all multiplex groups.</p>

216

217 **C.39.2 Structured Waveform Annotation Module**

218 This Module defines how a display device applies waveform annotations that are stored in a separate SR
 219 document to a waveform.

220

Table C.39.2-1. Structured Waveform Annotation Module Attributes

Attribute Name	Tag	Type	Attribute Description
Structured Waveform Annotation Sequence	(0040,B030)	1	Selects and provides display information for waveform annotations and measurements contained in the referenced SR document. One or more Items shall be included in this Sequence.
>Include Table 10-11 "SOP Instance Reference Macro Attributes"			This references an SR document which contains the annotations. The Instance referenced here shall be contained in the Referenced Instance Sequence (0008,114A) in the Referenced Series Sequence (0008,1115).
>Waveform Annotation Display Selection Sequence	(0040,B031)	3	Selects subsets of annotations in the referenced SR document for display. If no subset is selected (i.e. this Attribute is missing or the Sequence is empty) all annotations in the referenced SR document shall be displayed. One or more Items are permitted in this Sequence.
>>Annotation Group Number	(0040,A180)	1	References an annotation group number (130872, DCM, "Waveform Annotation Group Number") defined within the referenced SR document to which the display information applies.
>>Referenced Montage Index	(0040,B032)	3	The recommended viewing montage identified by the Montage Index (0040,B03D) in the Waveform Montage Sequence (0040,B039).
>>Text Color CIELab Value	(0070,0241)	3	A default color triplet value used to specify the text color in which it is recommended that the text be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1.

221

222 **C.39.3. Textual Waveform Annotation Module**

223 This Module defines Attributes of textual annotations that shall be made available by a display device to
 224 be applied to a waveform. The text is defined in position relative to the waveform time information.

225 A textual waveform Annotation shall be related to a waveform.

226

Table C.39.3-1. Textual Waveform Annotation Module Attributes

Attribute Name	Tag	Type	Attribute Description
Waveform Textual Annotation Sequence	(0040,B033)	1	Selects and provides textual annotations for a group of waveforms or channels within these waveforms. One or more Items shall be included in this Sequence.
>Annotation DateTime	(0040,B034)	3	The date and time the annotation was added.
>Referenced Waveform Sequence	(0008,113A)	1C	The waveform to which this annotation applies. One or more Items shall be included in this Sequence. Required if the annotation in this Item does not apply to all the waveforms and channels contained in Referenced Waveform Sequence (0008,113A) in the Referenced Series Sequence (0008,1115).
>>Include Table 10-11 "SOP Instance Reference Macro Attributes"			This references waveforms to which the annotation applies. The Instances referenced here shall be contained in the Referenced Waveform Sequence (0008,113A) in the Referenced Series Sequence (0008,1115).
>>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group (M) and channels (C) within the referenced SOP Instance using pairs of values (M,C). See Section C.10.10.1.1.
>Include Table C.39.8-1 "Temporal Range Macro Attributes"			Enumerated Values for Temporal Range Type (0040,A130): POINT MULTIPOINT
>Referenced Montage Index	(0040,B032)	3	The recommended viewing montage identified by the Montage Index (0040,B03D) in the Waveform Montage Sequence (0040,B039).
>Text Object Sequence	(0070,0003)	1	Describes a text annotation. A single Item shall be included in this Sequence.
>>Unformatted Text Value	(0070,0006)	1	The text to be displayed.
>>Text Color CIE Lab Value	(0070,0241)	3	A default color triplet value used to

Attribute Name	Tag	Type	Attribute Description
			specify the text color in which it is recommended that the text be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIE Lab. See Section C.10.7.1.1.

227

228 **C.39.4 Displayed Waveform Segment Module**

229 This Module defines Attributes required to define waveform segments and the properties how to display
 230 them. A waveform segment is a temporal portion of a waveform (“segment of interest”).

231 **Table C.39.4-1. Displayed Waveform Segment Module Attributes**

Attribute Name	Tag	Type	Attribute Description
Displayed Waveform Segment Sequence	(0040,B035)	1	Selects and provides display parameters for segments from a group of waveforms or channels within these waveforms. One or more Items shall be included in this Sequence.
>Segment Definition DateTime	(0040,B036)	3	The date and time the segment was defined.
>Referenced Waveform Sequence	(0008,113A)	1C	The waveforms to which the segment display parameters in this Item apply. One or more Items shall be included in this Sequence. Required if the segment display parameters in this Item do not apply to all the waveforms and channels contained in Referenced Waveform Sequence (0008,113A) in the Referenced Series Sequence (0008,1115).
>>Include Table 10-11 “SOP Instance Reference Macro Attributes”			This references waveforms to which the segment display parameters in this Item apply. The Instances referenced here shall be contained in the Referenced Waveform Sequence (0008,113A) in the Referenced Series Sequence (0008,1115).
>>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group (M) and channels (C) within the referenced SOP Instance using pairs of values (M,C). See Section C.10.10.1.1.

Attribute Name	Tag	Type	Attribute Description
>Include Table C.39.8-1 "Temporal Range Macro Attributes"			Enumerated Values for Temporal Range Type (0040,A130): SEGMENT MULTISEGMENT BEGIN END
>Waveform Display Background CIELab Value	(003A,0231)	1C	A color triplet value recommended for rendering the waveform display background on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1. Required if Channel Recommended Display CIELab Value (003A,0244) is not present. May be present otherwise.
>Channel Recommended Display CIELab Value	(003A,0244)	1C	A color triplet value recommended for rendering the channel on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1. Required if Waveform Display Background CIELab Value (003A,0231) is not present. May be present otherwise.

232

233 **C.39.5 Montage Activation Module**

234 This Module defines Attributes recording the timepoints of montage activation.

235

Table C.39.5-1. Montage Activation Module Attributes

Attribute Name	Tag	Type	Attribute Description
Montage Activation Sequence	(0040,B037)	1	Provides information about when a montage was activated. One or more Items shall be included in this Sequence. The Items shall be ordered by ascending Montage Activation Time Offset (0040,B038) value.
>Referenced Montage Index	(0040,B032)	1	The Montage Index (0040,B03D) of the montage in the Waveform Montage Sequence (0040,B039).
>Montage Activation Time Offset	(0040,B038)	1	Time offset in seconds relative to the beginning of the recording. The offset of the first Item shall be 0.

236

237 **C.39.6 Waveform Presentation Montage Module**

238 This Module contains Attributes describing presentation montages of waveform channels.

239 **Table C.39.6-1 Waveform Presentation Montage Module Attributes**

Attribute Name	Tag	Type	Description
Waveform Montage Sequence	(0040,B039)	1	Description of the waveform montage(s) in the Waveform Presentation State. One or more Items shall be included in this Sequence.
>Montage Name	(0040,B03B)	3	The name of the montage.
>Montage Index	(0040,B03D)	1	The index of the montage within this Sequence. The value shall start at 1 and increase monotonically by 1. This index will be used elsewhere to refer to this specific montage Sequence Item.
>Montage Channel Sequence	(0040,B03C)	1	The channel(s) that comprise this montage. One or more Items shall be included in this Sequence. The order of Items in this Sequence is significant.
<i>>>Include Table C.39.7-1 "Montage Channel Macro Attributes"</i>			
>Waveform Data Display Scale	(003A,0230)	3	The recommended time-based waveform data display scale in units of mm/s (see Section C.10.9.1.8). Note: This does not prevent applications to change this during display. The value might be used as an initial default setting.
>Waveform Display Background CIELab Value	(003A,0231)	3	A color triplet value recommended for rendering the waveform display background on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1.
>Waveform Presentation Group Sequence	(003A,0240)	3	Sequence of Items, each Item describing a Presentation Group of one or more waveform channels to be displayed together. Note A Presentation Group is conventionally denoted a "display page", and a waveform object may be rendered using several Presentation Groups under user display control. One or more Items are shall be included in this Sequence.
>>Presentation Group Number	(003A,0241)	1	A number that identifies the Presentation Group.
>>Channel Display Sequence	(003A,0242)	1	Sequence of Items, each Item describing a channel to be displayed in the Presentation

			Group. One or more Items shall be included in this Sequence.
>>>Referenced Montage Channel Number	(0040,B03A)	1	Number of the montage channel to be displayed in the Presentation Group. This is the ordinal number of the Item in the Montage Channel Sequence (0040,B03C).
>>>Channel Offset	(003A,0218)	3	The offset in seconds from the beginning of the montage channel waveform data to the first sample to be used for presentation. Value may be negative.
>>>Channel Recommended Display CIE Lab Value	(003A,0244)	1	A color triplet value recommended for rendering the channel on a color display. The units are specified in PCS-Values, and the value is encoded as CIE Lab. See Section C.10.7.1.1.
>>>Channel Position	(003A,0245)	1	Position of the channel within the Presentation Group display area (see Section C.10.9.1.9).
>>>Display Shading Flag	(003A,0246)	3	Specifies display area shading between the displayed waveform channel and another line. The nature of the shading (e.g., solid, or cross-hatching) is implementation dependent. Enumerated Values: NONE no shading BASELINE shading between the waveform and the channel display baseline (sample value 0 equivalent location) ABSOLUTE shading between the waveform and the channel real world actual value 0 (i.e., taking into account the Channel Baseline (003A,0213) value) DIFFERENCE shading between the waveform and a second waveform in the Presentation Group at the same channel position that also has Display Shading Flag (003A,0246) value DIFFERENCE.
>>>Fractional Channel Display Scale	(003A,0247)	1C	Fraction of the Presentation Group vertical display dimension assigned to the unit quantity (least significant bit) of the channel samples (see Section C.10.9.1.10). Required if Absolute Channel Display Scale (003A,0248) is not present, may be present otherwise.
>>>Absolute Channel Display Scale	(003A,0248)	1C	Nominal vertical display height in mm assigned to the unit quantity (least significant bit) of the channel samples (see Section C.10.9.1.10). Required if Fractional Channel Display Scale (003A,0247) is not present, may be present otherwise.

241

242 **C.39.7 Montage Channel Macro**

243 This Macro consists of Attributes describing a single channel of a waveform montage.

244

Table C.39.7-1. Montage Channel Macro Attributes

Attribute Name	Tag	Type	Description
Montage Channel Number	(0040,B03E)	1	The number of the montage channel.
Montage Channel Label	(0040,B03F)	3	Text label of the channel, which may be used for display purposes.
Montage Channel Source Code Sequence	(0040,B040)	1	A coded descriptor of the waveform channel source. This identifies a single channel in the recorded waveform in terms of the lead from which it is collected. Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			<i>DCID 3001 "ECG Leads"</i> <i>DCID 3004 "Arterial Pulse Waveform"</i> <i>DCID 3005 "Respiration Waveform"</i> <i>DCID 3030 "EEG Leads"</i> <i>DCID 3031 "Lead Location Near or in Muscle"</i> <i>DCID 3032 "Lead Location Near Peripheral Nerve"</i> <i>DCID 3033 "EOG Lead"</i> <i>DCID 3034 "Body Position Waveform"</i>
Source Waveform Sequence	(003A,020A)	1	A Sequence that provides reference to a waveform from which this channel was derived. One or more Items shall be included in this Sequence. If there are multiple Items in this Sequence, they shall share the same multiplex group identified by Multiplex Group UID (003A,0310).
>Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group (M) and channel (C) within the referenced SOP Instance using a pair of values (M,C). See Section C.10.10.1.1. Only a single channel shall be referenced.

Channel Derivation Description	(003A,020C)	3	Additional description of the channel derivation.
Contributing Channel Sources Sequence	(0040,B041)	2	A Sequence of Items each representing the source of a channel contributing to this montage. Zero or more Items shall be included in this Sequence.
>Channel Weight	(0040,B042)	1	The relative weight this channel contributes to the montage channel. The weights of all Items in this Sequence shall sum up to 1.
>Channel Source Sequence	(003A,0208)	1	A coded descriptor of the contributing waveform channel source. Only a single Item shall be included in this Sequence.
>>Include Table 8.8-1 "Code Sequence Macro Attributes"			<i>DCID 3001 "ECG Leads"</i> <i>DCID 3004 "Arterial Pulse Waveform"</i> <i>DCID 3005 "Respiration Waveform"</i> <i>DCID 3030 "EEG Leads"</i> <i>DCID 3031 "Lead Location Near or in Muscle"</i> <i>DCID 3032 "Lead Location Near Peripheral Nerve"</i> <i>DCID 3033 "EOG Lead"</i> <i>DCID 3034 "Body Position Waveform"</i>
>Source Waveform Sequence	(003A,020A)	1	Reference to waveforms from which this channel was derived. One or more Items shall be included in this Sequence. If there are multiple Items in this Sequence, they shall share the same multiplex group identified by Multiplex Group UID (003A,0310).
>>Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group (M) and channel (C) within the referenced SOP Instance using a pair of values (M,C). See Section C.10.10.1.1. Only a single channel shall be referenced here.
Channel Sensitivity	(003A,0210)	1C	Nominal numeric value of unit quantity of sample. See Section C.10.9.1.4.2. Required if samples represent defined (not arbitrary) units.
Channel Sensitivity Units Sequence	(003A,0211)	1C	A coded descriptor of the units of measure for the Channel Sensitivity (003A,0210). See Section C.10.9.1.4.2. Only a single Item shall be included in this

			Sequence. Required if Channel Sensitivity (003A,0210) is present.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			DCID 82 "Measurement Unit"
Channel Sensitivity Correction Factor	(003A,0212)	1C	Multiplier to be applied to encoded sample values to match units specified in Channel Sensitivity Units Sequence (003A,0211) (e.g., based on calibration data). See Section C.10.9.1.4.2. Required if Channel Sensitivity (003A,0210) is present.
Filter Low Frequency Characteristics Sequence	(003A,0318)	1C	The properties of low frequency (high-pass) filters applied to the waveform montage channel. Required if a high-pass filter is used. One or more Items shall be included in this Sequence.
>Include Table C.10.12-1 "Waveform Filter Characteristics Macro Attributes"			
Filter High Frequency Characteristics Sequence	(003A,0219)	1C	The properties of high frequency (low-pass) filters applied to the waveform montage channel. Required if a low-pass filter is used. One or more Items shall be included in this Sequence.
>Include Table C.10.12-1 "Waveform Filter Characteristics Macro Attributes"			
Notch Filter Characteristics Sequence	(003A,0321)	3	The properties of notch filters applied to the waveform montage channel. One or more Items are permitted in this Sequence.
>Include Table C.10.12-1 "Waveform Filter Characteristics Macro Attributes"			

245

246 **C.39.8 Temporal Range Macro**247 *Ed. Note: This Macro could also replace this set of Attributes in the Waveform Annotation Module C.10.10*

248 This macro contains Attributes that define one or more points in time or time ranges in waveforms or
 249 dedicated channels of those waveforms. The waveforms and channels are selected in the enclosing data
 250 set.

251

Table C.39.8-1. Temporal Range Macro Attributes

Attribute Name	Tag	Type	Description
----------------	-----	------	-------------

Temporal Range Type	(0040,A130)	1	See Section C.39.8.1 for Enumerated Values.
Referenced Sample Positions	(0040,A132)	1C	List of samples within a multiplex group specifying one or more temporal points. Position of first sample is 1. See Section C.39.8.2. Required if Referenced Time Offsets (0040,A138) and Referenced DateTime (0040,A13A) are not present.
Referenced Time Offsets	(0040,A138)	1C	List of time offsets by number of seconds after start defining one or more temporal points. Required if Referenced Sample Positions (0040,A132) and Referenced DateTime (0040,A13A) are not present.
Referenced DateTime	(0040,A13A)	1C	List of one or more temporal points by absolute datetime. Required if Referenced Sample Position (0040,A132) and Referenced Time Offsets (0040,A138) are not present.

252

253 **C.39.8.1 Temporal Range Type**

254 *Ed. Note: This is a rewording of existing C.10.10.1.2. In the current Standard this section only belongs to*
255 *the Waveform Annotation Module*

256 The Temporal Range Type (0040,A130) Attribute defines the type of temporal extent of ~~the annotated~~
257 ~~region-of-interest~~ **a selected region of waveform data**. A temporal point (or instant of time) may be
258 defined by a waveform sample offset (for a single waveform multiplex group only), time offset, or absolute
259 time.

260 **The value or the values shall be present either as Referenced Sample Positions (0040, A132), or as**
261 **Referenced Time Offsets (0040,A138), or as Referenced DateTimes (0040,A13A).**

262

263 Enumerated Values:

264 **POINT** a single temporal point; **a single value shall be present.**265 **MULTIPOINT** multiple temporal points; **multiple values shall be present.**266 **SEGMENT** a range between two **different** temporal points; **two values shall be present.**267 **MULTISEGMENT** multiple segments, each denoted by two temporal points. **An even number of values**
268 **shall be present, each pair representing one segment.**269 **BEGIN** range beginning at one temporal point, and extending beyond the end of the acquired data; **a**
270 **single value shall be present.**271 **END** a range beginning before the start of the acquired data, and extending to (and including) the
272 identified temporal point; **a single value shall be present.**

273

274

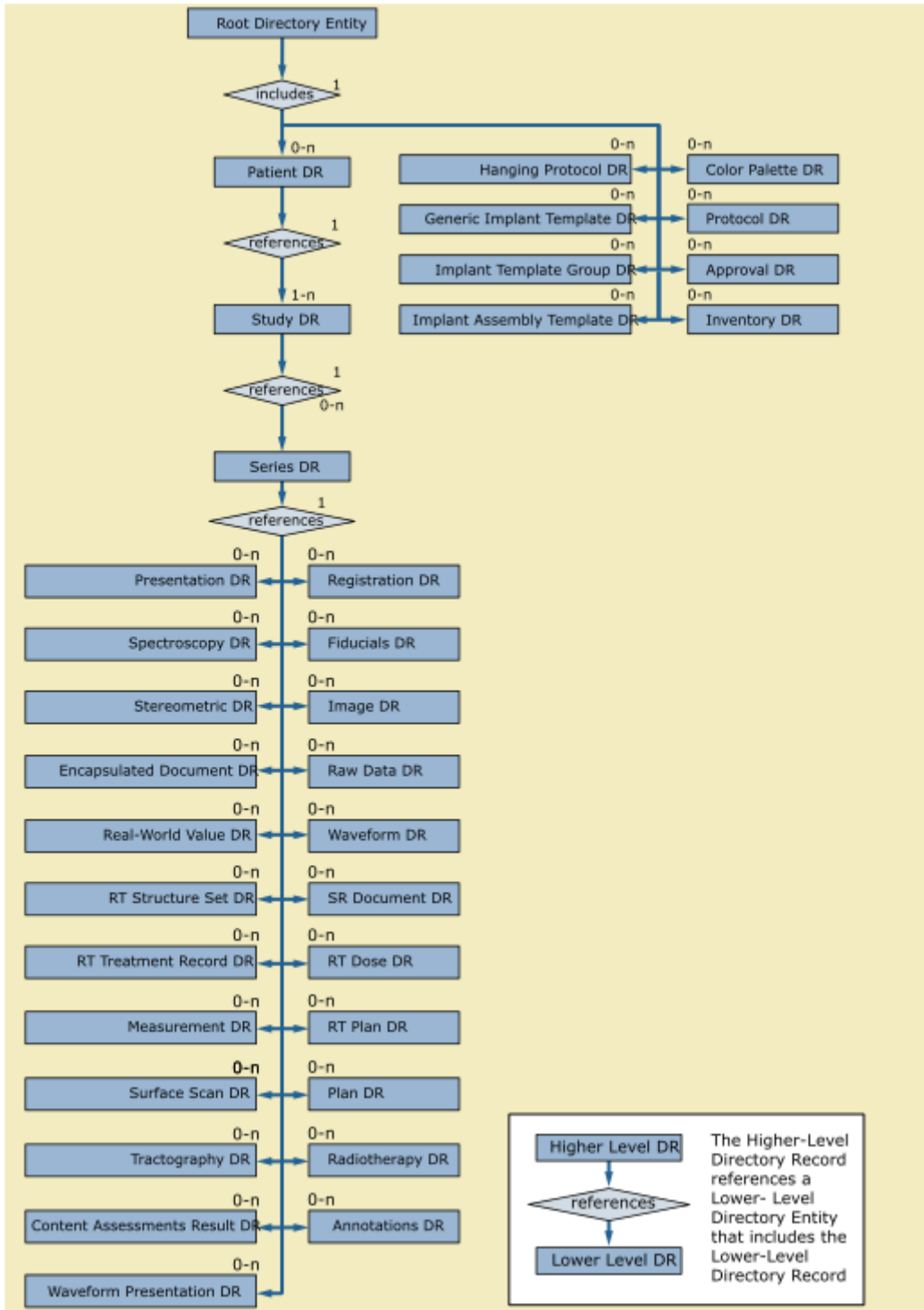
275 **C.39.8.2 Referenced Sample Position**

276 *Ed. Note: This is a rewording of existing C.10.10.1.3. In the current Standard this section only belongs to*
277 *the Waveform Annotation Module*

278 Referenced Sample Positions (0040,A132) may be used only if Referenced Waveform Channels
279 (0040,A0B0) **in the enclosing dataset** refers to channels within a single multiplex group. The sample
280 position is by channel, and applies to all channels specified in Referenced Channels (0040,A0B0) **in the**
281 **enclosing dataset.**

282

283 *Amend Figure F.4.1. Basic Directory IOD Information Model by adding a Waveform Presentation DR*



284

285

286

287 Add new Enumerated Value for the new Basic Directory Type to F.3-3 PS3 Section F.3

288

Table F.3-3. Directory Information Module Attributes

Key	Tag	Type	Attribute Description
-----	-----	------	-----------------------

Offset of the First Directory Record of the Root Directory Entity	(0004,1200)	1	Offset of the first byte ...
...			
>Directory Record Type	(0004,1430)	1	Defines as specialized type of Directory Record by reference to its position in the Media Storage Directory Information Model (see Section F.4). Enumerated Values: PATIENT STUDY ... <u>WF PRESENTATION</u> PRIVATE ...
>...			
>Include Record Selection Keys			A number of DICOM Data Elements that contain specific Keys defined for each type of Directory Record (0004,1430) defined in Section F.5.

289

290 Add new Enumerated Value for the new Basic Directory Type to Table F.4-1 Relationship Between
291 Directory Records

292

Table F.4-1. Relationship Between Directory Records

Directory Record Type	Section	Directory Record Types that may be included in the next lower-level directory Entity
...		
SERIES	F.5.3	IMAGE, RT DOSE, RT STRUCTURE SET, RT PLAN, RT TREAT RECORD, PRESENTATION, WAVEFORM, SR DOCUMENT, KEY OBJECT DOC, SPECTROSCOPY, RAW DATA, REGISTRATION, FIDUCIAL, ENCAP DOC, VALUE MAP, STEREOMETRIC, PLAN, MEASUREMENT, SURFACE, TRACT, ASSESSMENT, RADIOTHERAPY, ANNOTATION, <u>WF PRESENTATION</u> , PRIVATE
IMAGE	F.5.4	PRIVATE

...		
<u>WF PRESENTATION</u>	<u>F.5.49</u>	<u>PRIVATE</u>
PRIVATE	F.6.1	PRIVATE, (any of the above as privately defined)

293

294 *Add new Basic Directory Record PS3 Section F.5*

295 **F.5.49 Waveform Presentation State Directory Record Definition**

296 The Directory Record is based on the specification of Section F.3. It is identified by a Directory Record
 297 Type (0004,1430) of Value "WF PRESENTATION". Table F.5-49 lists the set of Keys with their
 298 associated Types for such a Directory Record Type. The description of these Keys may be found in the
 299 Modules related to the Waveform Presentation State IE of Waveform Presentation State IODs. This
 300 Directory Record shall be used to reference a Waveform Presentation State SOP Instance. This Type of
 301 Directory Record may reference a Lower-Level Directory Entity that includes one or more Directory
 302 Records as defined in Table F.4-1

303

304

Table F.5-49. Waveform Presentation Keys

Key	Tag	Type	Attribute Description
Specific Character Set	(0008,0005)	1C	Required if an extended or replacement character set is used in one of the Keys.
Presentation Creation Date	(0070,0082)	1	Date on which the waveform presentation was created. Note This date may be different from the date that the DICOM SOP Instance was created, since the presentation information contained may have been recorded earlier.
Presentation Creation Time	(0070, 0083)	1	Time at which this waveform presentation was created. Note: This time may be different from the time that the DICOM SOP Instance was created, since the presentation information contained may have been recorded earlier.
<i>Include Table 10-12 "Content Identification Macro Attributes"</i>			

Referenced Series Sequence	(0008,1115)	1C	<p>Sequence of Items where each Item includes the Attributes of one Series to which the Waveform Presentation State applies.</p> <p>One or more Items shall be included in this Sequence.</p> <p>Required if the IOD of the Waveform Presentation State SOP Instance referenced by this Directory Record includes the Waveform Presentation State Relationship Module.</p>
>Series Instance UID	(0020,000E)	1	<p>Unique identifier of a Series that is part of the Study defined by the Study Instance UID (0020,000D) in the enclosing data set.</p> <p>Note The Study Instance UID (0020,000D) value will be that of the Waveform Presentation State.</p>
>Referenced Instance Sequence	(0008,114A)	1C	<p>The set of SR documents containing waveform Annotations to which the Waveform Presentation State applies. These shall be of the Study defined by Study Instance UID (0020,000D) and the Series defined by Series Instance UID (0020,000E) in the enclosing Item.</p> <p>The referenced Instances shall be of SOP Class 1.2.840.10008.5.1.4.1.1.88.77 Waveform Annotation SR Storage.</p> <p>One or more Items shall be included in this Sequence.</p> <p>Required if Structured Waveform Annotation Sequence (0040,B030) is present.</p>
>> Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>Referenced Waveform Sequence	(0008,113A)	1C	<p>The set of waveforms to which the Waveform Presentation State applies. These shall be of the Study defined by Study Instance UID (0020,000D) and the Series defined by Series Instance UID (0020,000E) in the enclosing Item.</p> <p>One or more Items shall be included in this Sequence.</p> <p>The referenced SOP Class shall be the same for all SOP Instances in a single Item of this Referenced Series Sequence</p>

		(0008,1115) but may be different for different Items. Notes: 1. For example, some Series might represent EEG and some Series might represent ECG. 2. The Presentation State applies to waveforms that are referenced in annotations in Structured Waveform Annotation Sequence (0040,B030), thus those waveforms also need to be included here. Required if Referenced Instance Sequence (0008,114A) is not present.
>>Include Table 10-11 "SOP Instance Reference Macro Attributes"		
Any other Attribute of the Waveform Presentation State IE Modules	3	

305

Changes to NEMA Standards Publications PS 3.4

306

307

Digital Imaging and Communications in Medicine (DICOM)

308

309

Part 4: Service Class Specifications

310 *Add new SOP Class to PS3.4 Annex B tables*

311 B.5 Standard SOP classes

312 The SOP Classes in the Storage Service Class identify the Composite IODs to be stored. Table B.5-1
313 identifies Standard SOP Classes.

314 **Table B.5-1. Standard SOP Classes**

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)	Specialization
...			
<u>1.2.840.10008.5.1.4.1.1.9.100.1</u>	Waveform Presentation State Storage	<u>Waveform Presentation State IOD</u>	
<u>1.2.840.10008.5.1.4.1.1.9.100.2</u>	Waveform Acquisition Presentation State Storage	<u>Waveform Acquisition Presentation State IOD</u>	

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319

Changes to NEMA Standards Publications PS 3.6
Digital Imaging and Communications in Medicine (DICOM)
Part 6: Data Dictionary

320 *Add new Elements to PS3.6 6 Table 6-1. Registry of Data Elements*

321 **Table 6-1. Registry of DICOM Data Elements**

Tag	Name	Keywords	VR	VM	
(0040,B030)	Structured Waveform Annotation Sequence	StructuredWaveformAnnotationSequence	SQ	1	
(0040,B031)	Waveform Annotation Display Selection Sequence	WaveformAnnotationDisplaySelectionSequence	SQ	1	
(0040,B032)	Referenced Montage Index	ReferencedMontageIndex	US	1	
(0040,B033)	Waveform Textual Annotation Sequence	WaveformTextualAnnotationSequence	SQ	1	
(0040,B034)	Annotation DateTime	AnnotationDateTime	DT	1	
(0040,B035)	Displayed Waveform Segment Sequence	DisplayedWaveformSegmentSequence	SQ	1	
(0040,B036)	Segment Definition DateTime	SegmentDefinitionDateTime	DT	1	
(0040,B037)	Montage Activation Sequence	MontageActivationSequence	SQ	1	
(0040,B038)	Montage Activation Time Offset	MontageActivationTimeOffset	DS	1	
(0040,B039)	Waveform Montage Sequence	WaveformMontageSequence	SQ	1	
(0040,B03A)	Referenced Montage Channel Number	ReferencedMontageChannelNumber	IS	1	
(0040,B03B)	Montage Name	MontageName	LT	1	
(0040,B03C)	Montage Channel Sequence	MontageChannelSequence	SQ	1	
(0040,B03D)	Montage Index	MontageIndex	US	1	
(0040,B03E)	Montage Channel Number	MontageChannelNumber	IS	1	
(0040,B03F)	Montage Channel Label	MontageChannelLabel	LO	1	
(0040,B040)	Montage Channel Source Code Sequence	MontageChannelSourceCodeSequence	SQ	1	
(0040,B041)	Contributing Channel Sources Sequence	ContributingChannelSourcesSequence	SQ	1	
(0040,B042)	Channel Weight	ChannelWeight	FL	1	

322
323

324 Add new SOP Classes to PS3.6 Annex A Table A-1:

325

UID Value	UID Name	UID Keyword	UID Type	Part
...				
<u>1.2.840.10008.5.1.4.1.1.9.100.1</u>	<u>Waveform Presentation State Storage</u>	<u>WaveformPresentationStateStorage</u>	<u>SOP Class</u>	<u>PS3.4</u>
<u>1.2.840.10008.5.1.4.1.1.9.100.2</u>	<u>Waveform Acquisition Presentation State Storage</u>	<u>WaveformAcquisitionPresentationStateStorage</u>	<u>SOP Class</u>	<u>PS3.4</u>
...				

326

327

328

329

330

331 **Changes to NEMA Standards Publications PS3.15**
332
333 **Digital Imaging and Communications in Medicine (DICOM)**
334 **Part 15: Security and System Management Profiles**

335 *Add the new Modules from the new IODs to PS3.15 Section C.2 by continuation of the list*

336 ...

337 As a minimum, an implementation shall include the following Attributes in generating the Creator RSA Digital
338 Signature:

339 a. the SOP Class and Instance UIDs

340 b. the SOP Creation Date and Time, if present

341 c. the Study and Series Instance UIDs

342 d.

343 **ae. any Attributes of the Waveform Presentation State Relationship Module that are present**

344 **af. any Attributes of the Structured Waveform Annotation Module that are present**

345 **ag. any Attributes of the Textual Waveform Annotation Module that are present**

346 **ah. any Attributes of the Displayed Waveform Segment Module that are present**

347 **ai. any Attributes of the Montage Activation Module that are present**

348 **aj. any Attributes of the Waveform Presentation Montage Module that are present**

349 *Add new Data Elements to PS3.15 Annex E*

350

Table E.1-1. Application Level Confidentiality Profile Attributes

Attribute Name	Tag	Retd. (from PS3.6)	In Std. Comp. IOD (from PS3.3)	Basic Prof.	Rtn. Safe Priv. Opt.	Rtn. UIDs Opt.	Rtn. Dev. Id. Opt.	Rtn. Inst. Id. Opt.	Rtn. Pat. Chars. Opt.	Rtn. Long. Full Dates Opt.	Rtn. Long. Modif. Dates Opt.	Clean Desc. Opt.	Clean Struct. Cont. Opt.	Clean Graph. Opt.
...														
<u>Annotation DateTime</u>	<u>(0040,B034)</u>	<u>N</u>	<u>Y</u>	<u>X</u>						<u>K</u>	<u>C</u>			
<u>Montage Channel Label</u>	<u>(0040,B03F)</u>	<u>N</u>	<u>Y</u>	<u>X</u>								<u>C</u>		
<u>Montage Name</u>	<u>(0040,B03B)</u>	<u>N</u>	<u>Y</u>	<u>X</u>								<u>C</u>		
<u>Segment Definition DateTime</u>	<u>(0040,B036)</u>	<u>N</u>	<u>Y</u>	<u>X</u>						<u>K</u>	<u>C</u>			
...														

351

352

Changes to NEMA Standards Publications PS3.17

Digital Imaging and Communications in Medicine (DICOM) Part 17: Explanatory Information

357 **EEEE Waveform Presentation State (Informative)**

358 In clinical neurophysiology it is important to be able to recreate the presentation of the recorded data as it
359 was displayed during the recording or during review and reporting. This allows subsequent reviewers to
360 recreate the display as it was when the recording was made and when an annotation was created, which
361 allows for review of subtle features that may not be obvious in other montages or reference states.

362 In cardiology, technicians annotate previously recorded waveforms (e.g. from home monitoring Holter
363 ECG) and highlight areas of interest. This information is essential input for the cardiologist who reviews
364 the ECG and finally provides the report.

365 Waveform objects support limited display information, including only Attributes for color and scaling of
366 waveform channels. This leaves out much information about how waveforms were visualized by the
367 technician who recorded the study, including the mathematical derivation of channels needed for
368 visualization, the ordering of channels on the display screen, and filters used for channel visualization.

369 In neurophysiology, a montage defines the list of channels for visualization of the waveform data which is
370 created from the originally recorded channel sources and it conveys the method for their mathematical
371 (linear) recombination. Montages could be either predefined (for a common list of sources) and
372 referenced by a montage object identifier or defined for each specific recording, because the recording
373 could include a unique list of sources.

374 Waveform Annotations are textual or coded markers assigned to a specific timepoint or time range, related
375 to all channels or a selected set of channels. Annotations could be observations of waveforms, patient
376 stimuli, comments about the recording, as well as measurements.

377 A Waveform Presentation State object stores annotations, visualization filters, and montages used for a
378 given recording (patient related). A Waveform Presentation State object is stored together with the
379 waveform study (e.g. a Routine Scalp EEG recording) and can be exchanged between systems.

380
381 The Waveform Acquisition Presentation State object is created during the waveform recording in order to
382 persist the montages and filter settings used by the technologist. Over the course of the waveform
383 recording the technologist may use different montages and filter settings and this information is persisted
384 in the Waveform Acquisition Presentation State object.

385
386 The Waveform Presentation State object is created later during review or analysis of the waveform. This
387 persists a description of montages and filter settings associated with created annotations. Subsequent
388 viewers of the recording and the annotations might choose this same view by applying this Presentation
389 State.

390

391 **EEEE.1 Waveform Presentation State Usage**

392 **Use case: Post-hoc Review**

393 A physician acting as a post-hoc reviewer looks through a completed EEG recording and marks potential
394 epileptiform features. The annotations added by the technician during the recording are displayed for
395 anyone reviewing the recording and can provide details useful for the interpreting physician, such as
396 when a patient is moving their body. If the physician adds annotations a Waveform Annotation SR is
397 created. In addition, if triggered by the post-hoc study reviewer, a Waveform Presentation State object is
398 created to store used filter settings and montages.

399

400 **Use case: Electronic Health Record**

401 An epilepsy patient is treated in another organization and the neurologist wants to see the EEGs and
402 findings of previous epilepsy monitoring recordings (accessible via the patient's health record). Montages
403 and filter settings used during recording and review may be different between hospitals. So the reviewer
404 may decide to use either the Waveform Acquisition Presentation State object to see directly what the
405 outside EEG staff annotated and which filters and montages were used or may choose to review the data
406 with montage settings as provided in a Waveform Presentation State created by the outside neurologist.

407

408 Use case: Automated Waveform Analysis

409 Algorithms may store observations and measurements as annotations in a Waveform Annotation SR
410 object. Additionally, it might be useful to store montages and filter settings used by the algorithm in a
411 Waveform Presentation State object for future reference.

412 EEEEE.2 Waveform Acquisition Presentation State Usage**413 Use case: Recording**

414 When a technician performs an EEG recording, from time to time, the technician changes the
415 visualization filter settings and montage, in order to check the quality of the source signals and/or to better
416 visualize a potential abnormal signal pattern in the live neurophysiology recording. Based on this
417 information, during the live recording, the technician may adjust the physical parameters of the recording,
418 such as manually adjusting the surface electrode contact with the skin to improve the signal quality. If
419 abnormalities occur or if external circumstances change that could be of importance for the evaluation of
420 the recording, the technician may add an annotation at a particular time point. The Annotations added by
421 the technician during the recording may either be stored in this Waveform Acquisition Presentation State
422 object or in a separate Waveform Annotation SR object.

423

424 Use case: Quality Control

425 A neurophysiology technician makes a recording which is of suboptimal quality. The lead technician of the
426 lab reviews the recording with the technician who made the recording using the Waveform Acquisition
427 Presentation State object. They discuss the poor signal quality of certain sources not noticed during the
428 recording. This led to certain physical parameters not being adjusted during the recording, which would
429 have rectified the problem. The reason for that was that the technician used suboptimal filter and/or
430 montage settings. Such suboptimal filter and montage settings can include filter settings with notch filter on
431 which can hide line noise (which can indicate poor impedance) or a montage that does not include relevant
432 sources.

433